TERRADYNE
Engineers, Geologists & Environmental Scientists

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November 20, 2019

Bellaire Financial Inc.
4372 N Loop 1604 W, # 206
Shavano Park, Texas 78249

Attn.: Mr. James Japhet

Re: **Engineer's Concurrence Letter**
Subgrade Verification and Pavement Recommendations
The Reserve at Gruene Village
New Braunfels, Texas
Terradyne Project No.: A1151216-1

Dear Mr. Japhet:

Terradyne Engineering, Inc (Terradyne) issued a revised Geotechnical Report on June 29, 2016 (Terradyne Report No. A151216), in the revised report Terradyne recommended pavement sections for parking and driving area, upon reviewing the report we understood that the pavement sections are neighborhood local and collectors' roads. Based on Terradyne's understanding of the project requirements, the City of New Braunfels requirements and the design criteria provided in the original Geotechnical Report and supplemental design letter, the following pavement sections are recommended in Table 1.

Table 1: Recommended Pavement Sections

Flexible Pavement Section	**Thickness in Inches**	
	Residential Local	**Residential Collector**
Hot Mix Asphaltic Concrete (TXDOT Item 340, Type D)	**2.0**	**2.0**
Aggregate Base (TXDOT Item 247, Type A, Grade 1)	**10.0**	**15.0**
Compacted Subgrade	**6.0**	**6.0**

Table 2: Design ESALS: 15,000

Rigid Pavement Section	**Thickness in Inches**
	Alt 1
Portland Cement Concrete	5.0
Compacted Subgrade	8.0

Table 3:Design ESALS: 150,000

Rigid Pavement Section	Thickness in Inches
	Alt 1
Portland Cement Concrete	6.0
Compacted Subgrade	8.0

Moisture Conditioned Subgrade

Prior to flexible base placement, the subgrade should be moisture conditioned and properly compacted so that a proof-roll inspection may be completed and passed. If general fill materials are utilized to build the subgrade prior to flexible base placement, the fill materials should be properly compacted to 95% of the maximum dry density as determined per ASTM D 698 or TEX-114-E and the moisture content maintained between +/- 2 points of the optimum moisture content. A representative of Terradyne should be present for the testing for compliance with these recommendations.

If anyone on the project team has any questions, please contact our office for additional assistance. We look forward to continued service and involvement in the construction phases of this project.

Respectfully submitted,
Terradyne Engineering, Inc.
Texas Engineering Firm Registration No. F-6799

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

November 20, 2019

Preliminary Subsurface Exploration, Foundation Analysis, and Pavement Thickness Design
Proposed Cabins at Gruene Subdivision
New Braunfels, Texas

Terradyne Project No.: A151216

Mr. Rob Haug
Dilley Rental Estates, LTD.
29 San Giovani Court
Austin, Texas 78738

September 2, 2015

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Engineering the Future Since 1995

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Dilley Rental Estates, LTD.
29 San Giovani Court
Austin, Texas 78738

Terradyne Project No.: A151216

September 2, 2015

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Zack J. Munstermann, E.I.T.
Austin Branch Manager

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PROFESSIONAL ENGINEER

John A. Gunter, M.S., P.E
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Prepared by Aubrey M. Taylor

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September 2, 2015

Dilley Rental Estates, LTD.
29 San Giovani Court
Austin, Texas 78738

Attention: Rob Haug

Re: **Preliminary Subsurface Exploration, Foundation Analysis, and Pavement Thickness Design**
Proposed Cabins at Gruene Subdivision
New Braunfels, Texas
Terradyne Project No.: A151216

Dear Mr. Haug:

Terradyne AUS, Inc. 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,

Very Truly Yours,
Terradyne AUS, Inc.

