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Engineers, Geologists & Environmental Scientists

# Subsurface Exploration and Foundation Recommendations Proposed Residence at 9023 Stone Oak Drive Montgomery, Montgomery County, Texas

**Terradyne Project No.: H215042**

**Reagan Caldwell**
**15632 Knotty Oaks Trail**
**Magnolia, Texas 77355**

**February 23, 2021**

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February 23, 2021

**Reagan Caldwell**
**15632 Knotty Oaks Trail**
**Magnolia, Texas 77355**

Attention: Reagan Caldwell

Re: **Subsurface Exploration and Foundation Recommendations**
Proposed Residence at
9023 Stone Oak Drive
Montgomery, Montgomery County, Texas
**Terradyne Project No.:** H215042

Dear Reagan:

Terradyne Residential, Inc. (Terradyne) has completed a soil and foundation engineering report at the above referenced project site. The results of the exploration are presented in this report.

We appreciate and wish to thank you for the opportunity to service you on this project. Please do not hesitate to contact us if we can be of additional assistance during the Construction Materials Testing and Quality Control phases of construction.

Respectfully Submitted,

Terradyne Residential, Inc.
*Texas Firm Registration No. F-22173*

STATE OF TEXAS
JOHN A. GUNTER
47957
REGISTERED PROFESSIONAL ENGINEER

2/23/2021

Damalí F. Vera, E.I.T.
*Geotechnical Engineer*

John A. Gunter, M.S., P.E.
*Chief Engineer*

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## 1.0 INTRODUCTION

This report presents the results of a subsurface exploration and foundation analysis for the proposed residence at 9023 Stone Oak Drive in Montgomery, Texas. The objective of this investigation was to evaluate the physical properties of the soils underlying the site in order to provide recommendations for foundation, retaining wall design, slab support, and related earthwork for the structure.

## 2.0 PROJECT DESCRIPTION

Terradyne understands that the proposed residence will be a one or two-story wood framed house with a slab area of less than 5,000 square feet. If the final construction plans vary from what has been estimated, please contact Terradyne for further evaluation as the revisions may affect the recommendations provided in this report.

## 3.0 PURPOSE AND SCOPE OF SERVICES

The purpose of our geotechnical investigation was to evaluate the subsurface and groundwater conditions of the site and provide geotechnical engineering recommendations for the design and construction of the residence. Our scope of services includes the following:

1) Drilling and sampling of one (1) boring B-1 to a depth of 15 feet;
2) Evaluation of the in-place conditions of the subsurface soils through field penetration tests;
3) Observation of the groundwater conditions during drilling operations;
4) Performing laboratory tests such as Atterberg limits and moisture content tests;
5) Review and evaluation of field and laboratory tests;
6) Compilation, generalization and analysis of the field and laboratory data according to the project requirements;
7) Estimation of potential vertical movements;
8) Preparation of recommendations for the design and construction of the structure;
9) Consultations with Prime Professionals and members of the design team on findings and recommendations and the preparation of a written geotechnical engineering report for their use in the preparation of design and construction documents.

The Scope of Services does not include an environmental assessment of the presence or absence of wetlands and/or hazardous or toxic materials in the soil, surface water, groundwater, or air, in the proximity of this site. Any statements in this report or on the boring log regarding odors, colors or unusual or suspicious items or conditions are strictly for the information of the client.

## 4.0 SITE CONDITIONS

Boring B-1 was drilled at the approximate location shown on the attached site sketch provided by DS Squared in Figure 1-A. A site photo is included in Figure 1-B. The site is heavily wooded.

## 5.0 GEOTECHNICAL INVESTIGATION

The field exploration to determine the engineering characteristics of the subsurface materials was performed by DS Squared with a Little Beaver drilling rig using flight augers and obtaining disturbed grab samples. Boring B-1 was drilled to a maximum depth of 15 feet.

The samples were identified according to boring number and depth, encased in polyethylene plastic wrapping to protect against moisture loss, and transported to our laboratory.

### 5.1 Field Tests and Measurements

*Penetration Tests:* During the sampling procedures, penetration tests were performed on the samples with a pocket penetrometer (ASTM 1558). The penetration value is defined as the effort, in tons per square-foot (tsf) required to advance the probe into the sample one-quarter (¼) inch. The results of the pocket penetration tests indicate the relative density and comparative consistency of the soils. Additionally, a torvane shear device was used to provide a relative shear strength of soils ranging from 0 to 2.5 tsf.

