Subsurface Exploration and Pavement Analysis
Proposed New Streets
Miller Tract
Boerne, Texas

Great America Companies
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Geotechnical & Environmental Engineering • Construction Services • Geologic Assessment

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May 22, 2014

Great America Companies
10003 NW Military Highway, Suite 2201
San Antonio, Texas 78231

Attention: **Mr. Israel Fogiel**

Re: Subsurface Exploration and Pavement Analysis
Proposed New Streets
Miller Tract
Boerne, Texas

InTEC Project No. S131434-P

Gentlemen:

Integrated Testing and Engineering Company (InTEC) has completed a **subsurface exploration and pavement thickness evaluation 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 be of service to you on this project. If we can be of additional assistance during the foundations explorations, and materials testing-quality control phase of construction, please call us.

Respectfully Submitted,

MURALIK SUBRAMANIAM
102417

InTEC of SAN ANTONIO
F-7623

Very Truly Yours,
InTEC of San Antonio, L.P.

Murali Subramaniam, Ph.D., P.E.

E.A. "Paul" Palaniappan, Ph.D., P.E.
CHIEF ENGINEER

Copies Submitted: Above (1)

EXECUTIVE SUMMARY

The soil conditions at the location of **Miller Tract in Boerne, Texas** were obtained from **25 borings** to a depth of **8 to 15 feet.** Laboratory tests were performed on selected specimens to evaluate the engineering characteristics of various soil strata encountered in our borings.

The results of our exploration, laboratory testing and engineering evaluation indicate the underlying clays at this site **are low to highly expansive in character.** Potential vertical movements on the order of **1 ¼ to 3 inches** were estimated.

The proposed pavements at this site may be supported by flexible sections. Stratum I soils consist of expansive clays and extend to 1 to 6-ft in the borings. Subgrade stabilization will be needed where the finish street subgrade consists of expansive clays. Cut and fill information is not available at this time. Brown clay and marl to limestone subgrades are anticipated. At the time of construction, if the final street subgrade consists of material other than encountered in our borings, the recommendations may have to be revised. Pavement section recommendations for local, collector, and arterial type streets are presented.

Ground water seepage was not encountered in our borings at the time of our drilling.

Detailed descriptions of subsurface conditions, engineering analysis, and design recommendations are included in this report.

Minimum Flexible Pavement Recommendations - CBR = 3.0 **
Clay Subgrades

	Type D, Course Asphaltic	Aggregate Base	Lime Stabilized Subgrade	Structural Number
Classification	Concrete, inches	Thickness, inches	Thickness, inches	
Local	2.00	9.00	6*	2.62
Collector	3.00	14.50	8*	3.99
Arterial	3.00	19.50	8*	4.69

- Input parameters are shown in Table No. 8. Please call us to provide pavement recommendations, if needed, for different input values.
- If repetitive truck or heavy truck traffic is anticipated, please contact us for revised pavement recommendations.

Notes (*):

- subgrade stabilization using lime to depths of 6 or 8 inches. Lime content of 6 ½ percent of the dry weight of the soil to be treated should be used; a unit weight of the clay of 100 lbs per cubic feet may be used.

- The subgrade soils should be tested for soluble sulphate content prior to installation of the lime
    - Lime content: for **6 inch stabilization – 29.25 lbs per sq yard**
    - Lime content: for **8 inch stabilization – 39.00 lbs per sq yard**

Notes (**)

- In addition, pavement section recommendations are based on subgrades prepared as described in this report. If water is allowed to get underneath the asphalt or if moisture content of the base or subgrade changes significantly, then pavement distress will occur.

Fill Material:

If fill is used to raise the grade, fill material underneath the pavement should be on-site material, free of deleterious material with a minimum CBR value of 3.0. The gravel size should not exceed 3 inches in diameter. Lime application rate should be re-evaluated for the fill material. The material should be placed as per applicable city guidelines.

Minimum Flexible Pavement Recommendations - CBR = 6.0 **
Marl to Limestone Subgrades

	Type D, Course Asphaltic	Aggregate Base	Lime Stabilized Subgrade	Structural Number
Classification	**Concrete, inches**	**Thickness, inches**	**Thickness, inches**	
Local	2.00	8.50	None	2.07
Collector	3.00	13.00	None	3.14
Arterial	3.00	17.00	None	3.70

- Input parameters are shown in Table No. 8. Please call us to provide pavement recommendations, if needed, for different input values.
- If repetitive truck or heavy truck traffic is anticipated, please contact us for revised pavement recommendations.

Notes (**)

- In addition, pavement section recommendations are based on subgrades prepared as described in this report. If water is allowed to get underneath the asphalt or if moisture content of the base or subgrade changes significantly, then pavement distress will occur.

Fill Material:

If fill is used to raise the grade, fill material underneath the pavement should be on-site material, free of deleterious material with a minimum CBR value of 6.0 and a Plasticity Index value of 20 or less. The gravel size should not exceed 3 inches in diameter. The material should be placed as per applicable city guidelines.

Summary of Pavement Materials

Pavement Section	Material	Stabilization or Treatment	Thickness	Installation
Subgrade	Expansive Clays	Stabilization (lime) Sulphate content should be tested prior to stabilization	As recommended in pavement options (6 or 8 inches)	As per applicable city or county guidelines
	Marl to Limestone	None	Moisture Conditioned	As per applicable city or county guidelines
Base	TxDOT Item 247 A1 or A2	-	As recommended in pavement options (maximum of 6 inches per lift)	As per applicable city or county guidelines
Asphalt	Type D	-	As recommended in pavement options	As per applicable city or county guidelines

See report for more details

INTRODUCTION

General

This report presents the results of our **subsurface exploration and pavement thickness evaluation** for the proposed **new streets in Miller Tract in Boerne, Texas.** This project was authorized by **Mr. Israel Fogiel.**

Purpose and Scope of Services

The purpose of our subsurface investigation was to evaluate the site's subsurface and ground water conditions and provide pavement thickness recommendations for the planning and development phases of the project. Our scope of services includes the following:

1) drilling and sampling of 25 borings – to a depth of 8 to 15-ft;
2) observing the ground water conditions during drilling operations;
3) performing laboratory tests such as Atterberg limits, California Bearing Ratio (C.B.R.), Lime Series, and Moisture content tests;
4) review and evaluation of the field and laboratory test programs during their execution with modifications of these programs, when necessary, to adjust to subsurface conditions revealed by them;
5) compilation, generalization and analyses of the field and laboratory data in relation to the project requirements;
6) estimate of potential vertical movements;
7) preparation of pavement guidelines;
8) consultations with members of the design team on findings and recommendations at the time of report completion; and preparation of a written geotechnical engineering report for use by the members of the design team in their preparation of construction, contract, and specifications documents.

The Scope of Services **did not include any environmental assessment** for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors, colors or unusual or suspicious items or conditions are strictly for the information of the client.

Project Description

The proposed project involves the development of a single family residential subdivision at **Miller Tract in Boerne, Texas.** The proposed pavement areas are anticipated to include local, collector, and arterial type streets. Street profiles showing cut and fill information are not available at the time of our investigation. The scope of this study does not include Slope stability analysis or any environmental assessment for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site.

Site Description

The proposed project is located West of IH 10 and South of Highway 46 in Boerne, Texas. A review of topographic map shows the site's highpoint is on the south west corner of the tract. The site slopes generally from the highpoints to the east and north. The eastern half of the tract is relatively flat. In addition, a drainage area exists on the north west side of the site. A review of the aerial maps indicates two ponds and numerous dry ponds within the site. Based on the review of the proposed plat, some of the lots may lie in the areas of pond and the low drainage areas. The aerial maps also indicates thickly wooded areas on the western half of the tract. A review of the geologic map shows that the site is located within Kgru, Glen Rose, Formation. Karst features are formed in limestone, dolomite, or gypsum by dissolution. A geophysical study of the site would indicate the presence and potential impact of Karst features, caves, or significant cavities on the building performance and construction delays.

SUBSURFACE EXPLORATION

Scope

The field exploration to determine the engineering characteristics of the subsurface materials included a reconnaissance of the project site, drilling the borings, performing standard penetration tests, and obtaining Split Spoon samples.

Twenty five soil test borings were drilled at the approximate locations shown on the Boring Location Plan, **Plate 1** included in the Illustration Section of this report. These borings were drilled **to a depth of 8 to 15-ft** below the presently existing ground surface. Boring locations were selected by the project geotechnical engineer and established in the field by the drilling crew using normal taping procedures.

Drilling and Sampling

The soil borings were performed with a drilling rig equipped with a rotary head. Conventional solid stem augers were used to advance the holes and samples of the subsurface materials were obtained **using a Split spoon sampler.** 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 in special containers.

In summary, the following samples as presented in Table No. 1 were collected as a part of our field exploration procedure:

Table No. 1

Type of Sample	**Number Collected**
Split-spoon Samples	53
Auger Samples	49

Field Tests and Measurements

Penetration Tests - During the sampling procedures, **standard penetration tests were performed** in the borings in conjunction with the split-barrel sampling. The standard penetration value (N) is defined as the number of blows of a 140 pound hammer, falling thirty inches, required to advance the split-spoon sampler one foot into the soil. The sampler is lowered to the bottom of the drill hole and the number of blows recorded for each of the three successive increments of six inches penetration. The "N" value is obtained by adding the second and third incremental numbers. The results of the standard penetration test indicate the relative density and comparative consistency of the soils, and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components.

Water Level Measurements – **Ground water was not encountered in our borings at the time of drilling.** In relatively pervious soils, such as sandy soils, the indicated elevations are considered reliable ground water levels. In relatively impervious soils, the accurate determination of the ground water elevation may not be possible even after several days of observation. Seasonal variations, temperature and recent rainfall conditions may influence the levels of the ground water table and volumes of water will depend on the permeability of the soils.

Field Logs

A field log was prepared for each boring. Each log-contained information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as silt, clay, gravel or sand and observations of ground water. It also contained an interpretation of subsurface conditions between samples. **Therefore, these logs included both factual and interpretive information.**

Presentation of the Data

The final logs represent our interpretation of **the contents of the field logs for the purpose delineated by our client.** The final logs are included on **Plates 2 thru 26** included in the

Illustration Section. A key to classification terms and symbols used on the logs is presented on **Plate 27.**

LABORATORY TESTING PROGRAM

Purpose

In addition to the field exploration, a supplemental laboratory testing program was conducted to determine additional **pertinent engineering characteristics** of the subgrade materials necessary in evaluating the soil parameters.

Laboratory Tests

All phases of the laboratory testing program were performed **in general accordance with the indicated applicable** ASTM Specifications as indicated in Table No. 2.

Table No. 2

Laboratory Test	**Applicable Test Standard**
Liquid Limit, Plastic Limit and Plasticity Index of the Soils	ASTM D 4318
Moisture Content	ASTM D 2216
California Bearing Ratio	ASTM D 1883

In the laboratory, each sample **was examined and classified by a geotechnical engineer.** As a part of this classification procedure, the natural water contents of selected specimens were determined. Liquid and plastic limit tests were performed on representative specimens to determine the plasticity characteristics of the different soil strata encountered.

Presentation of the Data

In summary, the tests presented in Table No. 3 in the following page were conducted in the laboratory to evaluate the engineering characteristics of the subsurface materials:

Table No. 3

Type of Test	Number Conducted
Natural Moisture Content	102
Atterberg Limits	27
California Bearing Ratio	2
Lime Series	1

The results of all these tests are presented on appropriate boring logs. These laboratory test results were used to classify the soils encountered generally according to the Unified Soil Classification System (ASTM D 2487).

GENERAL SUBSURFACE CONDITIONS

Soil Stratigraphy

The soils underlying the site may be grouped into **two generalized strata** with similar physical and engineering properties. The lines designating the interface between soil strata on the logs represent approximate boundaries. Transition between materials may be gradual. The soil stratigraphy information at the boring locations are presented in **Boring Logs, Plates 2 thru 26.** Karst features are formed in limestone, dolomite, or gypsum by dissolution. A geophysical study of the site would indicate the presence and potential impact of Karst features, caves, or significant cavities on the building performance and construction delays. The soil conditions in between our borings may vary across the site. We should be called upon at the time of construction to verify the soil conditions between our borings.

The engineering characteristics of the underlying soils, based on selected samples that were tested, are summarized and presented in Table No. 4.

Table No. 4

Stratum No. and Description	**Depth, Range, Feet**	**Liquid Limit Range**	**Plasticity Index, Range**	**Blows per Foot, Range**
Stratum I Dark Brown Clay, Brown Clay, Dark Brown Sandy Clay	0 – 6	39 – 82	22 – 60	12 – 62/9”
Stratum II Tan Silty Clay, Tan Clay	2 – 15	50	34	39
Stratum III Tan Marl, Light Tan Marl, Light Tan Weathered Limestone, Light Tan Limestone	1 – 15	22 – 36	08 – 21	39 – 50/3”

The above description presented in the boring logs is of a generalized nature to highlight the major soil stratification features and soil characteristics. Soil Stratigraphy may vary between boring locations. **If deviations from the noted subsurface conditions are encountered during construction, they should be brought to the attention of InTEC. We may revise the recommendations after evaluating the significance of the changed conditions.**.

Ground Water Observations

Ground water seepage **was not observed in our borings during site investigation.** Short term field observations generally do not provide accurate ground water levels. The contractor should check the subsurface water conditions prior to any excavation activities. The low permeability of the soils would require several days or longer for ground water to enter and stabilize in the bore holes. Ground water levels will fluctuate with seasonal climatic variations and changes in the land use.

It is not unusual to encounter shallow groundwater during or after periods of rainfall. The surface water tends to percolate down through the surface until it encounters a relatively impervious layer.

PAVEMENTS ON EXPANSIVE SOIL

General

There are many plastic clays that swell considerably when water is added to them and then shrink with the loss of water. Pavements constructed on these clays are subjected to large uplifting forces caused by the swelling.

In the characterization of a pavement site, two major factors that contribute to potential shrink-swell problems must be considered. Problems can arise if a) the soil has expansive and shrinkage properties and b) the environmental conditions that cause moisture changes to occur in the soil.

Evaluation Of The Shrink-Swell Potential Of The Soils

Subsurface sampling, laboratory testing and data analyses are used in the evaluation of the shrink-swell potential of the soils under the pavements.