Zack J. Munstermann, E.I.T.
Geotechnical Project Manager

Copies Submitted: Above (1)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The soil conditions at the site of the proposed residential structures and roadways for the proposed Cabins at Gruene Subdivision in New Braunfels, Texas were explored by drilling five (5) borings to a maximum depth of 15 feet below the existing ground surface elevation. However, due to site access limitations and Limestone at shallow depths, only four (4) borings were drilled to auger refusal between 6 and 7 feet below the existing ground surface elevation. Laboratory tests were performed on selected soil samples to evaluate the engineering characteristics of the soil strata encountered in our borings. This investigation is preliminary in nature and based on a very limited number of borings. The foundation design parameters presented in this report are for informational and comparative purposes only and should not be used for actual foundation design.

The results of our exploration, laboratory testing and engineering evaluation indicate that the underlain shallow soils at this site are of low expansion potential. Potential vertical movement on the order of 1 ¼ inches was estimated for average to dry soil moisture conditions.

If it is desirable to design the foundation systems utilizing the simplifying assumption that the loads are carried by the beams, an allowable bearing pressure value of 1,700 pounds per square foot should be used for beams founded at a minimum depth of 12 inches below the existing grade. If structure existing grade has to be raised to achieve design grade, select structural fill should be placed, compacted and tested. An allowable bearing pressure value of 2,300 pounds per square foot should be used for beams bearing on a minimum of 12 inches of compacted select structural fill. The depth of the beams should be at least 12 inches and also should be 10 inches wide to prevent local shear failure of the bearing soils. Design plasticity index values of 15 to 18 are recommended for slabs bearing on compacted natural subgrade soils.

Groundwater was not encountered in our borings during drilling.

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

8) Consultations with the Prime Professional and members of the design team on findings and recommendations; and preparation of a written geotechnical engineering report for use by the members of the design team in their preparation of design, contract documents, and specifications.

The Scope of Services did not include any environmental assessment for 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 bore hole logs regarding odors, colors or unusual or suspicious items or conditions are strictly for the information of the client.

2.1 Site Description

The subject site is located at 1656 Gruene Road in New Braunfels, Texas within an undeveloped property. The subject property is located on the northwest side of Gruene Road and west of Ervendberg Avenue in New Braunfels, Texas. The property is relatively flat with short grass and trees. Borings B-1 through B-4 were drilled at/near the following GPS location (Lat. 30.735691, Long. -97.113923). An aerial map of the GPS location is included in Plate 7.

3.0 GEOTECHNICAL INVESTIGATION

The field exploration to determine the engineering characteristics of the subsurface materials included a reconnaissance of the project site, drilling the borings, and recovering samples. Due to site access limitations and Limestone at shallow depths, only four (4) borings were drilled to auger refusal between 6 and 7 feet below the existing ground surface elevation.

The soil borings were performed with a drilling rig equipped with a rotary head. Conventional solid stem continuous augers were used to advance the hole and samples of the subsurface materials were sampled using a two-inch O.D. split barrel sampler (ASTM D 1586).

3.1 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: Water level observations were made during the excavation operations and the results are noted on the boring logs. 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.

3.2 Field Logs

A field log was prepared for each boring. The logs include information concerning the samples attempted and recovered, indications of the presence of material (such as calcareous clays, sandy clay, etc.) and groundwater observations. It also includes an interpretation of the subsurface conditions between samples. Therefore, these logs include both factual and interpretive information.

3.3 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 through 9 in the Illustration Section. A key to classification terms and symbols used on the logs is presented on Plate 10.

3.4 Laboratory Testing Program

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

Table No. 1

Laboratory Test	Applicable Test Standard
Liquid Limit, Plastic Limit, & Plasticity Index of Soil	ASTM D-4318
Moisture Content	ASTM D-2216

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 the soil samples were determined. Atterberg limit tests were performed on representative soil samples to determine the plasticity characteristics of the soil strata encountered. The following tests, presented in Table No. 2, were performed in the laboratory to evaluate the engineering characteristics of the subsurface materials. The results of these tests are presented on the appropriate boring logs.