*Water Level Measurements:* Water level observations were made during drilling operations and the results are noted on the boring log. In relatively pervious soils, such as sandy soils, the indicated elevations are considered reliable groundwater levels. In relatively impervious soils, an accurate determination of the groundwater elevation may not be possible even after several days of observation. Seasonal variations, temperature and recent rainfall conditions may influence the level of the groundwater table and the volume of water encountered will depend on the permeability of the soils.

### 5.2 Boring Log

The log includes information concerning the boring method, samples attempted and recovered, the presence of various materials (such as clay, sand and silt) and groundwater observations. It also includes an interpretation of the subsurface conditions between samples. Therefore, the log includes both factual and interpretive information.

The final log represents our interpretation of the contents of the field log and laboratory test results for the purpose delineated by our client. The final log is included on Figure 2 in the Appendix. A key to classification terms and symbols used on the log is presented on Figure 3.

### 5.3 Laboratory Testing Program

In addition to field exploration, a laboratory testing program was conducted to determine additional pertinent engineering characteristics of the subsurface materials that are necessary to evaluate the soil parameters. All phases of the laboratory testing program were performed in general accordance with the indicated applicable ASTM Specifications presented in Table No. 1.

**Table No. 1 – Summary of Laboratory Testing**

| Type of Test | Applicable Test Standard |
|---|---|
| Natural Moisture Content | ASTM D-2216 |
| Atterberg Limits | ASTM D-4318 |
| Passing #200 Sieve | ASTM D-1140 |

In the laboratory, each sample was examined and classified by a geotechnical engineer. As a part of this classification procedure, the natural water content of selected specimens was determined. Liquid and Plastic Limit tests were performed on representative specimens to determine the plasticity characteristics of the soil strata encountered. The results of these tests are presented on the boring log.

### 5.4 General Subsurface Conditions

The site is located within the Willis Formation (Qwc). [1]

Groundwater was encountered at approximately 13 feet below the existing ground surface during the time of drilling. Groundwater levels will fluctuate with seasonal climatic variations and changes in the land use. The low permeability of the shallow soils may require several days for groundwater to enter and stabilize in the borehole. It is not unusual to encounter shallow groundwater during or after periods of rainfall. Surface water tends to percolate through the surface until it encounters a relatively impervious layer.

## 6.0 FOUNDATIONS ON EXPANSIVE SOIL

There are many plastic clays that swell when water is added to them and shrink when water is removed. Foundations constructed on these clays are subjected to large uplifting forces caused by the swelling. Two factors contribute to potential shrink-swell problems within a building site. Problems can arise if a) the soil has expansive or shrinkage properties or b) environmental conditions cause the moisture levels in the soil to change.

*Evaluation of the Shrink-Swell Potential of the Soils:* Subsurface sampling, laboratory testing, and data analysis is used to evaluate the shrink-swell potential of the soils under the foundation.

*The Mechanism of Swelling:* The mechanism of swelling in expansive clays is influenced by a number of factors. The expansion in clays is a result of changes in the soil-water system that disturbs the internal stress equilibrium. Clay particles have negative electrical charges on their surfaces and positively charged ends. The negative charges are balanced by actions in the soil-water and give rise to an electrical interparticle force field. In addition, adsorptive forces exist between the clay crystals and water molecules, and Van Der Waals surface forces exist between particles. Thus, there exists an internal electro-chemical force system that must be in equilibrium with the externally applied stresses and capillary tension in the soil water. If the soil-water

[1] Source: Geologic Units of Texas; USGS https://pubs.er.usgs.gov/publication/i1420(NH14)

chemistry is altered, either by changing the amount of water or chemical composition in the soil, the inter-particle force field will change. If the change in internal forces is not balanced by a corresponding change in the state of stress, the particle spacing changes until equilibrium is reached. This change in particle spacing manifests itself as a shrinkage or swelling.

*Antecedent Rainfall Ratio:* This is defined as the total monthly rainfall for the current and previous months prior to laying the slab, divided by twice the average monthly rate measured for the period. The intent of this ratio is to give a relative measure of ground moisture conditions at the time the slab is placed. Thus, if a slab is placed at the end of a wet period, the slab shall be expected to experience some loss of support around the perimeter as the wet soil begins to dry out and shrink. The opposite effect could be anticipated if the slab is placed at the end of an extended dry period; as the wet season occurs, uplift around the perimeter may occur as the soil at the edge of the slab gains in moisture content.

*Age of Slab:* The length of time since the slab was cast provides an indication of the type of swelling the soil profile may have beneath the slab.