The Mechanism Of Swelling

The mechanism of swelling in expansive clays is complex and is influenced by a number of factors. Basically, expansion is a result of changes in the soil-water system that disturbs the internal stress equilibrium. Clay particles in general 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 chemistry is changed either by changing the amount of water or the chemical composition, the interparticle 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 will change so as to adjust the interparticle forces until equilibrium is reached. This change in particle spacing manifests itself as a shrinkage or swelling.

Initial Moisture Condition And Moisture Variation

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 relative to possible limits, or ranges, in moisture content. Moisture content alone is useless as an indicator or predictor of shrink-swell potential. The relationship of moisture content to limiting moisture contents such as the plastic limit and liquid limit must be known.

If the moisture content is below or near plastic limit, the soils have high potential to swell. It has been reported that expansive soils with liquidity index[*] in the range of 0.20 to 0.40 will tend to experience little additional swell.

The availability of water to an expansive soil profile is influenced by many environmental and man made factors. Generally, the upper few feet of the profile are subjected to the widest ranges of moisture variation, and are least restrained against 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 surficial boundary moisture conditions are changed significantly simply by placing a barrier such as a building floor slab or pavement between the soil and atmospheric environment. Other obvious and direct causes of moisture variation result from altered drainage conditions or man-made sources of water, such as irrigation or leaky plumbing. The latter factors are difficult to quantify and incorporate into the analysis, but should 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 should always be taken into consideration.

Man Made 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, either the owner or the designer has some control over whether the factor will be avoided altogether or if not avoided, the degree to which the factor will be allowed to influence the shrink-swell process.

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[*] LIQUIDITY INDEX = {NATURAL WATER CONTENT - PLASTIC LIMIT} / **{** LIQUID LIMIT - PLASTIC LIMIT}

Antecedent Rainfall Ratio This is a measure of the local climate and is defined as the total monthly rainfall for the month of and the month prior to laying the pavement 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 pavement is placed. Thus, if a pavement is placed at the end of a wet period, the pavement should be expected to experience some loss of support around the perimeter as the wet soils begin to dry out and shrink. The opposite effect could be anticipated if the pavement 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 pavement in moisture content.

Age of Pavement The length of time since the pavement was cast provides an indication of the type of swelling of the soil profile that can be expected to be found beneath the pavement.

Drainage This provides a measure of the slope of the ground surface with respect to available free surface water that may accumulate around the pavement. Most builders are aware of the importance of sloping the final grade of the soil away from the pavement so that rain water is not allowed to collect and pond against or adjacent to the pavement. If water were allowed to accumulate next to the pavement, it would provide an available source of free water to the expansive soil underlying the pavement. Similarly, surface water drainage patterns or swales must not be altered so that runoff is allowed to collect next to the pavement.

Pre-Construction Vegetation Large amount of vegetation existing on a site before construction may have desiccated the site to some degree, especially where large trees grew before clearing. Constructing over a desiccated soil can produce some dramatic instances of heave and associated structural distress and damage as it wets up.

Post-Construction Vegetation The type, amount, and location of vegetation that has been allowed to grow since construction can cause localized desiccation. Planting trees or large shrubs near a pavement can result in loss of foundation support as the tree or shrub removes water from the soil and dries it out. Conversely, the opposite effect can occur if flowerbeds or shrubs are planted next to the pavement and these beds are kept well watered or flooded. This practice can result in swelling of the soil around the perimeter where the soil is kept wet.

<u>Utilities Underneath the Pavement</u> The utilities such as sewer, water, electricity, gas, and communication lines are often installed underneath the streets. The sewer utility construction, for example, typically involves trenching to the desired depth, installing gravel a gravel bed underneath the sewer main, installing primary backfill (gravel), and placing back the secondary backfill (generally excavated soils). The secondary backfill material is compacted in lifts. In addition, sewer service lines run laterally from each house (for a typical subdivision, approximately every 50-ft). These trenches with gravel and onsite material backfill are conducive to carrying water. In addition, the sewer service lines can carry water from behind the curb. Occasionally, the sewer line may be encased in concrete which will cause ponding of any travelling water within the sewer trenches. Any water travelling within these trenches can cause expansive clays to swell. If the backfill is not adequately compacted or if excessive water is flowing in these trenches, the trench backfill can potentially settle.

Summation

It is beyond the scope of this investigation to do more than point out that the above factors have a definite influence on the amount and type of swell to which a pavement is subjected during its useful life. The design engineer must be aware of these factors as he develops his design and make adjustments as necessary according to the results of special measurements or from his engineering experience and judgment.

DESIGN ENGINEERING ANALYSIS

Pavement Design Considerations

Review of the borings and test data indicates that the following factors will affect the pavement design and construction at this site:

1) The site is underlain by clays of low to high plasticity. Structures supported on or within these soils will be subjected to potential vertical movements on the order of **1 ¼ to 3 inches**.
2) The strengths of the underlying soils are adequate to support the proposed new streets.
3) Based on the stratigraphy observed at this site (Table No. 4), the final street subgrade is anticipated to be in the stratum I clays or marl to limestone. The cut and fill information is not available at this time. The final street subgrade should be observed and delineated by InTEC at the time of construction.
4) Ground water was not encountered in our borings at the time of the subsurface exploration phase.

Vertical Movements

The potential vertical rise (PVR) for slab-on grade construction at the location of the structures had been estimated using Texas Department of Transportation Procedure 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 twelve to fifteen feet at the project site.

The estimated PVR value provided is based on the proposed floor system applying a sustained surcharge load of approximately 1.0 lb. per square inch on the subgrade materials. **Potential vertical movement on the order of 1 ¼ to 3 inches was estimated at the existing grade elevation**.

The PVR values are based on the current site grades. If cut and fill operations in excess of 6 inches are performed, the P.V.R. values could change significantly. Higher P.V.R. values than the above mentioned values will occur in areas where water is allowed to pond for extended periods.

If proper drainage is not maintained (allowing subgrade moisture content to change significantly) and / or if the pavement is underlain by utility trenches, resulting (a) potential vertical movements will be much greater than 2 or 3 times the anticipated vertical movements and (b) the subgrade strength may be reduced significantly reduced.

If the finish grade elevation is higher than the existing grade, compacted select fill should be used to raise the grade level. Any select fill should be placed and compacted as recommended under "Select Fill, Construction Guidelines Section" of this report. Each lift should be compacted and tested by InTEC to verify Compaction Compliance.

Method to Reduce Vertical Movements

The underlying clays may be removed to a depth of 0 to 3-ft and replaced by compacted crushed limestone select fill. The depth options and the respective anticipated movements after selection of one of the depth options are presented in Table No. 5.

Table No. 5

Removal of Existing Clays and Replacement with Select Fill (feet)	Potential Vertical Movement (inches)
0	3
2	2
3	1 ½

The select fill should be placed and compacted as recommended under select fill, Construction Guidelines Section of this report. The compacted select fill should extend a minimum of 3-ft outside the edges of the pavement. Each lift should be tested and approved by InTEC before placement of the subsequent lift.

If over excavation and select fill replacement is used to lower potential vertical movements, the bottom of excavation should be drained properly. It should not act as a bathtub and hold water in the event any accidental source of water enters the excavation. Gravel fill and perforated drainpipes with perforations at the bottom, outlet pipes with a gradient, and day-lighting the pipes with head walls should be considered for proper drainage. If additional options are required, please contact InTEC.

When the clay removal and select fill replacement method is used to reduce potential vertical movements, the select fill extending 3 to 5-ft outside the pavement area should be covered by 2-ft thick compacted impervious clay. The impervious clay (with plasticity index value 35 or greater) should be placed in 8 inch loose lifts and compacted to a minimum of 95 percent of the maximum TxDOT 114E dry density at a water content between Optimum and Optimum Plus two percentage points. The top surface of clay seal should be sloped away from the building perimeter. If other options are required to reduce PVR, please contact InTEC.

It should be noted that expansive clay does not shrink/swell without changes in moisture content, and thus good site design is very important to minimize movements. Coping with problems of shrink/swell due to expansive clays is a “fact of life” in the Texas region of south western U.S.A.

PAVEMENT GUIDELINES

General

Pavement area at this unit is expected to include Local, Collector, and Arterial type streets. The following recommendations are presented as a guideline for pavement design and construction. These recommendations are based on a) our previous experience with subgrade soils like those encountered at this site, b) pavement sections which have proved to be successful under similar design conditions, c) final pavement grades will provide adequate drainage for the pavement areas and that water will not be allowed to enter the pavement system by either edge penetration adjacent to landscape areas or penetration from the surface due to surface ponding, or inadequate maintenance of pavement joints, or surface cracks that may develop.

Pavement Design

Pavement designs provide an adequate thickness of structural sections over a particular subgrade (in order to reduce the wheel load to a distributed level so that the subgrade can support load). The support characteristics of the subgrade are based on strength characteristics of the subgrade soils and not on the shrinkage and swelling characteristics of the clays. Therefore, the pavement sections may be adequate from a structural stand point, may still experience cracking and deformation due to shrinkage and swelling characteristics of the soils. In addition, if the proposed new pavements are used to carry temporary construction traffic, then heavier sections may be needed. Please contact InTEC to discuss options.

It is very important to minimize moisture changes in the subgrade to lower the shrinkage and swell movements of the subgrade clays. The pavement and adjacent areas should be well drained. Proper maintenance should be performed by sealing the cracks as soon as they develop to prevent further water penetrations and damage. In our experience,

(a) majority of the pavement distress observed over the years were caused by changes in moisture content of the underlying subgrade and / or excessive moisture in the base section,

(b) pavements with a grade of one percent or more have performed better than the pavements with allowable minimum grade,

(c) pavements with no underground utilities have performed better than pavements with underground utilities and the associated laterals,

(d) pavements that are at a higher grade elevation than the surrounding lots have performed better, and

(e) any design effort that minimizes moisture penetration into the pavement layers have performed better.

“Alligator” type Cracks

A layer of aggregate base is typically used underneath the concrete curbs around the pavement areas. This layer of aggregate base underneath the concrete curb is conducive to the infiltration of surface water into the pavement areas. Water infiltration into the base layer can result in “alligator type” cracks especially when accompanied by construction traffic. Increasing the moisture content of the pavement sections will significantly impact the support characteristics. Penetrating the concrete curbs at least six inches into the native clays soils will act as a barrier to this type of water infiltration. In addition, French Drains installed on the outside of the curbs will reduce this type of water infiltration. Alligator type cracks are also caused by weak / soft pockets within the pavement layers.

Longitudinal Cracks

Asphalt pavements in highly expansive soil conditions, such as the soils encountered at this site, can develop longitudinal cracks along the pavement edges. The longitudinal cracking typically occurs about 1 to 4 feet inside of the pavement edges and they run parallel to the pavement edge. The longitudinal cracks are generally caused by differential drying and shrinkage of the underlying expansive clays. The moisture content change of the underlying subgrade clays can be reduced by installing moisture barriers. Vertical moisture barriers along the edge of the pavement or horizontal moisture barriers such as paved side walks will help reduce the development of the longitudinal cracks.

Periodic Maintenance

The pavements constructed on clay subgrades such as the one encountered at this site will be subjected to swell related movements. Hence, proper maintenance should be performed by sealing the cracks as soon as they develop to prevent further water penetrations and damage.

Pavement Sections

Local and collector type residential streets may be designed with flexible pavements. Cut and fill information is not available at the time of our investigation. The final finish street subgrade is expected to be in dark brown clay to brown clay areas. Minimum flexible pavement sections for the anticipated clay subgrades are presented in Table No. 6 and limestone subgrades in Table No. 7. Input parameters used in the pavement section calculations are presented in Table No. 8.

- If pavement design for parameters other than those shown in Table No. 8 is needed or if repetitive / heavy truck traffic is anticipated, please contact us for additional pavement section recommendations.
- The pavement sections are not based on shrink / swell characteristics of the subgrade soils.
- The recommended pavement sections are based on the subgrade soil support characteristics.
- The subgrade soil support characteristics will be significantly affected by changes in moisture content.

The cut and fill information is not available at this time. The final street subgrade should be verified by InTEC at the time of construction.

Table No. 6 – Minimum Flexible Pavement Recommendations - CBR = 3.0 **

	Type D, Course Asphaltic	Aggregate Base	Lime Stabilized Subgrade	Structural Number
Classification	**Concrete, inches**	**Thickness, inches**	**Thickness, inches**	
Local	2.00	9.00	6*	2.62
Collector	3.00	14.50	8*	3.99
Arterial	3.00	19.50	8*	4.69

- Input parameters are shown in Table No. 8. Please call us to provide pavement recommendations, if needed, for different input values.
- If repetitive truck or heavy truck traffic is anticipated, please contact us for revised pavement recommendations.

Notes (*):

- subgrade stabilization using lime to depths of 6 or 8 inches. Lime content of 6 ½ percent of the dry weight of the soil to be treated should be used; a unit weight of the clay of 100 lbs per cubic feet may be used.
- The subgrade soils should be tested for soluble sulphate content prior to installation of the lime
    - Lime content: for **6 inch stabilization – 29.25 lbs per sq yard**
    - Lime content: for **8 inch stabilization – 39.00 lbs per sq yard**

Notes (**)

- In addition, pavement section recommendations are based on subgrades prepared as described in this report. If water is allowed to get underneath the asphalt or if moisture content of the base or subgrade changes significantly, then pavement distress will occur.

Fill Material:

If fill is used to raise the grade, fill material underneath the pavement should be on-site material, free of deleterious material with a minimum CBR value of 3.0. The gravel size should not exceed 3 inches in diameter. Lime application rate should be re-evaluated for the fill material. The material should be placed as per applicable city guidelines.

Table No. 7 – Minimum Flexible Pavement Recommendations - CBR = 6.0 **

	Type D, Course Asphaltic	Aggregate Base	Lime Stabilized Subgrade	Structural Number
Classification	**Concrete, inches**	**Thickness, inches**	**Thickness, inches**	
Local	2.00	8.50	None	2.07
Collector	3.00	13.00	None	3.14
Arterial	3.00	17.00	None	3.70

- Input parameters are shown in Table No. 8. Please call us to provide pavement recommendations, if needed, for different input values.
- If repetitive truck or heavy truck traffic is anticipated, please contact us for revised pavement recommendations.