Table No. 2

Type of Test	Number Conducted
Natural Moisture Content	4
Atterberg Limits	4

3.5 General Subsurface Conditions

The soils underlying this site may be grouped into generalized strata. The soil stratigraphy information and the engineering properties of the underlying soils, based on our professional engineering experience is presented on the Boring Logs, Plates 2 through 5.

During the field investigation, subsurface water was not encountered the test holes. In addition, the soil samples were considered to be in and average to dry condition. Based upon this information and past projects in the surrounding areas of the site, groundwater is not anticipated to be major concern during construction activities. However, groundwater condition can fluctuate due to seasonal and climatic variations, and may be encountered at shallow depths during high precipitation seasons.

4.0 FOUNDATION DESIGN CONSIDERATIONS

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 structures 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 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 a slope from moving downhill with the soil, it must be designed to compensate for this lateral soil influence.

Pre-Construction Vegetation: No vegetation was on a site prior to construction. 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 foundations 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 his design, using his engineering experience and judgment as a guide.

5.0 DESIGN ENGINEERING ANALYSIS

Foundation Design Considerations: Review of the borings and test data indicates that the following factors will affect the foundation designs and construction at this site:

1) The site at shallow depths is underlain by subsurface soils of low expansiveness in character. Structures supported at shallow depths will be subjected to potential vertical movement of 1 ¼ inches.
2) The strengths of the underlying soils are adequate to support the proposed structure.
3) Groundwater seepage was not encountered in our borings during the subsurface exploration phase.

Vertical Movements: The potential vertical movement (PVR) for slab-on grade construction at this site has been estimated using the general guidelines presented in a) the Texas Department of Transportation Test Method TXDOT-124-E and b) based on our experience with the swelling characteristics of the clays that are similar to those at the project site. The Texas Department of

Transportation method utilizes the liquid limits and plasticity indices for soils in the seasonally active zone, estimated to be about twelve (11) to fifteen (15) 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 movement of 1 ¼ inches was estimated for dry soil moisture conditions at the finish grade elevation. The PVR value is based on the current site grades. Higher PVR values than the above mentioned value will occur in areas where water is allowed to pond for extended periods.

The bottom of the excavation should be shaped so that it is well drained against any water entering the select fill. The excavation and any select fill should not be allowed to become a "bathtub", holding water in the fill. Any surface of the select fill outside of the house should be covered in a fashion to prevent surface water from entering the fill.

If the existing grade of the structures has to be raised to attain finish grade elevation, select structural fill should be used, placed in lifts and compacted as recommended under the section titled Select Structural Fill provided in this report.

6.0 FOUNDATION RECOMMENDATIONS

This investigation is a preliminary investigation and is based on a very limited number of borings. The design values provided in the report are for comparative purposes only and should not be used for actual design.

6.1 Stiffened Grid Type Beam and Slab Foundations

A stiffened grid type beam and slab foundation may be considered to support the proposed buildings provided the anticipated vertical movement will not impair the performance of the structures.

It is desirable to design the foundation systems using an assumption that the beams carry the loads. An allowable bearing pressure of 1,700 pounds per square foot should be used for beams founded at a minimum depth of 12 inches below the existing undisturbed soils. If the existing grade of the structure has to be raised to achieve design grade, select structural fill should be placed, compacted and tested. An allowable bearing pressure of 2,300 pounds per square foot should be used for beams bearing on a minimum of 12 inches of compacted select structural fill. Beams should be at least 12 inches deep and 10 inches wide to prevent local shear failure of the bearing soils. Design plasticity index values were evaluated at the boring locations and are presented below in Table No. 3.

Table No. 3

Boring	Design Plasticity Index
1	18
2	15
3	18
4	15

6.2 Post-Tensioned Beam and Slab Foundation

A post-tensioned slab-on-grade foundation may also be considered to support the structures provided the anticipated movement will not impair the performance of the structures. Pertinent design parameters were evaluated and are presented in the following paragraphs.