*Initial Moisture Condition and Moisture Variation:* A volume change in an expansive soil mass is the result of increases or decreases in water content. The initial moisture content influences the swell and shrink potential of a soil. However, moisture content alone is useless as an indicator or predictor of shrink-swell potential. The relationship between moisture content and other soil characteristics, such as the Plastic Limit and Liquid Limit, must also be known.

If the moisture content is below or near the Plastic Limit, the soils may have a high potential to swell. Expansive soils with Liquidity Index[2] in the range of 0.20 to 0.40 tend to experience little additional swell.

The availability of water in an expansive soil profile is influenced by many environmental and manmade factors. Generally, the upper few feet of the profile are subjected to the widest ranges of moisture variation and are the least restrained from movement by overburden. This upper stratum of the profile is referred to as the active zone. Moisture variation in the active zone of a natural soil profile is affected by climatic cycles at the surface and fluctuating groundwater levels at the lower moisture boundary. The superficial boundary moisture conditions are changed by placing a barrier, such as a building floor slab or pavement, between the soil and atmospheric environment. Other causes of moisture variation result from altered drainage conditions or manmade sources of water, such as irrigation or leaky plumbing. The latter factors are difficult to quantify and incorporate into the analysis but shall be controlled to the extent possible for each situation. For example, proper drainage and attention to landscaping are simple means of minimizing moisture fluctuations near structures and shall always be taken into consideration.

[2] $$\text{LIQUIDITY INDEX} \equiv \frac{\text{NATURAL WATER CONTENT} - \text{PLASTIC LIMIT}}{\text{LIQUID LIMIT} - \text{PLASTIC LIMIT}}$$

*Manmade Conditions That Can Be Altered:* There are a number of factors that can influence whether a soil might shrink or swell and the magnitude of this movement. For the most part, the owner and/or designer have some control over whether these factors can be avoided, and if not avoided, the degree to which these factors may influence the shrink-swell process.

*Lot Drainage:* How a lot is graded affects the accumulation of surface water around the slab. Most builders are aware of the importance of grading the soil away from the structure so that rainwater does not collect and pond adjacent to the foundation. If allowed to accumulate next to the foundation, water may infiltrate the expansive soils underlying the foundation, which could cause the foundation to settle. Similarly, runoff from surface water drainage patterns and swales must not collect adjacent to the foundation.

*Topography:* As it swells, soil heaves perpendicularly to the ground surface or slope, but as it shrinks, it recedes in the direction of gravity and gradually moves downslope in a sawtooth fashion over a number of shrink-swell cycles. In addition to this shrink-swell influence, soil will exhibit viscoelastic properties and creep downhill under the steady influence of the weight of the soil. Therefore, to avoid a structure constructed on this slope from moving downhill with the soil, it must be designed to compensate for this lateral soil influence.

*Pre-Construction Vegetation:* A large amount of vegetation, especially large trees, on a site prior to construction may have desiccation at the site. Constructing over a desiccated soil can produce some dramatic instances of heave and associated structural distress and damage as it becomes wet.

*Post-Construction Vegetation:* The type, amount, and location of vegetation that has grown since construction can cause localized desiccation. Planting trees or large shrubs near a building can result in the loss of foundation support as the vegetation robs moisture from the foundation soil. Conversely, the opposite effect can occur if flowerbeds or shrubs are planted next to the foundation and these beds are kept well-watered or flooded. This practice can result in swelling of the soil around the perimeter where the soil remains wet.

*Summation:* It is beyond the scope of this investigation to do more than point out the factors that may influence the amount and type of swell a slab-on-grade foundation may be subjected to during its lifetime. The design engineer must be aware of these factors in developing their design, using their engineering experience and judgment as a guide.

## 7.0 DESIGN ENGINEERING ANALYSIS

*Structural Assumptions:* Based on Terradyne's experience, it is anticipated that the proposed structure will be one or two-story wooden framed structure. This structure is expected to create moderately light loads to be carried by the foundation system. This structure will utilize wood frame construction and brick or stucco exterior walls. It is assumed that the maximum column loads will not exceed five (5) kips, while maximum exterior wall loading will be in the range of one kip per foot.

*Vertical Movements:* The potential vertical rise (PVR) for slab-on grade construction at the location has been estimated using the general guidelines presented in the Texas Department of Transportation Test Method TXDOT-124-E. This method utilizes the liquid limits, plasticity indices, and in-situ moisture contents for soils in the seasonally active zone, estimated to be about eight to ten feet in the project area.

The estimated PVR value provided is based on the proposed floor system applying a sustained surcharge load of approximately one pound per square inch on the subgrade materials. Potential vertical movements are calculated using average soil moisture conditions. The finish grade elevation was assumed to be ½ to one foot above the existing grade level. Select structural fill shall be used to raise the elevation by ½ to one foot.