Notes (**)

- In addition, pavement section recommendations are based on subgrades prepared as described in this report. If water is allowed to get underneath the asphalt or if moisture content of the base or subgrade changes significantly, then pavement distress will occur.

Fill Material:

If fill is used to raise the grade, fill material underneath the pavement should be on-site material, free of deleterious material with a minimum CBR value of 6.0 and a Plasticity Index value of 20 or less. The gravel size should not exceed 3 inches in diameter. The material should be placed as per applicable city guidelines.

Table No. 8– Input Parameters used in Asphalt Pavement Section Calculation

	Local	**Collector**	**Arterial**
ESAL	ESAL= 100,000	ESAL= 1,000,000	ESAL= 2,000,000
Reliability Level	R-80	R-90	R-90
Initial and Terminal Serviceability	4.2 and 2.0	4.2 and 2.0	4.2 and 2.5
Standard Deviation	0.45	0.45	0.45
Service Life	20 years	20 years	20 years
If heavy truck traffic is anticipated, please contact InTEC with anticipated traffic data for revised recommendations.			

Subgrade Preparation

It is important that any existing pavement and organic and compressible soils are removed and the exposed subgrade is properly prepared prior to pavement installation. The subgrade should be prepared as described in the applicable city or TxDOT Guidelines. Base course material should be placed immediately upon completion of the subgrade compaction operation to prevent drying of the soils due to exposure.

The finish grade elevation of the subgrade should be such that water drains downward freely towards a drainage area. At the drainage area, 3x5 rock may be provided at the subgrade level and the collected water at the drainage area should be taken out (such as into the existing concrete drainage channel). If any voids in the subgrade should be filled in with the same subgrade material and compacted in lifts.

The approved fill material should be placed in 8 inch lifts (6 inches compacted) and compacted as recommended in the Site Preparation section of the Construction Guidelines presented in this report. If the fill depth exceeds 4 feet, the potential subgrade settlement should be considered. Please contact InTEC with the cut and fill information to evaluate the effect of proposed cut and fill on the recommendations and to provide fill material and compaction recommendations.

Base Course

Based on the survey of available materials in the area, a base course of crushed limestone aggregate or gravel appears to be the most practical material for asphalt pavement project. The base course should conform to Texas State Department of Highways and Public Transportation Standard Specification, Item 247, Type A, Grade 1 or 2. The aggregate base course should be installed as per applicable city or TxDOT Guidelines.

At a minimum the base course should be brought to near optimum moisture conditions and compacted in lifts to at least 95 percent of maximum dry density as determined by test method TxDOT 113E.

Asphaltic Concrete

The asphaltic concrete surface course should conform to applicable city guidelines or Texas State Department of Highways and Public Transportation Standard Specifications, Item 340, Type D. The asphaltic concrete should be installed as per applicable city or TxDOT Guidelines.

Perimeter Drainage

It is important that proper perimeter drainage be provided so that infiltration of surface water from compacted areas surrounding the pavement is minimized, or if this is not possible, curbs should extent through the base and into the subgrade. A crack sealant compatible to both asphalt and concrete should be installed at the concrete-asphalt interfaces.

Wherever there are drastic grade changes in the pavement area (such as from 3 to 4 percent grade to 1 to 2 percent grade) 3 x 5 inch gravel subgrade with a subsurface drain system (such as Akwadrain® on the sides of the pavement) and outlet should be considered. This aspect will provide for a better drainage system in this area. Please contact InTEC for drainage recommendations.

CONSTRUCTION GUIDELINES

Construction Monitoring

As Geotechnical Engineer of Record for this project, InTEC should be involved in monitoring the pavement construction and earth work activities. Performance of any pavement system is not only dependent on the pavement design, but is strongly influenced by the quality of construction. Please contact our office prior of construction so that a plan for pavement construction and earthwork monitoring can be incorporated in the overall project quality control program. The testing requirements shall comply with the minimum testing requirements as per applicable city and county guidelines.

Site Preparation

Site preparation will consist of **preparation of the subgrade, and placement of select structural fill.** The project geotechnical **engineer InTEC should approve the subgrade preparation, the fill materials, and the method of fill placement and compaction.**

In any areas where soil-supported concrete structure or pavement are to be used, vegetation and all loose or excessively organic material should be stripped to a minimum depth of six inches and removed from the site. Subsequent to stripping operations, the subgrade should be proof rolled prior to fill placement and recompacted to a minimum of **95 percent of the maximum dry density as determined by ASTM D 698 test method within optimum moisture content and three percent above optimum moisture content.** The exposed subgrade should not be allowed to dry out prior to placing structural fill. Each lift should be tested by InTEC geotechnical engineer or his representative prior to placement of the subsequent lift.

Ponds were noted within the project site. Voids caused by site preparation, such as removal of trees, should be compacted as described below:

Densification

Site grading plan is not available for review at this time. If any low areas or disturbed areas encountered during construction should be appropriately prepared and compacted. Any deleterious or wet materials should be removed and wasted. The fill placement in the low areas should not be in a “bowl shape”. The sides of the fill area should be “squared up” and the excavated bottom should be proof rolled as described in *Proof Rolling* section of this report. On site material, with no deleterious material, may be used to raise the grade. After proof rolling operation, the fill should be placed in 6 inch lifts and compacted to a minimum of **95 percent of the maximum dry density as determined by ASTM D 698 test method within optimum and three percent above optimum moisture content.** Each lift should be tested by InTEC for compaction compliance and approved before placement of the subsequent lifts. The exposed subgrade should not be allowed to dry out prior to placing structural fill. It is recommended that any given lot does not straddle filled areas and natural areas to help reduce differential movement of the structures.

The excavation boundaries should be set such that building or pavement areas do not straddle fill and natural areas. The anticipated potential vertical movement may be significantly affected after the cut and fill operations are performed in this area.

Proof Rolling

Proof rolling should be accomplished in order to locate and densify any weak compressible zones under the structure and pavement areas and prior to placement of the select fill or base. A minimum of 10 passes of a 25 ton pneumatic roller should be used for planning purposes. The operating load and tire pressure should conform to the manufactures specification to produce a minimum ground contact pressure of 90 pound per square inch. Proof rolling should be performed under the observation of the InTEC Geotechnical Engineer or his representative. The soils that yield or settle under proof rolling operations should be removed, dried and compacted or replaced with compacted select fill to grade. Density tests should be conducted as specified under *Control Testing and Filed Observation* after satisfactory proof rolling operation.

Proper site drainage should be maintained during construction so that ponding of surface run-off does not occur and cause construction delays and/or inhibit site access.

Select Fill

Any select structural fill used under the building should have a liquid limit less than 40 and a plasticity index in between 5 and 20 and be crushed limestone. The fill should contain no particles greater than 3 inches in diameter. **The percent passing U.S. Standard Sieve No. 4 should be**

in between 40 and 80 percent and Sieve No. 40 passing should be in between 10 and 50 percent. The percent passing Sieve No. 200 should be less than 20 percent.

Crushed limestone with sufficient fines to bind the aggregate together is a suitable select structural fill material. The fill materials should be placed in loose lifts not to exceed 8 inches thick (6-inches compacted) and compacted to 95 percent of the maximum dry density as determined by ASTM D 1557 procedure at a moisture content within 2 percent of the optimum water content.

General Fill

General fill materials may consist of clean on-site material, select fill materials, or any clean imported fill material. The purpose of a general fill is to provide soils with good compaction characteristics that will provide uniform support for any non-habitable structures that are not movement sensitive. The general fill may also be used underneath the pavement areas. The pavement recommendations should be re-evaluated based on the fill material characteristics. The general fill material should be free of any deleterious material, construction debris, organic material, and should not have gravels larger than 6 inches in maximum dimension. The top two feet of fill material used underneath pavement areas should not have gravels larger than 3 inches in maximum dimension. A maximum design plasticity index value of 40 is recommended for material to be used as general fill. The percent passing U.S. Standard Sieve No. 4 should be not be greater than 80 percent.

It should be understood that the use of the general fill may result in greater than anticipated potential vertical movements and differential movements. If the greater potential vertical movements or differential soil movements cannot be tolerated, then select fill material should be used and should conform to the Select Fill recommendations.

General Fill Compaction

The general fill materials should be placed in lifts not to exceed 8 inches thick and compacted to a minimum of 95 percent of the maximum dry density as determined by test method ASTM D 698 at a moisture content within 3 percent of the optimum water content. Each lift should be compacted and tested by a representative of a geotechnical laboratory to verify compaction compliance and approved before placement of the subsequent lifts.

The general fill compaction requirements can also be discussed and determined in consultation with the owner prior to construction.

Ground Water

In any areas where significant cuts (2-ft or more) are made to establish final grades for pavement, attention should 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 should be carefully addressed during construction. Our office could be contacted to visually inspect final pads to evaluate the need for such drains.

The ground water seepage may happen several years after construction if the rainfall rate or drainage changes within the project site or outside the project site. If seepage run off occurs towards the pavement areas an engineer should be called on to evaluate its effect and provision of French Drains at this location.

Drainage

Ground water seepage was not encountered in our borings at the time of our investigation. However, minor ground water seepage may be encountered within the pavement areas and grading excavations at the time of construction, especially after periods of heavy precipitation. **Small quantities of seepage may be handled by conventional sump and pump methods of dewatering.**

Temporary Drainage Measures

Temporary drainage provisions should be established, as necessary, to minimize water runoff into the construction areas. If standing water does accumulate, it should be removed by pumping as soon as possible.

Adequate protection against sloughing of soils should be provided for workers and inspectors entering the excavations. This protection should meet O.S.H.A. and other applicable building codes.

Temporary Construction Slopes

Temporary slopes on the order of 1H to 1V may be provided for excavations through Strata I clays.

Fill slopes on the order of 1H to 1V may be used provided a) the fill materials are compacted as recommended and b) the slopes are temporary.

Fill slopes should be compacted. Compacting operations shall be continued until the slopes are stable but not too dense for planting on the slopes. Compaction of the slopes may be done in increments of 3 to 5-ft in fill height or the fill is brought to its total height for shallow fills.

Permanent Slopes

Maximum permanent slope of 1V to 3H is recommended in Stratum I clays. In areas where people walk on sloped areas, a slope of 1V to 5H is recommended.

Time of Construction

If the pavement is installed during or after an extended dry period, the subgrade may experience greater movement around the edges when the soil moisture content increases, such as due to rain or irrigation. Similarly, a pavement installed during or after a wet period may experience greater movement around the edges during the subsequent drying of the soils.

Control Testing and Field Observation

Subgrade preparation and base and asphalt placement should be monitored by the project geotechnical engineer or his representative of InTEC. As a guideline, at least one in-place density test should be **performed for every 100 lineal feet (or as per respective city and county requirements, whichever requires more frequent testing) of street of compacted surface lift.** However, a minimum of three density tests should be performed by InTEC on the subgrade or subsequent lifts of compaction. Any areas not meeting the required compaction should be re-compacted and retested until compliance is met.

DRAINAGE AND MAINTENANCE

Final drainage is very important for the performance of the proposed pavement. Landscaping, plumbing, and downspout drainage is also very important. It is vital that drainage be transported away from the pavement so that no water ponds around the pavement (such as behind the curbs) which can result in soil volume change under the pavement. Any leaks or drainage issues should be repaired as soon as possible in order to minimize the magnitude of moisture change under the pavement. Large trees and shrubs should not be planted in the immediate vicinity of the pavement, since root systems can cause a substantial reduction in soil volume in the vicinity of the trees during dry periods. Silt fences placed adjacent to the curb can potentially allow water to get into the pavement area.

Trench backfill for utilities should be properly placed and compacted as outlined in this report and in accordance with all applicable requirements such local City / County / SAWS Standards. Since granular bedding backfill is used for most utility lines, the backfilled trench should be prevented from becoming a conduit and allowing an access for surface or subsurface water to travel toward the new pavement. Concrete cut-off collars or clay plugs should be provided where utility lines cross curbs to prevent water traveling in the trench backfill and entering beneath the pavement. If concrete encasing is used around the sewer pipes, an alternate path for water to continue to drain should be installed.

In areas with sidewalks or other structures adjacent to the new pavement, a positive seal must be provided and maintained between the structures 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 should be used for paving and flatwork to prevent areas where water can pond. In addition, allowances in final grades should take into consideration post construction movement of flatwork particularly if such movement would be critical. **Normal maintenance should include inspection of all joints in paving and sidewalks, etc. as well as re-sealing where necessary.**

Several factors relate to civil and architectural design and/or maintenance which can significantly affect future movements of the pavement systems:

1. Where positive surface drainage cannot be achieved by sloping away of the ground surface adjacent to the pavement, a drainage system should carry runoff water a away from the completed pavement.

2. Planters located adjacent to the pavement should preferably be **self contained**. Sprinkler mains should be located a minimum of five feet from the pavement.

3. Planter box structures placed adjacent to pavement should be provided with a means to assure concentrations of water are not available to the subsoils stratigraphy.

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

5. Moisture conditions should be maintained **“constant” around the edge of the pavements.** Ponding of water in planters, in unpaved areas, and around joints in paving and sidewalks can cause movements beyond those predicted in this report and significantly reduce the subgrade support.

Adequate drainage should be provided to reduce seasonal variations in moisture content of soils around the pavement. The P.V.R. values estimated and stated under Vertical Movements are based on provision and maintenance of positive drainage to divert water away from the pavement areas. If the drainage is not maintained, the wetted front may move below the assumed twelve feet depth, and resulting **P.V.R. will be much greater than 2 or 3 times the stated values under Vertical Movements. Utility line leaks may contribute water and cause similar movements to occur. In addition, if the soil is allowed to dry, the associated shrinkage can cause pavement cracks. Similarly, significant changes in moisture content of the underlying pavement layers, will impact the support characteristics of the subgrade.**

Dry Periods

Close observations should be made around pavements during extreme dry periods to ensure that adequate watering is being provided to keep soil from separating or pulling back from the curb and to minimize the shrinkage related cracks.