Differential vertical movements should be expected for shallow type foundations at this site due to the 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 soils data obtained from both the field and laboratory tests performed on the soil samples.

Differential vertical movements have been estimated for the center lift and edge lift conditions. The PTI Design Parameters are presented in Table No. 4. Refer to the Stiffened Grid Type Beam and Slab Foundation section for allowable bearing capacities.

Table No. 4
PTI 3rd Edition

Design Plasticity Index/PVR (inches)	Differential Vertical Movement, y_m Inches		Edge Moisture Variation Distance, e_m Feet	
	Center Lift	Edge Lift	Center Lift	Edge Lift
15 to 18/1 ¼	1.25	1.90	9.0	4.6

6.3 Utilities

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

6.4 Contraction, Control or Expansion Joints

Contraction, control and/or expansion joints should 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 normally occurs due to soil movements, material shrinkage, thermal affects, and other related structural conditions.

6.5 Lateral Earth Pressure

Some retaining walls may be needed at the site. The equivalent fluid density values were evaluated for various backfill materials. These values are presented in Table No. 5.

Table No. 5

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 should be used. For rigid non-yielding walls which are part of the buildings, the values "at rest condition" should be used. The compactive effort should 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 should be maintained between 95 and 98 percent of standard Proctor (ASTM D698) maximum dry density.

The backfill behind the wall should 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 insure that the drains are not clogged by fine particles, they should be surrounded by a granular filter. In spite of 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 inches 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 the clay soils should not exceed 1,200 pounds per square foot. An adhesion value of 290 pounds per square foot should be used to check against sliding for wall footings bearing on clay.

7.0 PAVEMENT GUIDELINES

7.1 General

Pavement areas for the proposed building are expected to include parking areas for cars and light trucks and driveways and loading areas for occasional heavy truck traffic. 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 and b) that 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.

7.2 Pavement Sections

Parking areas, driveways may be designed with either a rigid or flexible pavement. Pavement sections for both rigid and flexible types are recommended as follows for heavy traffic areas and parking areas (Tables 6 and 7):

Table No. 6

Rigid Pavement Section	Thickness in Inches	
	Parking Areas	Truck Areas
Continuous Reinforced Concrete Pavement	5.0	6.0
Compacted Subgrade	6.0	6.0

Table No. 7

Flexible Pavement Section	Thickness in Inches	
	Parking Areas	Drive Areas
Hot Mix Asphaltic Concrete (TXDOT Item 340, Type D)	1.5	2.0
Aggregate Base (TXDOT Item 247, Type A, Grade 1)	8.0	10.0
Compacted Subgrade	6.0	6.0

In any areas where pavements are to be constructed, vegetation and all loose or organic material should be stripped and removed from the site. Subsequent to stripping operations, the subgrade should be proof-rolled with heavy sheep's-foot roller compactor a minimum of **3-passes** to identify soft zones. Any soft zone detected should be removed to a firm subgrade soils and replaced with compacted suitable soils to reach subgrade level. Upon the acceptance of proof-rolling operations the subgrade should be scarified to a depth of 6 inches, moisture conditioned and compacted to a 95 percent of maximum dry density as determined by ASTM D 698, between optimum and 3 percentage points above of optimum moisture content. The exposed subgrade should not be allowed to dry out prior to placing structural fill.

7.3 Base Course

Based on the surveys 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 Specifications, Item 247, Type A, Grade 1.

The base course should be moisture conditions within ± 2 percentage points of optimum moisture content and compacted in two lifts to at least 95 percent of maximum dry density as determined by test method TxDOT 113-E test method.

7.4 Asphaltic Concrete

The asphaltic concrete surface course should conform to Texas State Department of Highways and Public Transportation Standard Specifications, Item 340, Type D. The asphaltic concrete should be designed for a stability of at least 40. The asphaltic concrete should be compacted to between 92 and 97 percent of the theoretical density as determined by ASTM D 2041.