***If the existing grade has to be raised to attain the finish grade elevation, select fill shall be placed, compacted and tested for compaction compliance by Terradyne.***

## 8.0 FOUNDATION RECOMMENDATIONS

The type and depth of foundation suitable for a given structure primarily depends on several factors: the subsurface conditions, the function of the structure, the loads it may carry and the cost of the foundation. Additional considerations may include acceptable performance criteria set by the owner, architect, or structural designer with respect to vertical and differential movements that the structure can withstand without damage. Based on these conditions and our engineering design analysis, a post tensioned beam and slab foundation, or a stiffened grid type beam and slab foundation are acceptable for this site.

### 8.1 Stiffened Grid Type Beam and Slab Foundation

A stiffened grid-type beam and slab foundation may be considered to support the proposed structure provided the potential vertical movements presented will not impair the performance of the structure.

It is desirable to design the foundation system using an assumption that the beams carry the loads. A maximum allowable bearing capacity of 1,000 pounds per square foot may be used for the beams founded at the depths shown in Table No. 2 within the undisturbed native/existing soils. If the existing grade of the structure must be raised to achieve design grade, select structural fill should be placed compacted and tested. An allowable bearing pressure of 1,200 pounds per square foot should be used for beams bearing on a minimum of 18 inches of compacted select structural fill. A minimum beam width of at least 10 inches is recommended.

The beams shall intersect at heavy load areas, such as columns. The beam intersection may be widened to act as spread footings and sized for an allowable bearing capacity of 1,200 pounds per square foot. Refer to Table No. 2 for the Design Plastic Index value for the site.

**8.2 Post-Tensioned Beam and Slab Foundation**

A post-tensioned slab-on-grade foundation may be considered to support the proposed structure provided the potential vertical movements will not impair the performance of the structure. Pertinent design parameters were evaluated and are presented in the following paragraphs.

Differential vertical movements shall be expected for shallow type foundations at this site due to expansive soil conditions that were encountered. Differential vertical movements have been estimated for both the center lift and edge lift conditions for post-tensioned slab-on grade construction at this site. These movements were estimated using the procedures and criteria discussed in the Post-Tensioning Institute Manual entitled "Design and Construction of Post-Tensioned Slabs-on-Ground," 3rd Edition. This procedure uses the soil data obtained from the field and laboratory tests performed on the soil samples.

Differential vertical movements have been estimated for the center lift and edge lift conditions. These values are presented in Table No.2.

**Table No. 2 – 3rd Edition PTI Values**

| Soil Conditioning Method | | Grade Beam Depth (Inches) | PVR (Inches) | Design Plasticity Index | Differential Vertical Movement, ($Y_m$) Inches | | Edge Moisture Variation Distance, ($E_m$) feet | |
|---|---|---|---|---|---|---|---|---|
| Type | Depth (ft) | | | | Center Lift | Edge Lift | Center Lift | Edge Lift |
| Existing Cond. | N/A | 18 | 1 | 15 | 0.4 | 0.6 | 9.0 | 6.3 |

**8.3 Utilities**

Utilities that project through slab-on-grade floors shall be designed with either some degree of flexibility or with sleeves in order to prevent damage to these lines should vertical movements occur.

**8.4 Contraction, Control and/or Expansion Joints**

Contraction, control and/or expansion joints shall be designed and placed in various portions of the structure. Properly planned placement of these joints will assist in controlling the degree and location of material cracking that occurs due to soil movements, material shrinkage, thermal affects, and other related structural conditions.

**8.5 Lateral Earth Pressure**

Some retaining walls may be needed at this site. The equivalent fluid density values were evaluated for various backfill materials. These values are presented in Table No. 3.

**Table No. 3 – Lateral Earth Pressure Parameters**

| Backfill Material | Equivalent Fluid Density, PCF | | |
|---|---|---|---|
| | Active Condition | At Rest Condition | Passive Condition |
| a. Crushed Limestone | 40 | 60 | 530 |
| b. Clean Sand | 40 | 60 | 360 |
| c. Select Fill (PI ≤ 15) | 65 | 85 | 265 |

These equivalent fluid densities do not include the effect of seepage pressures, surcharge loads such as construction equipment, vehicular loads, or future storage near the walls.