LIMITATIONS

The analyses and recommendations submitted in this report are based upon the data obtained from twenty five borings drilled at the site. This report may not reflect the exact variations of the soil conditions across the site. Based on the noted topography within the site, cut and fill are anticipated. The pavement recommendations presented in the report should be reviewed and confirmed based on the proposed cut and fill and observation at the time of construction.

If deviations from the noted subsurface conditions are encountered during construction, they should be brought to the attention of the geotechnical engineer. The information contained in this report and on the boring logs is not intended to provide the contractor with all the information needed for proper selection of equipment, means and methods, or for cost and schedule estimation purposes. The use of information contained in the report for bidding purposes should be done at the contractor's option and risk.

Final plans for the proposed streets should be reviewed by the project geotechnical engineer so that he may determine if changes in the recommendations are required. The soil conditions may need to be verified if the proposed street profiles show deeper cuts from the existing grade elevation.

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.

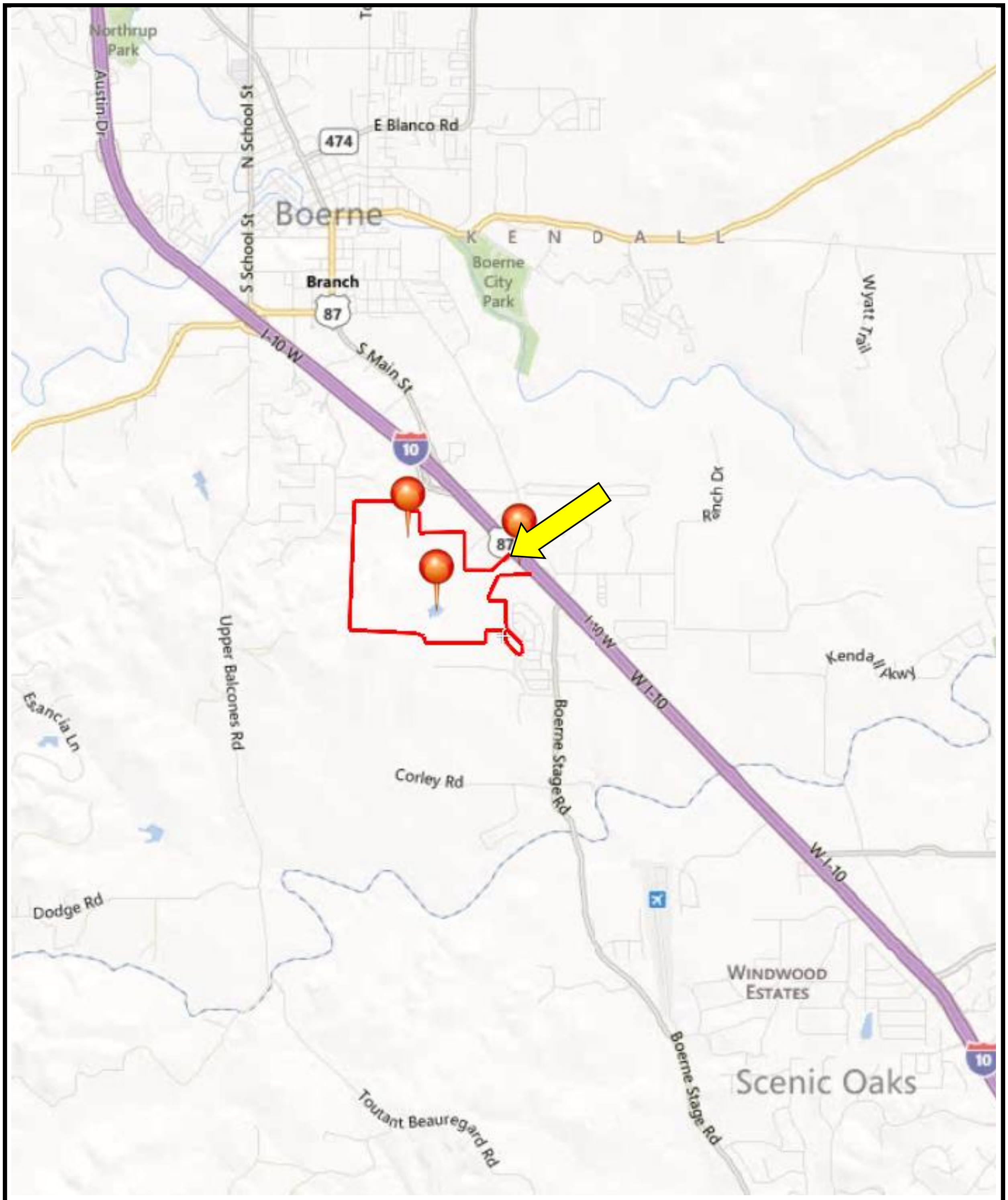
This report has been prepared for the exclusive use of Great America Companies for pavement thickness evaluation for the proposed **new streets in Miller Tract in Boerne, Texas.**

Illustration Section

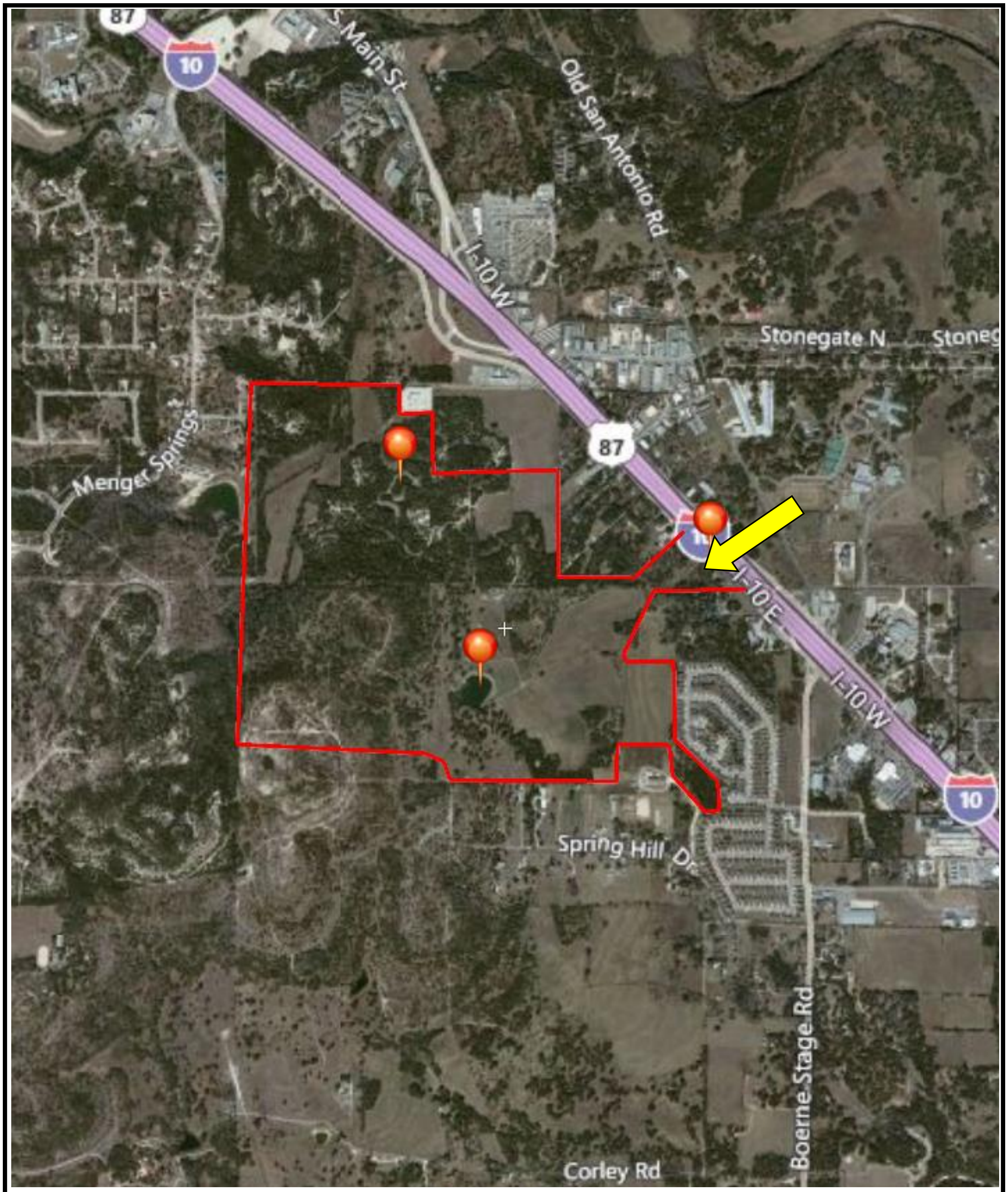
Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

InTEC Project Number:
S131434-P

Date:
05/05/2014



Subsurface Exploration and Pavement Analysis Miller Tract Boerne, Texas	**Vicinity Map**	
	InTEC Project Number: **S131434-P**	Date: 05/05/2014