7.5 Reinforced Concrete

Concrete should be designed to exhibit a flexural strength (3 point loading) of at least 550 psi at 28 days. As an option, a 28 day compressive strength requirement of 3,500 psi may be utilized.

7.6 Concrete Pavement

Concrete pavement slabs should be provided with adequate steel reinforcement. Proper finishing of concrete pavements requires the use of sawed and sealed joints which should be designed in accordance with current Portland Cement Association guidelines. Dowel bars should be used to transfer loads at transverse joints. Related civil design factors such as drainage, cross-sectional configurations, surface elevations and environmental factors which will significantly affect the service life must be included in the preparation of the construction drawings and specifications. Normal periodic maintenance will be required, especially for open jointed areas which may allow surface water infiltration into the subgrade.

7.7 Continuous Repetitive Traffic Areas and Trash Dump Area, and Loading Dock Area

Concrete pavement is recommended in areas, which receive continuous repetitive traffic such as drive-through lanes even if asphaltic concrete pavement is used in other areas.

A concrete pad of at least 7 inches is recommended in front of trash dumps due to high wheel and impact loads that this area receives.

8.0 CONSTRUCTION CONSIDERATIONS

8.1 Site Drainage

We recommend that an effective site drainage plan be devised by others prior to commencement of construction to provide positive drainage away from the foundation perimeters and off the site, both during and after construction.

8.2 Site Preparation

In any areas where soil-supported floor slabs are to be constructed, vegetation and all loose or organic material should be stripped and removed from the site. Subsequent to stripping operations, the subgrade should be proof-rolled to identify soft zones. Any soft zone detected should be removed to expose firm soil or rock and replaced with compacted suitable soils to reach subgrade level.

8.3 Select Structural Fill

Select fill material used at this site should 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 5 and 20. The fill should be compacted to at least 95 percent of the maximum dry density as determined by TxDOT-113-E, within ± 2 percentage points of optimum moisture content.

8.4 Groundwater

In any areas where significant cuts (one foot or more) are made to establish final grades for building pads, 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 building pads should 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 residence, an engineer should be notified to evaluate its' effect and determine whether French Drains are required at the location.

8.5 Earthwork and Foundation Acceptance

Exposure to 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 are extended to final grade and the footings constructed as soon as possible to minimize potential damage to bearing soils or rock. The foundation bearing level should be free of loose soil; ponded water or debris and should be inspected and approved by the geotechnical engineer or his representative prior to concreting.

Foundation concrete should 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 should be monitored by the soils engineer or his representative. As a guideline, at least one in-place density test should be performed for each 2,500 square feet of compacted surface per lift. Any areas not meeting the required compaction should be re-compacted and retested until compliance is met.

9.0 DRAINAGE AND MAINTENANCE

Final drainage is very important for the performance of the structure. Landscaping, plumbing, and downspout drainage is also very important. It is vital that all roof drainage be transported away from the building so that no water ponds around the building which can result in soil volume change under the building. Plumbing leaks should be repaired as soon as possible in order to minimize the magnitude of moisture change under the slab. **Large trees and shrubs should not be planted in the immediate vicinity of the structures, since root systems can cause a substantial reduction in soil volume in the vicinity of the trees during dry periods.**

Adequate drainage should be provided to reduce seasonal variations in moisture content of foundation soils. All pavement and sidewalks within 10-feet of the structure should be sloped away from the structure to prevent ponding of water around the foundation. Final grades within 10-feet of the structure should be adjusted to slope away from structures preferably at a minimum slope of 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 underlain 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.

There are several factors, which relate 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 sloping the ground surface adjacent to the building, a complete system of gutters and downspouts should carry runoff water a minimum of 10-feet from the completed structure.
2. Planters located adjacent to the structure should preferably be self contained. Sprinkler mains should be located a minimum of 5-feet from the building line.
3. Planter box structures placed adjacent to buildings should be provided with a means to assure concentrations of water are not available to the subsoil stratigraphy.
4. Large trees and shrubs should not be allowed 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 should 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 should discharge on pavement or be extended away from the structures. Ideally, roof drains should discharge to storm sewers by closed pipe.