If the basement wall or cantilever retaining wall can tilt forward to generate "active earth pressure" condition, the values under active condition shall be used. For rigid non-yielding walls which are part of the building, the values" at rest condition" shall be used. The compactive effort shall be controlled during backfill operations. Over compaction can produce lateral earth pressures in excess of at rest magnitudes. Compaction levels adjacent to below-grade walls shall be maintained between 95 and 98 percent of standard Proctor (ASTM D698) maximum dry density.

The backfill behind the wall shall be drained properly. The simplest drainage system consists of a drain located near the bottom of the wall. The drain collects the water that enters the backfill and this may be disposed of through outlets along the base of the wall. To ensure that the drains are not clogged by fine particles, they shall be surrounded by a granular filter. Despite a well-constructed toe drain, substantial water pressure may develop behind the wall if the backfill consists of clays or silts. A more satisfactory drainage system, consisting of a back drain of 12 inch to 24 inches width gravel may be provided behind the wall to facilitate to drainage.

The maximum toe pressure for wall footings founded a minimum depth of 12 inches into clay soils shall not exceed 1,000 pounds per square foot. An adhesion value of 300 pounds per square foot shall be used to check against sliding for wall footings bearing on clay.

## 9.0 CONSTRUCTION GUIDELINES

### 9.1 Construction Monitoring

As Geotechnical Engineer of Record for this project, Terradyne, shall be involved in monitoring the foundation installation and earthwork activities. The performance of any foundation system is not only dependent on the foundation design but is strongly influenced by the quality of construction. Prior to construction, please contact our office so that a Foundation and Earthwork Monitoring Plan can be incorporated into the Project Quality Control Program.

### 9.2 Site Preparation

In any areas where soil-supported floor slabs or pavement are to be constructed, vegetation and all loose or organic material shall be stripped and removed from the site. Subsequent to stripping operations, the subgrade shall be proofrolled to identify soft zones. Any soft zone detected shall be removed to a firm subgrade soils and replaced with compacted suitable soils to reach subgrade level. Upon the acceptance of proofrolling operations the subgrade shall be scarified to a minimum depth of 8 inches, moisture conditioned and compacted to a 95 percent of maximum dry density as determined by ASTM D 698, within three (3) percentage points of optimum moisture content. The exposed subgrade shall not be allowed to dry out prior to placing structural fill.

Select fill material used at this site shall be clayey sand (SC), lean clay with gravel (CL) or clayey gravel (GC) with maximum liquid limit of 35 percent and plasticity index (PI) between five (5) and fifteen (15). The fill shall be compacted to at least 95 percent of the maximum dry density as determined by ASTM D 698, within ± 2 percentage points of optimum moisture content.

### 9.3 Groundwater

Groundwater seepage was encountered at a depth of approximately 13-feet below the surface during drilling. However, minor groundwater seepage may be encountered within the proposed building foundation and grading excavations at the time of construction, especially after periods of heavy precipitation. Small quantities of seepage may be removed by conventional sump and pump methods of dewatering.

### 9.4 Temporary Drainage Measures

Temporary drainage provisions shall be established to minimize water runoff into construction areas. If standing water does accumulate, it shall be removed by pumping as soon as possible. Adequate protection against sloughing of soils shall be provided for workers and inspectors entering the excavations. This protection shall meet OSHA and other applicable building codes.

### 9.5 Drainage

In areas where significant cuts (2-feet or more) are made to establish final grades for building pads, attention shall be given to possible seasonal water seepage that could occur through natural cracks and fissures in the newly exposed stratigraphy. Subsurface drains may be required to intercept seasonal groundwater seepage. The need for these, or other dewatering devices, on building pads shall be carefully addressed during construction. Our office could be contacted to visually inspect final pads to evaluate the need for such drains.

Groundwater seepage may occur several years after construction if the rainfall rate or drainage changes in the vicinity of the project site. If seepage runoff occurs towards the building, an engineer shall be contacted to evaluate its’ effect and determine whether French drains are required at the location.

### 9.6 Control Testing and Field Observation

Subgrade preparation and select structural fill placement shall be monitored by the project geotechnical engineer or their representative. As a guideline, at least one in-place density test shall be performed for each 2,500 square feet of compacted surface lift.

A minimum of two density tests shall be performed on the subgrade or per lift of compaction. Any areas not meeting the required compaction shall be re-compacted and retested until compliance is met.

### 9.7 Earthwork and Foundation Acceptance

Exposure to the environment may weaken the soils at the foundation bearing level if the excavation remains open for long periods of time. Therefore, it is recommended that all foundation excavations be extended to final grade and the footings constructed as soon as possible to minimize potential damage to bearing soils. The foundation bearing level shall be free of loose soil, ponded water or debris sand, and shall be inspected and approved by the geotechnical engineer or their representative prior to concreting.