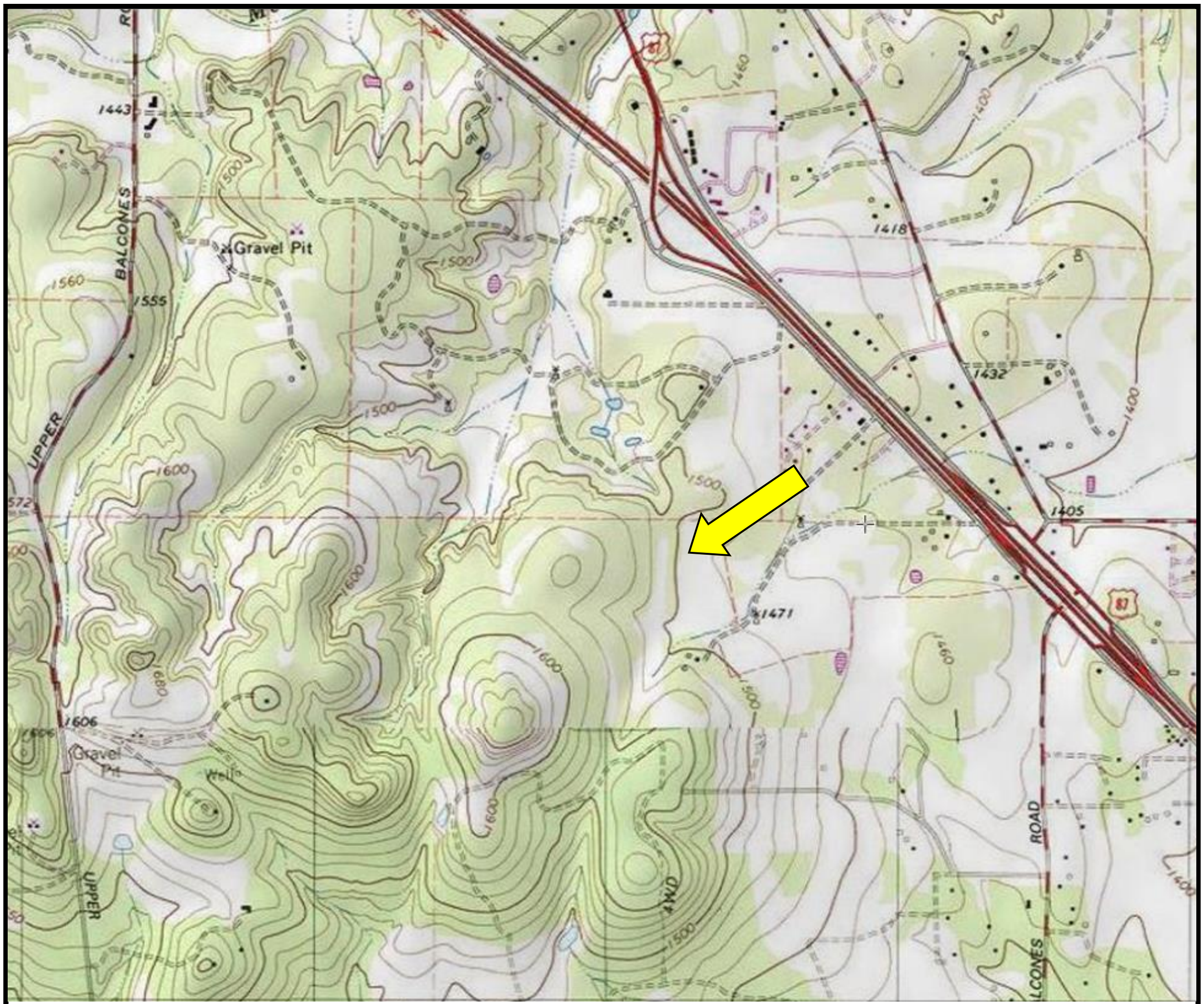


Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

Aerial Map—Approximate Location

InTEC Project Number:
S131434-P

Date:
05/05/2014

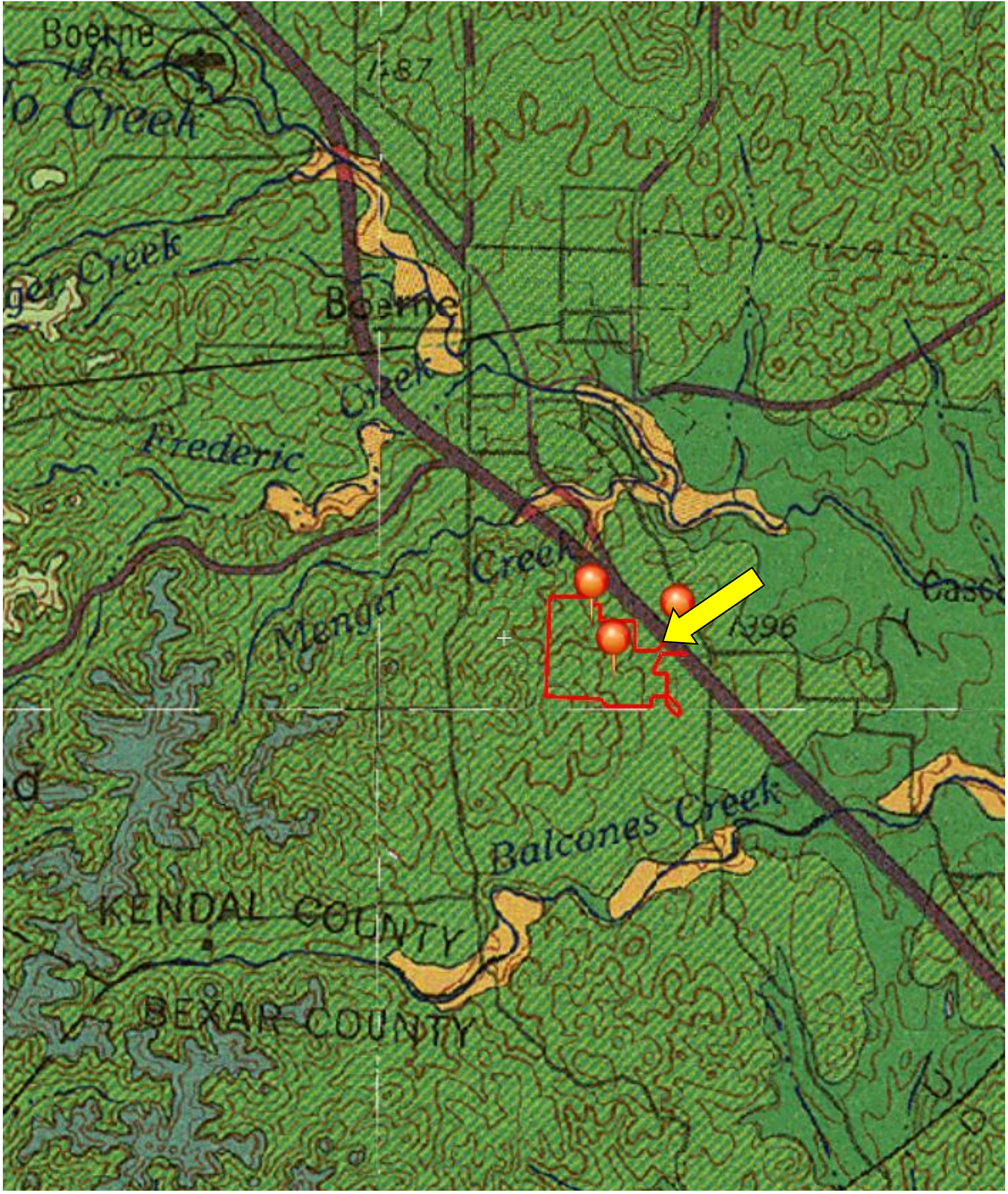


Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

Topographic Map—Approximate Location

InTEC Project Number:
S131434-P

Date:
05/05/2014



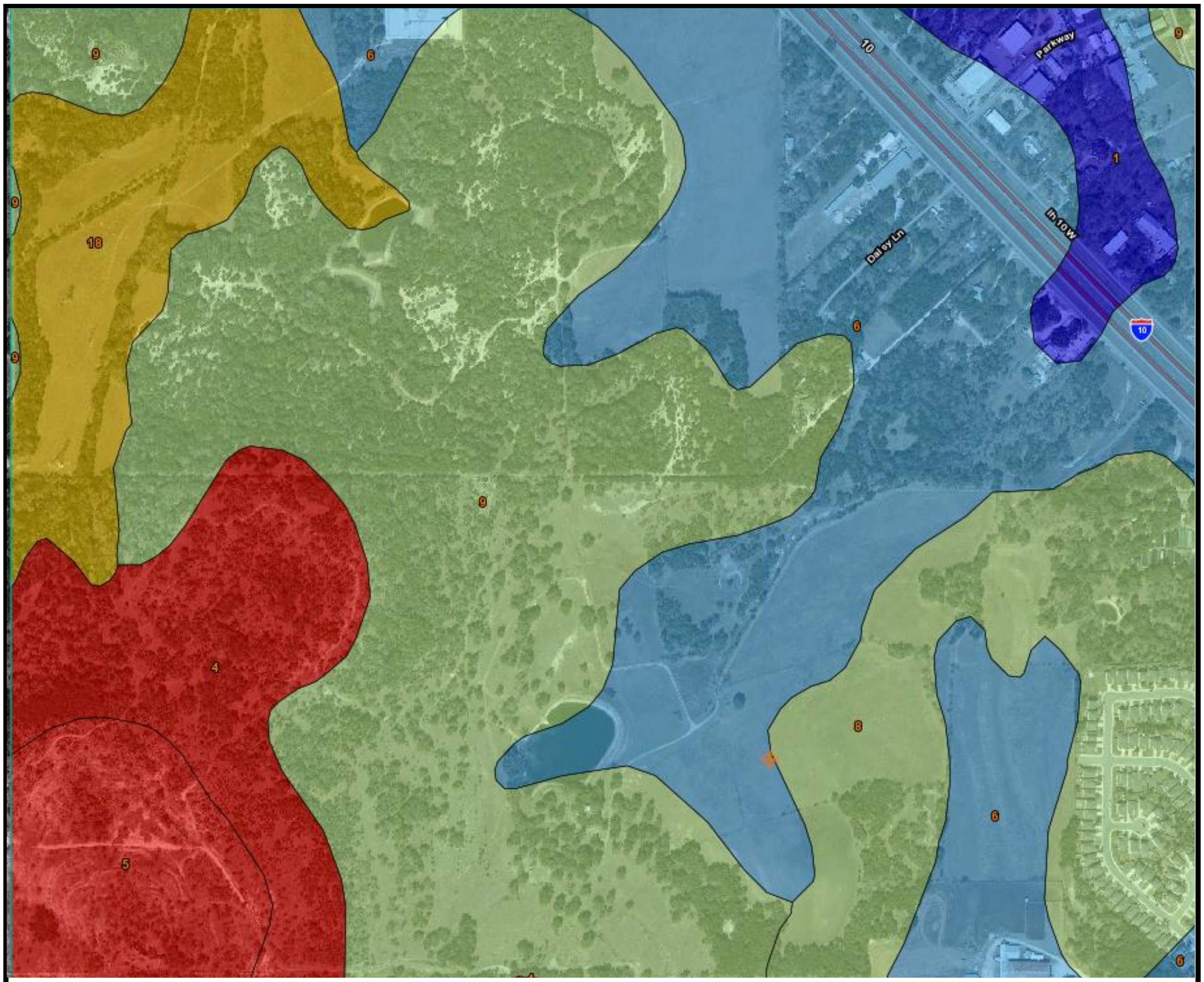
Kgru-Glen Rose formation

Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

Geologic Map—Approximate Location

InTEC Project Number:
S131434-P

Date:
05/05/2014



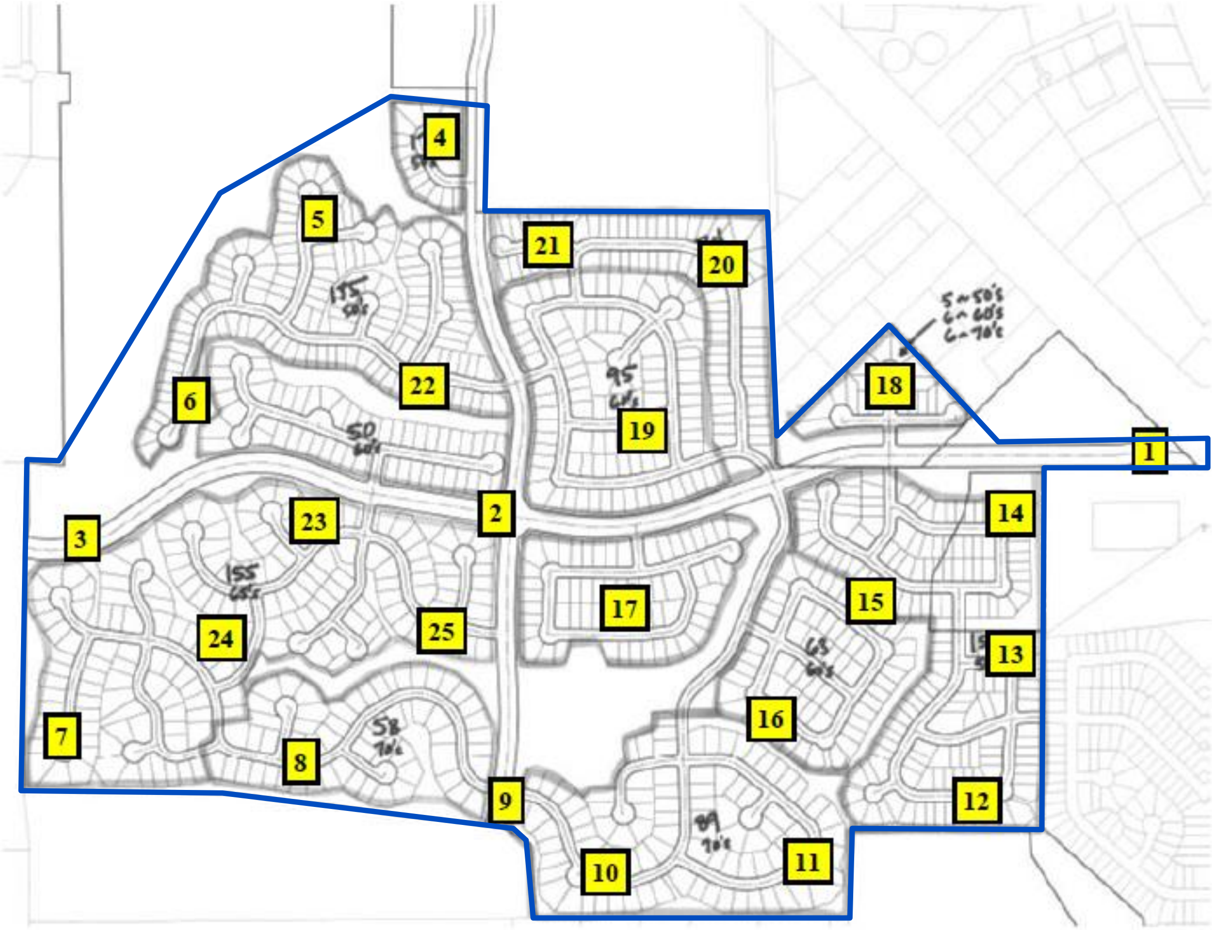
1	Anhalt clay, 1 to 3 percent slopes
4	Brackett association, undulating
5	Brackett-Real association, hilly
6	Denton silty clay, 1 to 3 percent slopes
8	Doss silty clay, 1 to 5 percent slopes
9	Doss-Brackett association, undulating
18	Tarpley clay, 1 to 3 percent slopes

Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

Soil Map—Approximate Location

InTEC Project Number:
S131434-P

Date:
05/05/2014



Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

Approximate Boring Locations

InTEC Project Number:
S131434-P

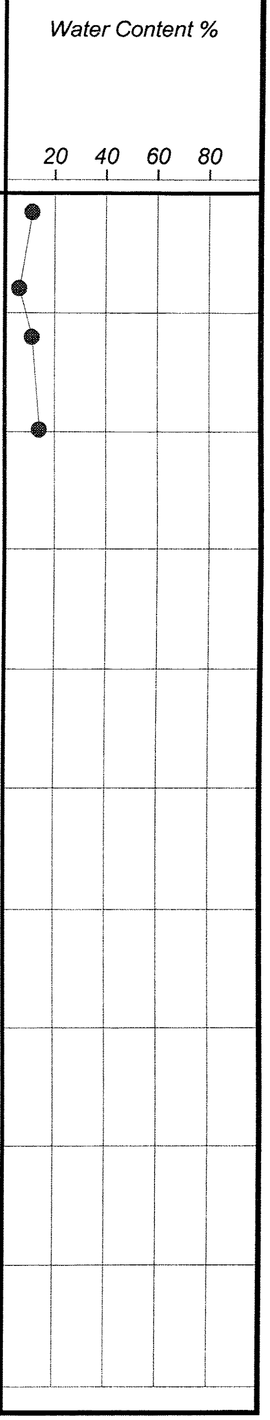
Date:
05/05/2014

LOG OF BORING NO. B-1

PROJECT: Miller Tract **DATE:** 01-16-2014

LOCATION: Boerne, Texas **PROJECT NO:** S131434

DEPTH	SYMBOL	SAMPLES	SUBSURFACE PROFILE SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			31		66	32
		AU	Hard Light Tan Weathered Limestone to Limestone						
5		AU	- with Clay Seams			50/3"		36	21
		AU							
10									
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'	Ground Water Observed No	Date: 01-16-2014

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 2

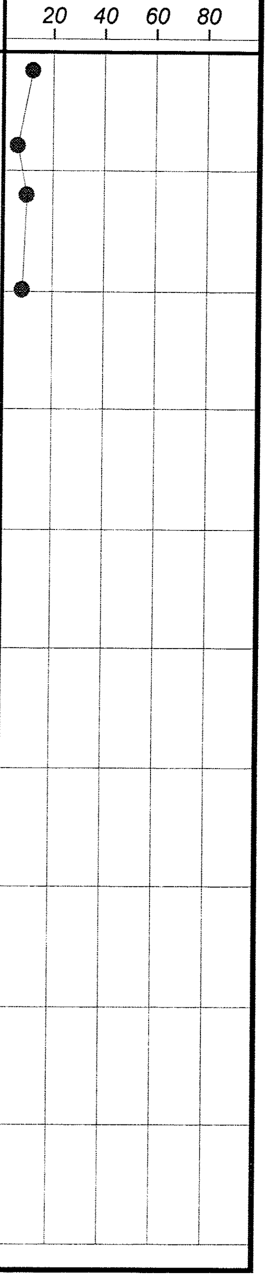
LOG OF BORING NO. B-2

PROJECT: Miller Tract **DATE:** 12-13-2013

LOCATION: Boerne, Texas **PROJECT NO:** S131434

DEPTH	SYMBOL	SAMPLES	SUBSURFACE PROFILE SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Very Stiff Dark Brown Clay			18			
	▤	SS	Hard Tan Marl						
5	▤	SS	- with Limestone Seams - with Caliche			50/4"			
	▤							35	21
10	▤	SS							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 11' Ground Water Observed No Date: 12-13-2013

S.S. by P.P.- Shear Strength in TSF
by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

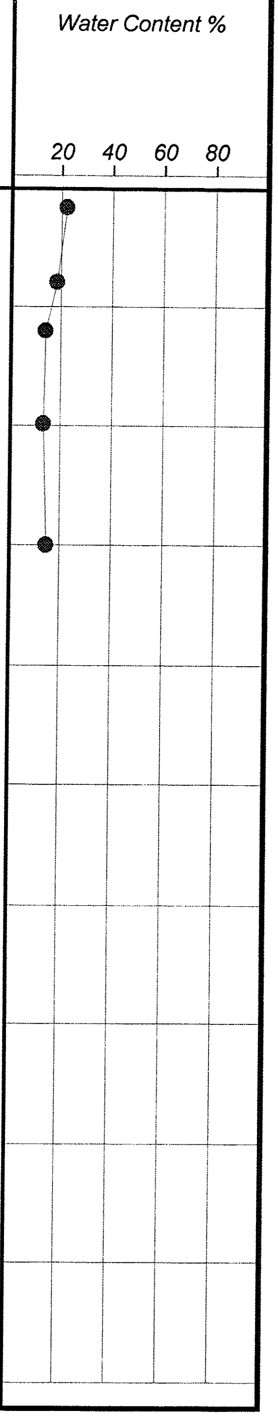
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-3

PROJECT: Miller Tract
DATE: 12-13-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Stiff to Very Stiff Dark Brown Sandy Clay			12			
	▨	SS				19		47	29
5	▨	SS				28			
	▨		Very Stiff Tan Clay to Tan Silty Clay						
	▨	AU							
10	▨								
	▨	AU							
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 15'
Ground Water Observed No
Date: 12-13-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer
S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-4

PROJECT: Miller Tract

DATE: 12-19-2013

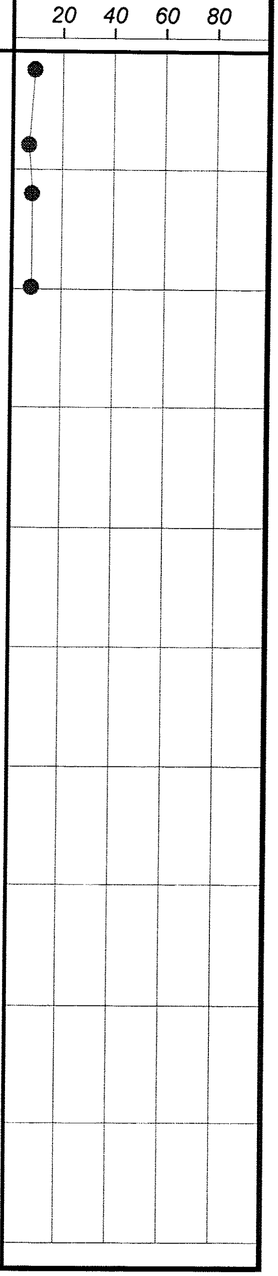
LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Brown Clay			18			
	▦	SS	Hard Tan to Light Tan Marl to Limestone			50/6"			
5	▦	AU							
	▦	AU							
10	▦							22	09
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 11'

Ground Water Observed No

Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 5

LOG OF BORING NO. B-5

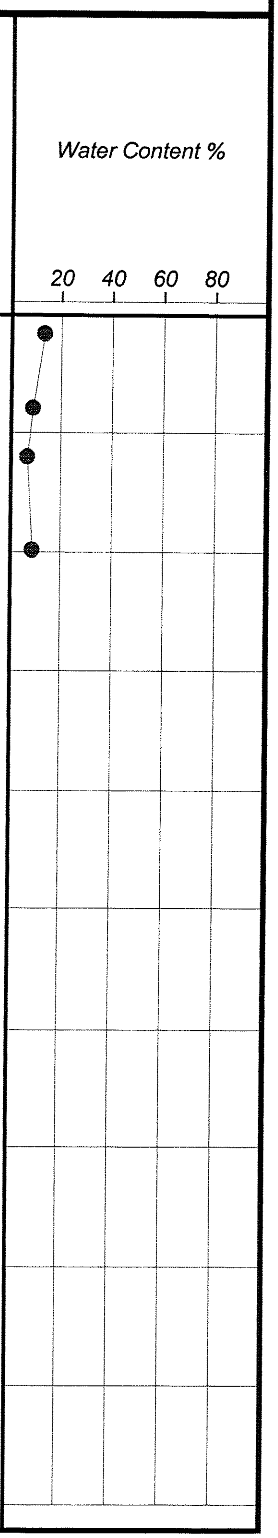
PROJECT: Miller Tract

DATE: 12-19-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
		SS	Very Stiff Brown Clay			16		47	31
		SS	Hard Tan Weathered Limestone						
5		SS	Hard Light Tan Limestone			39		30	15
			- with Clay Seams and Caliche			50/7"			
10		AU							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'

Ground Water Observed No

Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 6

LOG OF BORING NO. B-6

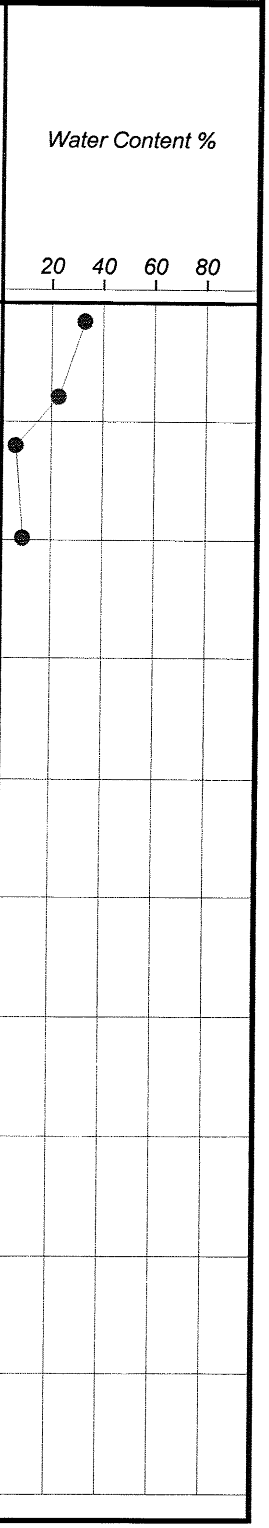
PROJECT: Miller Tract

DATE: 12-13-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Stiff to Very Stiff Dark Brown Clay			14			
	▨	SS							
5	▨	SS				19		82	60
	▦		Hard Light Tan Limestone - with Caliche			50/5"			
10	▦	AU							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'

Ground Water Observed No

Date: 12-13-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

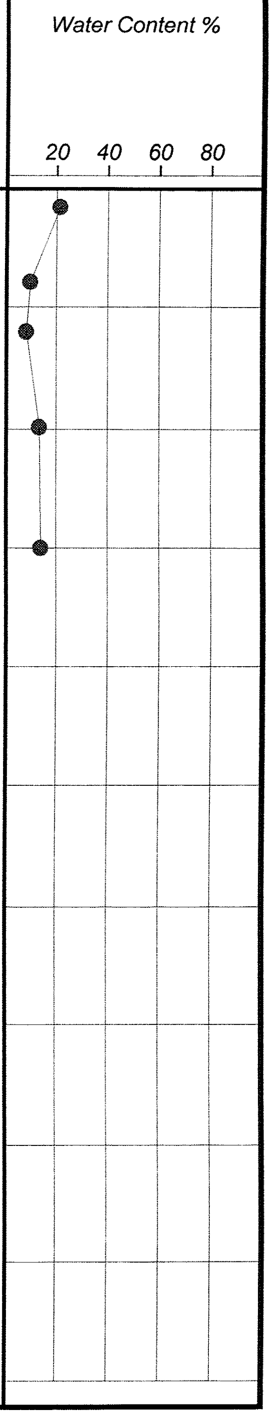
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 7

LOG OF BORING NO. B-7

PROJECT: Miller Tract
DATE: 12-13-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Stiff to Very Stiff Dark Brown Sandy Clay			13			
	▨	SS				18			
5	▨	SS	Very Stiff Tan Clay to Tan Silty Clay - with Marl Seams			39			
	▨								
	▨	AU							
10	▨								
	▨	AU							
15								50	34
20									
25									
30									
35									
40									
45									
50									



Completion Depth 15'
Ground Water Observed No
Date: 12-13-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

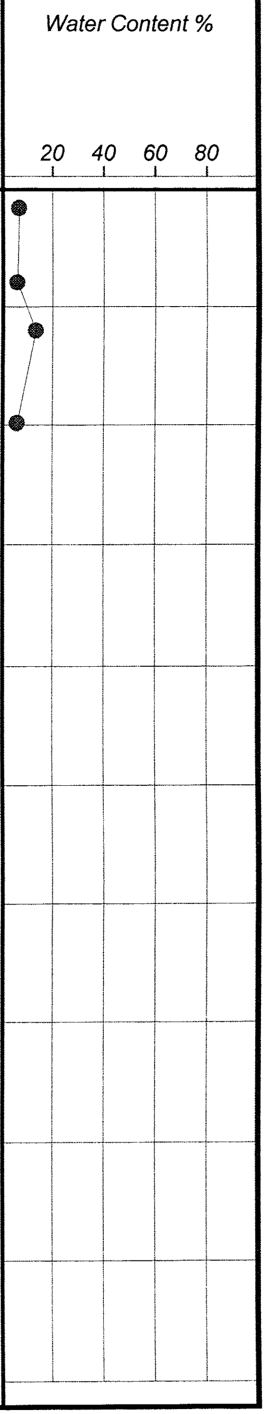
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-8

PROJECT: Miller Tract
DATE: 12-19-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Brown Clay			31			
		SS	Hard Light Tan Marl to Limestone - with Clay Seams and Caliche			50/4"		23	09
5		AU							
10		AU							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'
Ground Water Observed No
Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 9

LOG OF BORING NO. B-9

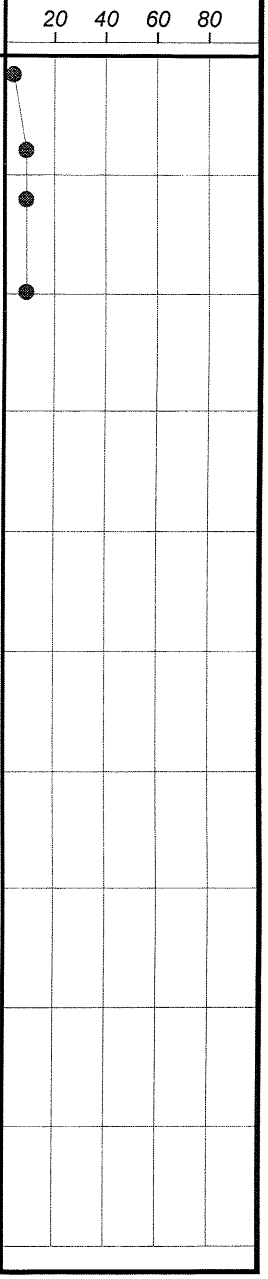
PROJECT: Miller Tract **DATE:** 12-18-2013

LOCATION: Boerne, Texas **PROJECT NO:** S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
		SS	Dark Brown Clay			31			
		SS	Hard Light Tan Marl to Limestone - with Caliche			50/8"		22	08
5		SS	- with Clay Seams			41			
		AU							
10									
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 11' Ground Water Observed No Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 10

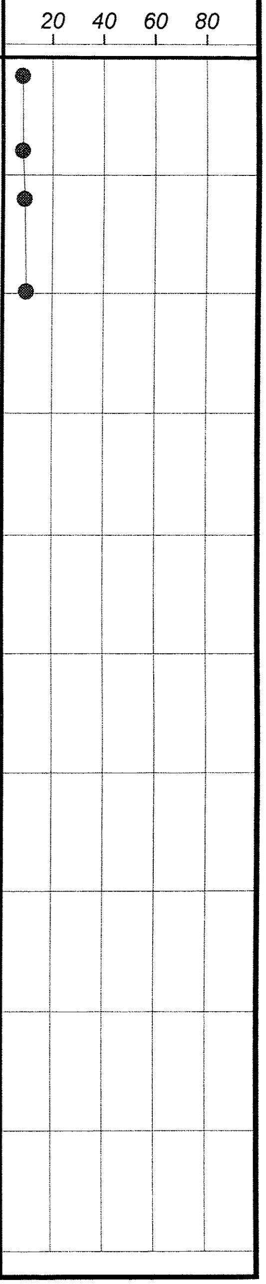
LOG OF BORING NO. B-10

PROJECT: Miller Tract
DATE: 12-18-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			61/11"			
		SS	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams and Layers			50/5"		24	10
5		AU							
		AU							
10									
15			Auger Refusal						
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 14'
Ground Water Observed No
Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 11

LOG OF BORING NO. B-11

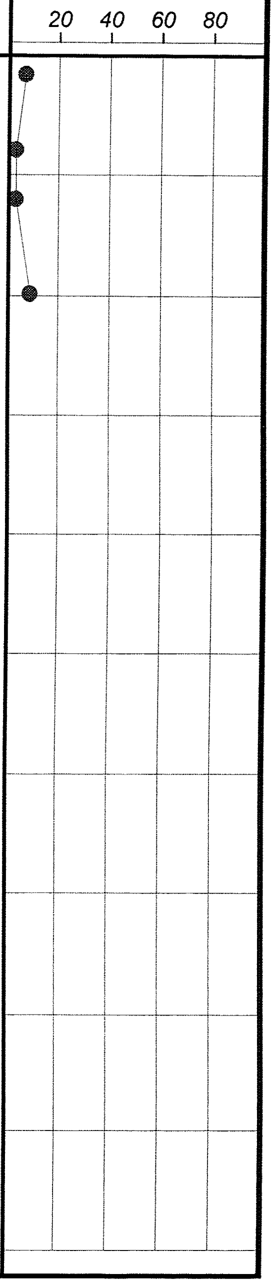
PROJECT: Miller Tract
DATE: 12-18-2013

LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
		SS	Dark Brown Clay			19			
		SS	Hard Light Tan Limestone - with Clay Seams and Layers - with Caliche			50/3"			
5		AU							
		AU							
10			Auger Refusal					24	12
15									
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 10'
Ground Water Observed No
Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-12