Foundation concrete shall not be placed on soils that have been disturbed by rainfall or seepage. If the bearing soils are softened by surface water intrusion during exposure or by desiccation, the unsuitable soils must be removed from the foundation excavation and replaced prior to placement of concrete.

Subgrade preparation and fill placement operations shall be monitored by the geotechnical engineer or their representative. As a guideline, at least one in-place density test shall be performed for each 2,500 square feet of compacted surface lift. Any areas not meeting the required compaction shall be recompacted and retested until compliance is met.

## 10.0 DRAINAGE AND MAINTENANCE

Final drainage is important for the performance of the proposed structure and pavement. Landscaping, plumbing, and downspout drainage is also important. It is vital that all roof drainage be transported away from the building so that water does not pond around it, which can result in a soil volume change underneath the building. Plumbing leaks shall be repaired as soon as possible in order to minimize the magnitude of a moisture change under the slab. Large trees and shrubs shall not be planted in the immediate vicinity of the structure, since root systems can cause a substantial reduction in soil volume in the vicinity of the trees during dry periods.

Adequate drainage shall be provided to reduce seasonal variations in moisture content of foundation soils. All pavement and sidewalks within 10-feet of the structure shall be sloped away from the structure to prevent ponding of water around the foundations. Final grades within 10-feet of the structure shall be adjusted to slope away from structures preferably at a minimum slope of three (3) percent. Maintaining positive surface drainage throughout the life of the structure is essential.

In areas with pavement or sidewalks adjacent to the new structure, a positive seal must be provided and maintained between the structure and the pavement or sidewalk to minimize seepage of water into the underlying supporting soils. Post-construction movement of pavement and flat-work is not uncommon. Maximum grades practical shall be used for paving and flatwork to prevent areas where water can pond.

In addition, allowances in final grades shall take into consideration post construction movement of flatwork, particularly if such movement would be critical. Normal maintenance shall include inspection of all joints in paving and sidewalks, etc. as well as re-sealing where necessary.

There are several factors related to civil and architectural design and/or maintenance that can significantly affect future movements of the foundation and floor slab systems.

1. Where positive surface drainage cannot be achieved by grading the ground surface adjacent to the building, a complete system of gutters and downspouts shall carry runoff water a minimum of 10-feet from the completed structure.

2. Planters located adjacent to the structure shall preferably be self-contained. Sprinkler mains shall be located a minimum of five feet from the building line.

3. Planter box structures placed adjacent to the building shall be provided with a means to assure concentrations of water do not infiltrate the subsoils stratigraphy.

4. Large trees and shrubs shall not be planted closer to the foundation than a horizontal distance equal to roughly their mature height due to their significant moisture demand upon maturing.

5. Moisture conditions shall be maintained "constant" around the edge of the slabs. Ponding of water in planters, in unpaved areas, and around joints in paving and sidewalks can cause slab movements beyond those predicted in this report.

6. Roof drains shall discharge on pavement or be extended away from the structure. Ideally, roof drains shall discharge to storm sewers by closed pipe.

Trench backfill for utilities shall be properly placed and compacted, as outlined in this report, and in accordance with the requirements of local City, County and/or State Standards. Since granular bedding backfill is used for most utility lines, the backfilled trench shall be prevented from becoming a conduit and allowing an access for surface or subsurface water to travel toward the new structure. Concrete cut-off collars or clay plugs shall be provided where utility lines cross building lines to prevent water from traveling in the trench backfill and entering beneath the structure.

The PVR values estimated and stated under "Vertical Movements" are based on the provision that positive drainage shall be maintained to divert water away from the building and adjacent pavement. If the drainage is not maintained, the wetted front may occur below the assumed fifteen feet depth, and the resulting PVR may be two (2) to three (3) times greater than the stated values shown in this report. Utility leaks may also cause similar high movements to occur.

## 11.0 SHORING

Shoring of excavations and design of shoring systems are governed by federal, state, and local regulations. The design of shoring systems on this project is beyond the scope of our services. The owner or the contractor should retain a shoring design professional to design shoring systems for excavations on this site.

## 12.0 LIMITATIONS

The analysis and recommendations submitted in this report are based upon the data obtained from the one (1) boring drilled at the site. This report may not reflect the exact variations of the soil conditions across the site. The nature and extent of variations across the site may not become evident until construction commences. If variations appear evident, it will be necessary to re-evaluate our recommendations after performing on-site observations and tests to establish the engineering significance of any variations. The project geotechnical engineer should review the final plan for the proposed building so that they may determine if changes in the foundation recommendations are required. The project geotechnical engineer declares that the findings, recommendations, or professional advice contained herein have been made and this report prepared in accordance with generally accepted professional engineering practice in the fields of geotechnical engineering and engineering geology. No other warranties are implied or expressed.

This report is valid until site conditions change due to disturbance (cut and fill grading) or changes to nearby drainage conditions or for three (3) years from the date of this report, whichever occurs first. Beyond this expiration date, Terradyne shall not accept any liability associated with the engineering recommendations in the report, particularly if the site conditions have changed. If this report is desired for use for design purposes beyond this expiration date, we highly recommend drilling additional borings so that we can verify the subsurface conditions and validate the recommendations in this report.

This report has been prepared for the exclusive use of Reagan Caldwell for the specific application to the proposed residence at 9023 Stone Oak Drive in Montgomery, Texas.

# Site Sketch

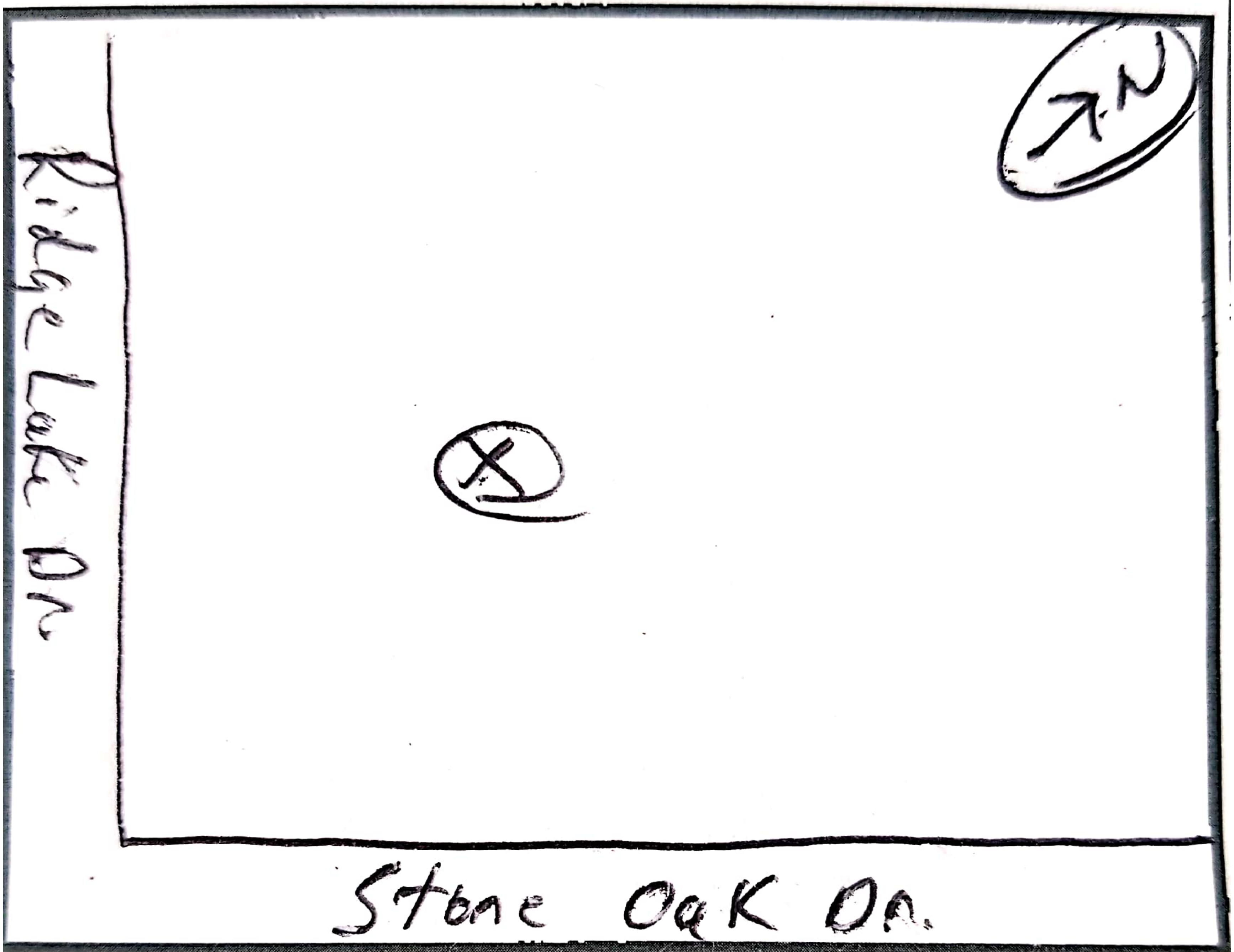

**Figure 1-B**

| | |
|---|---|
| Project: **Proposed Residence at 9023 Stone Oak Drive** | **Log of Boring B-1** |
| Project Location: **Montgomery, Montgomery County, Texas** | **Sheet 1 of 1** |
| Terradyne Project Number: **H215042 (T-550-2021)** | |