PROJECT: Miller Tract

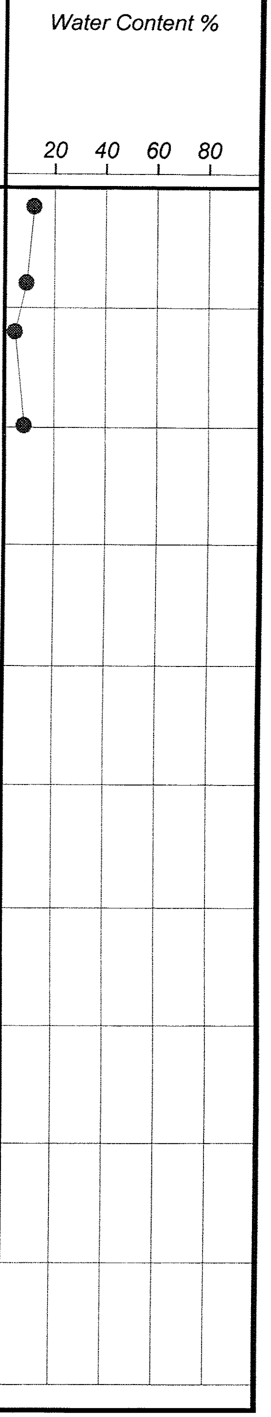
DATE: 12-18-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Very Stiff Dark Brown to Brown Clay			19		53	32
	▦	SS	Hard Tan Weathered Limestone to Limestone			50/3"			
5	▦	AU	- with Clay Seams and Layers						
	▦								
10	▦	AU							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'

Ground Water Observed No

Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

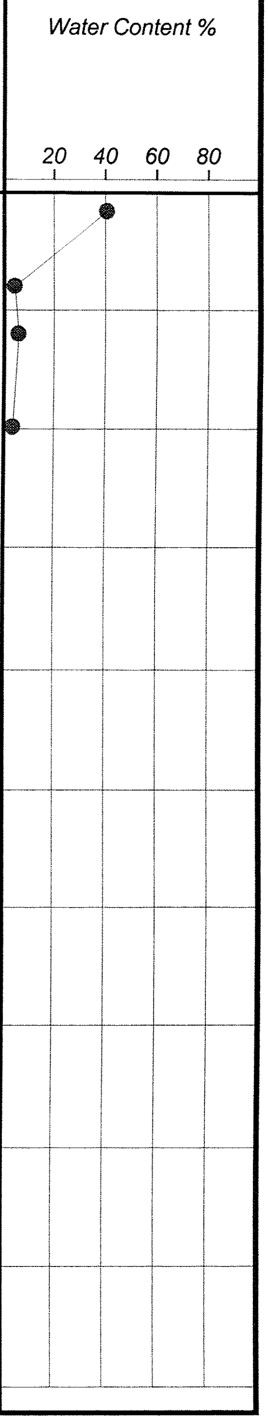
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-13

PROJECT: Miller Tract
DATE: 12-18-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	*SYMBOL*	*SAMPLES*	*SOIL DESCRIPTION* *Surf. Elev.*	*UNIT DRY WT. IN PCF*	*S.S. BY P.P.*	*BLOWS PER FOOT*	*SHEAR STRENGTH TSF*	*LIQUID LIMIT*	*PLASTICITY INDEX*
	▨	SS	Very Stiff Dark Brown Clay			15			
	▨	SS							
5	▦	SS	Hard Light Tan Weathered Limestone to Limestone - with Caliche			28		62	44
	▦					50/4"			
10	▦	AU							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'
Ground Water Observed No
Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer
S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-14

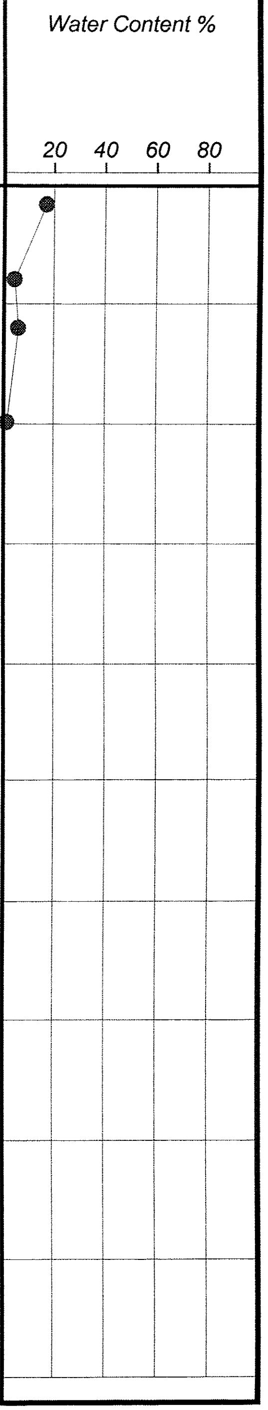
PROJECT: Miller Tract

DATE: 12-18-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Very Stiff Dark Brown Clay			18		39	22
	▦	SS	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams			50/5"			
5	▦	AU							
	▦								
	▦	AU							
10	▦								
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'

Ground Water Observed No

Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

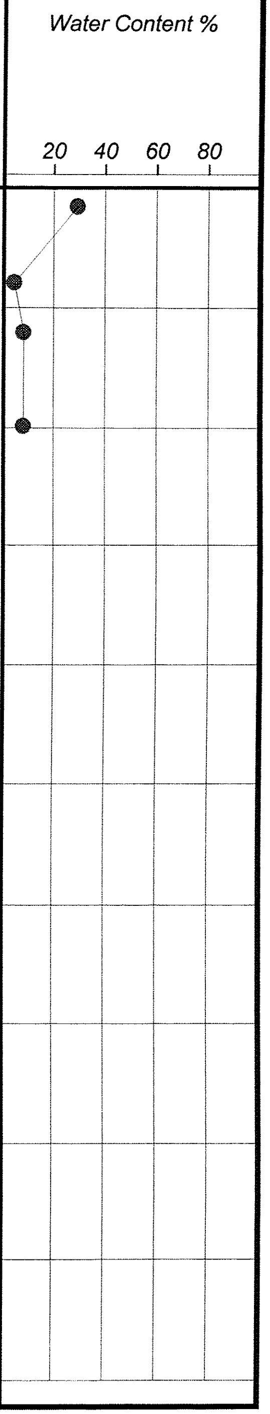
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-15

PROJECT: Miller Tract
DATE: 12-18-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Very Stiff Dark Brown Clay to Brown Clay			21			
	▦	SS	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams and Layers - with Caliche			50/4"			
5	▦	AU							
	▦							31	16
	▦	AU							
10	▦								
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'
Ground Water Observed No
Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer
S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-16

PROJECT: Miller Tract

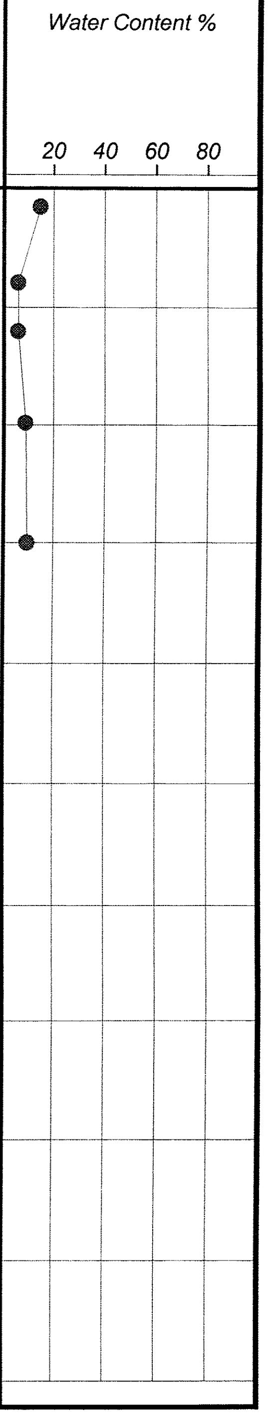
DATE: 12-17-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			39			
		SS	Hard Light Tan Weathered Limestone to Limestone - with Caliche			50/4"			
5		AU							
								22	08
		AU							
10									
		AU	- with Sandy Clay Seams Below 13-ft						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 15'

Ground Water Observed No

Date: 12-17-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 17

LOG OF BORING NO. B-17

PROJECT: Miller Tract

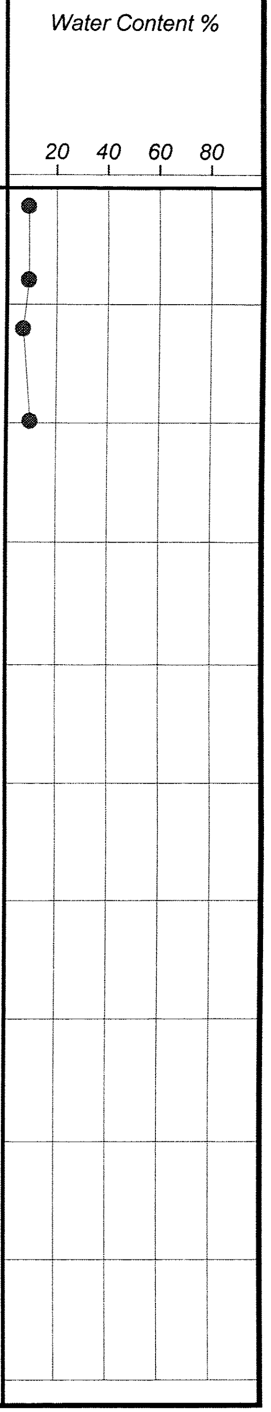
DATE: 12-18-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Brown Clay			41			
	▦	SS	Hard Light Tan Weathered Limestone to Limestone - with Caliche			50/8"		28	13
5	▦	AU							
	▦	AU							
10			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 10'

Ground Water Observed No

Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

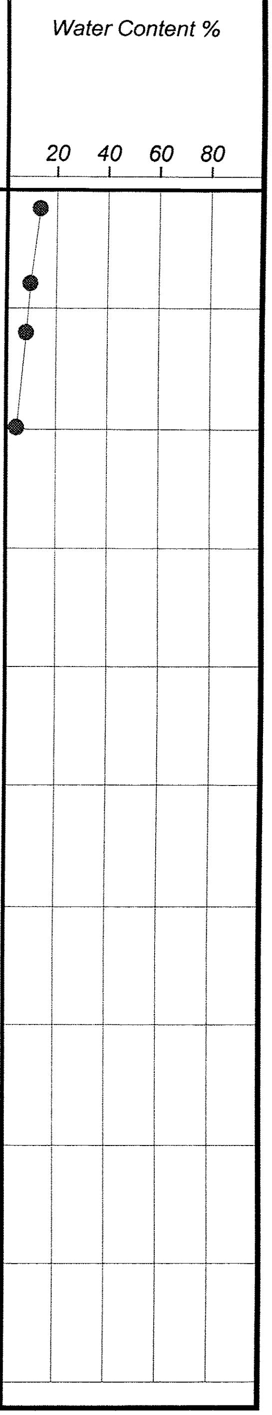
LOG OF BORING NO. B-18

PROJECT: Miller Tract **DATE:** 12-18-2013

LOCATION: Boerne, Texas **PROJECT NO:** S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			38			
	▦	SS	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams			50/4"		29	11
5	▦	AU							
	▦								
10	▦	AU							
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11' Ground Water Observed No Date: 12-18-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

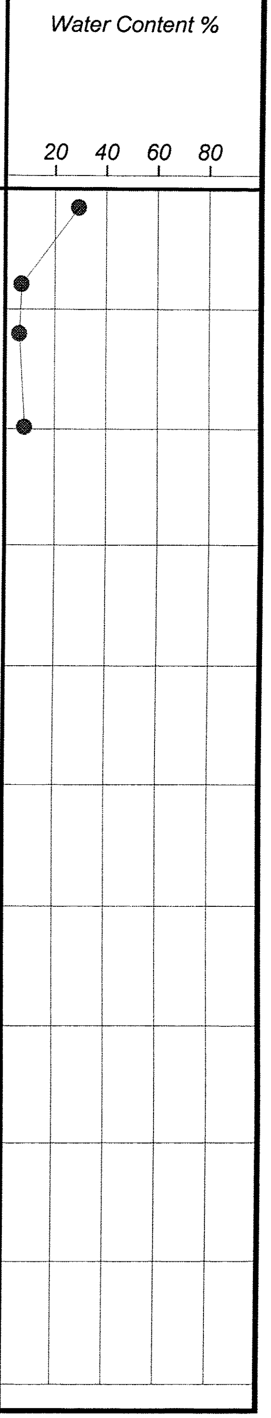
Plate: 19

LOG OF BORING NO. B-19

PROJECT: Miller Tract
DATE: 12-19-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX	Water Content %
	▨	SS	Stiff Dark Brown Clay			14		76	49	
	▨	SS								
	▦		Hard Light Tan Limestone - with Clay Seams			69/10"		28	12	
5	▦	AU								
	▦									
	▦	AU								
10	▦									
			Auger Refusal							
15										
20										
25										
30										
35										
40										
45										
50										



Completion Depth 11'
Ground Water Observed No
Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

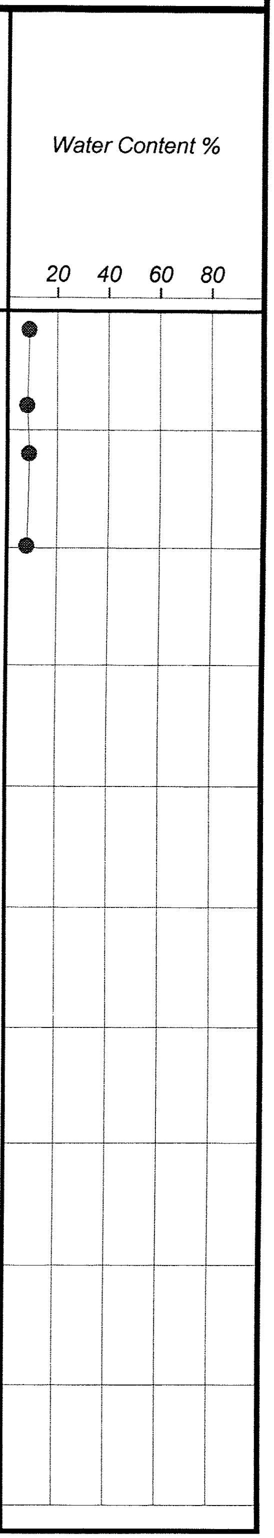
Plate: 20

LOG OF BORING NO. B-20

PROJECT: Miller Tract
DATE: 12-19-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			30			
	▦	SS	Hard Light Tan Weathered Limestone to Limestone			50/4"			
5	▦	AU	- with Clay Seams					27	13
	▦	AU							
10	▦								
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'
Ground Water Observed No
Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer
S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 21