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| | | | |
|---|---|---|---|
| Date(s) Drilled | **1/26/2021** | | |
| Drilling Method | **Flight Auger** | Total Depth of Borehole | **15-feet** |
| Drill Rig Type | **Little Beaver** | Approximate Surface Elevation | **Existing Ground Surface** |
| Groundwater Level and Date Measured | **Encountered at 13-Feet** | Sampling Method(s) | **Grab** |
| Borehole Backfill | **Natural Soils** | Location | **See Site Sketch** |

| Depth (feet) | Sample Type | T (tsf) | PP (tsf) | Graphic Log | MATERIAL DESCRIPTION | Water Content, % | Dry Unit Weight, pcf | Passing #200 Sieve, % | LL, % | PL, % | PI, % | UC, tsf | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | Silty Clayey Sand, brown, moist (SM-SC) | | | | | | | | |
| | | 0.13 | 0.25 | | | 11 | | 34 | | | | | |
| | | 0.13 | 0.25 | | | 13 | | | 19 | 11 | 8 | | |
| 5 | | 0 | 0 | | | 16 | | 32 | | | | | |
| | | 0.13 | 0 | | | 16 | | | 15 | 4 | 11 | | |
| | | | | | -becomes reddish brown | | | | | | | | |
| | | 0 | 0 | | | 23 | | | | | | | |
| 10 | | | | | | | | | | | | | |
| | | | | | ▽ (groundwater) | | | | | | | | |
| 15 | | 0 | 0 | | End of Borehole | 24 | | | | | | | |

**Figure 2**

| Project: **Proposed Residence at 9023 Stone Oak Drive** | Key to Log of Boring |
|---|---|
| Project Location: **Montgomery, Montgomery County, Texas** | **Sheet 1 of 1** |
| Terradyne Project Number: **H215042 (T-550-2021)** | |

| Depth (feet) | Sample Type | T (tsf) | PP (tsf) | Graphic Log | MATERIAL DESCRIPTION | Water Content, % | Dry Unit Weight, pcf | Passing #200 Sieve, % | LL, % | PL, % | PI, % | UC, tsf | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |

**COLUMN DESCRIPTIONS**

1 Depth (feet): Depth in feet below the ground surface.

2 Sample Type: Type of soil sample collected at the depth interval shown.

3 T (tsf): The Relative shear strength of the soil, measured by Pocket Torvane Shear Vane in tons/square foot

4 PP (tsf): The Relative Consistency of the soil, measured by Pocket Penetrometer in tons/square foot

5 Graphic Log: Graphic depiction of the subsurface material encountered.

6 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.

7 Water Content, %: Water content of the soil sample, expressed as percentage of dry weight of sample.

8 Dry Unit Weight, pcf: Dry weight per unit volume of soil sample measured in laboratory, in pounds per cubic foot.

9 Passing #200 Sieve, %: The percent fines (soil passing the No. 200 Sieve) in the sample.

10 LL, %: Liquid Limit, expressed as a water content

11 PL, %: Plastic Limit, expressed as a water content.

12 PI, %: Plasticity Index, expressed as a water content.

13 UC, tsf: Unconfined compressive strength.

14 REMARKS AND OTHER TESTS: Comments and observations regarding drilling or sampling made by driller or field personnel.

**FIELD AND LABORATORY TEST ABBREVIATIONS**

T: Pocket Torvane Shear Vane
LL: Liquid Limit, percent
PL: Plastic Limit, percent
PI: Plasticity Index, percent
PP: Pocket Penetrometer

**TYPICAL MATERIAL GRAPHIC SYMBOLS**

Silty to Clayey SAND (SM-SC)

**TYPICAL SAMPLER GRAPHIC SYMBOLS**

Grab Sample

**OTHER GRAPHIC SYMBOLS**

Water level (at time of drilling, ATD)

Water level (after waiting)

Minor change in material properties within a stratum

Inferred/gradational contact between strata

Queried contact between strata

**GENERAL NOTES**

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

TERRADYNE
Engineers, Geologists & Environmental Scientists

**Figure 3**