LOG OF BORING NO. B-21

PROJECT: Miller Tract

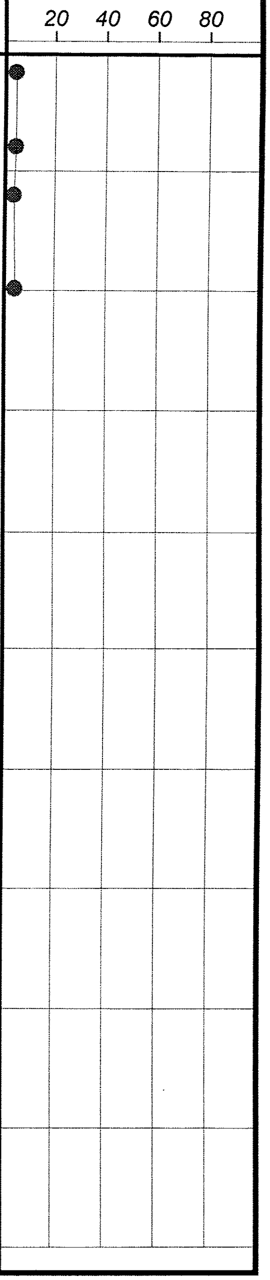
DATE: 12-19-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Brown Clay			50/6"			
	▦	AU	Hard Light Tan Limestone						
5	▦	AU							
	▦								
	▦	AU							
10			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 10'

Ground Water Observed No

Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF
by Hand Penetrometer

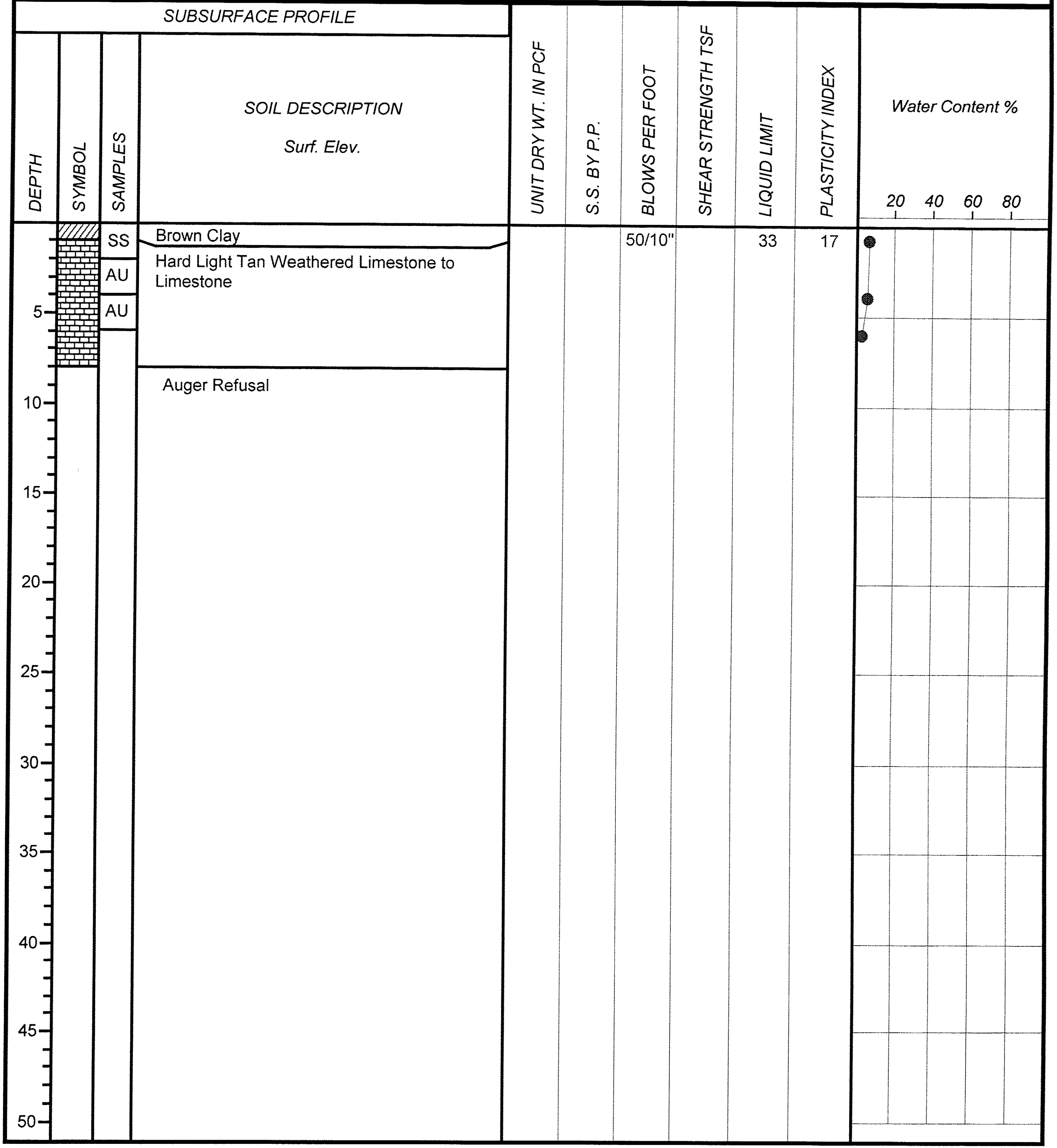
S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 22

LOG OF BORING NO. B-22

PROJECT: Miller Tract
DATE: 12-13-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434



SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	SS	Brown Clay			50/10"		33	17
	AU	Hard Light Tan Weathered Limestone to Limestone						
	AU							
		Auger Refusal						

Completion Depth 8'
Ground Water Observed No
Date: 12-13-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

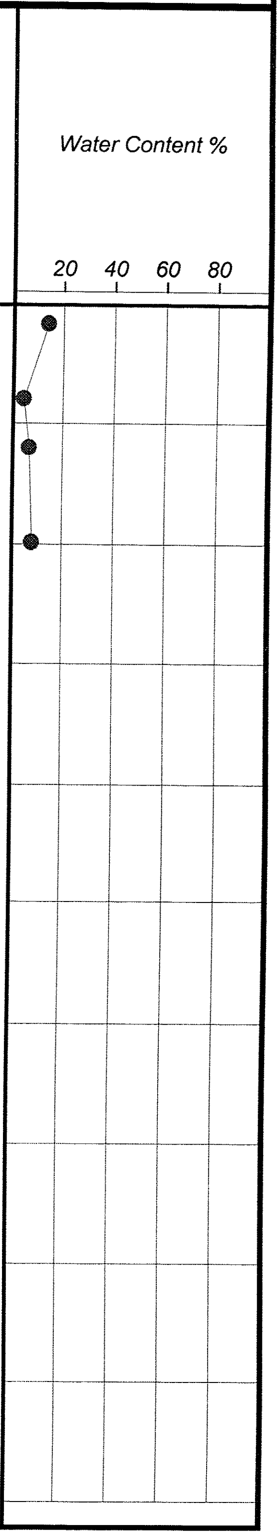
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 23

LOG OF BORING NO. B-23

PROJECT: Miller Tract
DATE: 12-13-2013
LOCATION: Boerne, Texas
PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			62/9"			
	▦	AU	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams						
5	▦	AU							
	▦							24	09
	▦	AU							
10	▦								
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'
Ground Water Observed No
Date: 12-13-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer
S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample
L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-24

PROJECT: Miller Tract

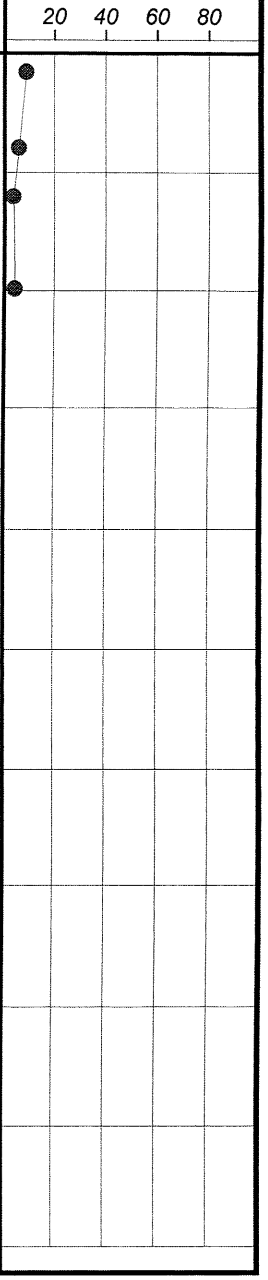
DATE: 12-19-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
		SS	Dark Brown Clay			60/9"			
		AU	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams						
5		AU						24	09
		AU							
10									
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									

Water Content %



Completion Depth 11'

Ground Water Observed No

Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

LOG OF BORING NO. B-25

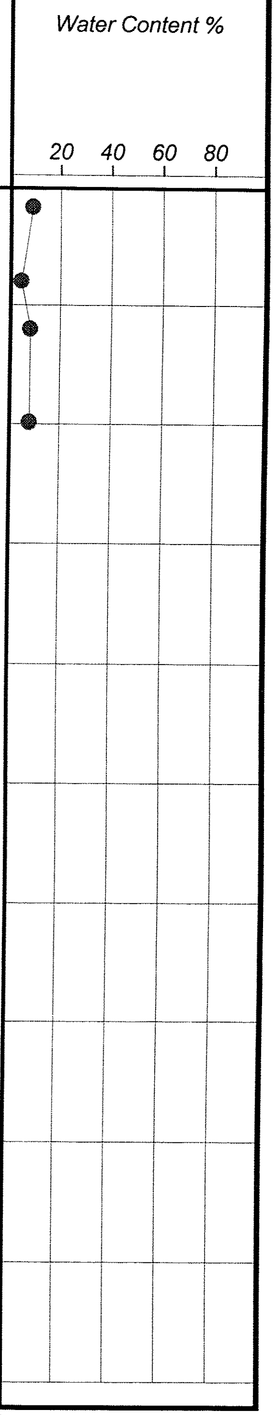
PROJECT: Miller Tract

DATE: 12-19-2013

LOCATION: Boerne, Texas

PROJECT NO: S131434

SUBSURFACE PROFILE									
DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	UNIT DRY WT. IN PCF	S.S. BY P.P.	BLOWS PER FOOT	SHEAR STRENGTH TSF	LIQUID LIMIT	PLASTICITY INDEX
	▨	SS	Dark Brown Clay			56			
	▦	SS	Hard Light Tan Weathered Limestone to Limestone - with Clay Seams			50/3"			
5	▦	AU							
	▦							21	08
	▦	AU							
10	▦								
			Auger Refusal						
15									
20									
25									
30									
35									
40									
45									
50									



Completion Depth 11'

Ground Water Observed No

Date: 12-19-2013

S.S. by P.P.- Shear Strength in TSF by Hand Penetrometer

S.S.- Split Spoon Sample
S.T.- Shelby Tube Sample
AU- Auger Sample

L.L- Liquid Limit
P.L.- Plastic Limit
M.C.- Moisture Content

Plate: 26

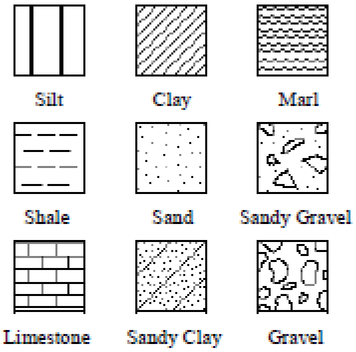
KEY TO CLASSIFICATIONS AND SYMBOLS

Soil Fractions

Component	Size Range
Boulders	Greater than 12"
Cobbles	3" - 12"
Gravel	3" - #4 (4.76mm)
Coarse	3" - ¾"
Fine	¾" - #4
Sand	#4 - #200 (0.074mm)
Coarse	#4 - #10 (2.00mm)
Medium	#10 - #40 (0.42mm)
Fine	#40 - #200 (0.074mm)
Silt and Clay	Less than #200

Soil or Rock Types

(Shown in symbols column)
(Predominate Soil Types Shown Heavy)



TERMS DESCRIBING SOIL CONSISTENCY

Description (Cohesive Soils)	Unconfined Compression TSF	Blows/Ft. Std. Penetration Test	Description (Cohesionless Soils	Blows/Ft. Std. Penetration Tests
Very Soft	0.25	<2	Very Loose	0 – 4
Soft	0.25 – 0.50	2 – 4	Loose	4 – 10
Firm	0.50 – 1.00	4 – 8	Medium Dense	10 – 30
Stiff	1.00 – 2.00	8 – 15	Dense	30 – 50
Very Stiff	2.00 – 4.00	15 – 30	Very Dense	50
Hard	>4.00	>30		

SOIL STRUCTURE

Calcareous	Containing deposits of calcium carbonate; generally nodular.
Slickenside	Having inclined planes of weakness that are slick and glossy in appearance.
Laminated	Composed of thin layers of varying color and texture.
Fissured	Containing shrinkage cracks frequently filled with fine sand or silt. Usually more or less vertical.
Interbedded	Composed of alternate layers of different soil types.
Jointed	Consisting of hair cracks that fall apart as soon as the confining pressure is removed.
Varved	Consisting of alternate thin layers of sand, silt or clay formed by variations in sedimentations during the various seasons of the year, of often exhibiting contrasting colors when partially dried. Each layer is generally less than ½" in thickness.
Stratified	Composed of, or arranged in layers (usually 1 inch or more)
Well-graded	Having a wide range of grain sizes and substantial amount of all intermediate particle sizes.
Poorly or Gap-graded	Having a range of sizes with some intermediate sizes missing.
Uniformly-graded	Predominantly of one grain size.

Subsurface Exploration and Pavement Analysis
Miller Tract
Boerne, Texas

InTEC Project Number:
S131434-P

Date:
05/05/2014