Trench backfill for utilities should be properly places and compacted as outlined in this report and in accordance with requirements of local City 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 structure. Concrete cut-off collars or clay plugs should be provided where utility lines cross building lines to prevent water 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. If the this drainage is not maintained, the wetted front may occur below the assumed fifteen feet depth, and the resulting PVR may be 2 to 3 times greater than the stated values shown in this report. Utility leaks may also cause similar high movements to occur.

10.0 LIMITATIONS

The exploration and analysis of the subsurface conditions reported herein are considered sufficient to form a reasonable basis for the preliminary foundation designs. The recommendations submitted are based upon the data obtained from our borings at the project site. If deviations from the noted subsurface conditions are encountered during construction, they should be brought to the attention of the geotechnical engineer. The geotechnical engineer declares that the findings, recommendations, specifications or professional advise contained herein, have been made after being prepared in accordance with generally accepted professional engineering practice, in the fields of geotechnical engineering, soil mechanics and engineering geology. No other warranties are implied or expressed. This preliminary report has been prepared for the specific application to the proposed residential structures and roadways for the proposed Cabins at Gruene Subdivision in New Braunfels, Texas.

ILLUSTRATIONS

Approximate Location of Exploratory Borings

Cabins at Gruene Subdivision
New Braunfels
Comal County, Texas

TERRADYNE
Engineers Geologists & Environmental Scientists

TERRADYNE
AUSTIN, TEXAS

Prepared By: AMT	Scale: Not to Scale	Project # A151216
Base Plan By: HMT	Date: September 2015	Figure # 1

Terradyne AUS

LOG OF BORING # B-2

PROJECT: Preliminary - Cabins at Gruene Subdivision **DATE:** August 30, 2015

LOCATION: See Figure 1 **PROJECT #:** A151216

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	PP (tsf)	% Fines	Moisture Content (%)	THD (blows per foot)	Vertical Swell (%)	Liquid Limit (LL)	Plasticity Index (PI)	Water Content % (10, 30, 50, 70)
			SILT, hard, dry-moist, brown, (ML)								
		THD	LIMESTONE			08	53		46	13	
		THD					50/0" 50/0"				
5		A					50/0" 50/0"				
			End of Borehole								
10											
15											
20											

Completion Depth: Refusal at 6' Ground Water Observed: None Date:

THD - TxDOT Cone Penetrometer
PP - Pocket Penetrometer
RC - Rock Core

SS - Split Spoon Sample
ST - Shelby Tube Sample
A - Auger Sample

LL - Liquid Limit
PL - Plastic Limit
NP - Non-Plastic

Figure 3

Terradyne AUS

LOG OF BORING # B-3

PROJECT: Preliminary - Cabins at Gruene Subdivision **DATE:** August 30, 2015

LOCATION: See Figure 1 **PROJECT #:** A151216

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	PP (tsf)	% Fines	Moisture Content (%)	THD (blows per foot)	Vertical Swell (%)	Liquid Limit (LL)	Plasticity Index (PI)	Water Content % (10, 30, 50, 70)
		THD	ELASTIC SILT, hard, moist, brown, (MH)			12	39		63	30	
			LIMESTONE								
		THD					50/2" 50/0"				
5		A					50/0" 50/0"				
			End of Borehole								
10											
15											
20											

Completion Depth: Refusal at 7' Ground Water Observed: None Date:

THD - TxDOT Cone Penetrometer
PP - Pocket Penetrometer
RC - Rock Core

SS - Split Spoon Sample
ST - Shelby Tube Sample
A - Auger Sample

LL - Liquid Limit
PL - Plastic Limit
NP - Non-Plastic

Figure 4

Terradyne AUS

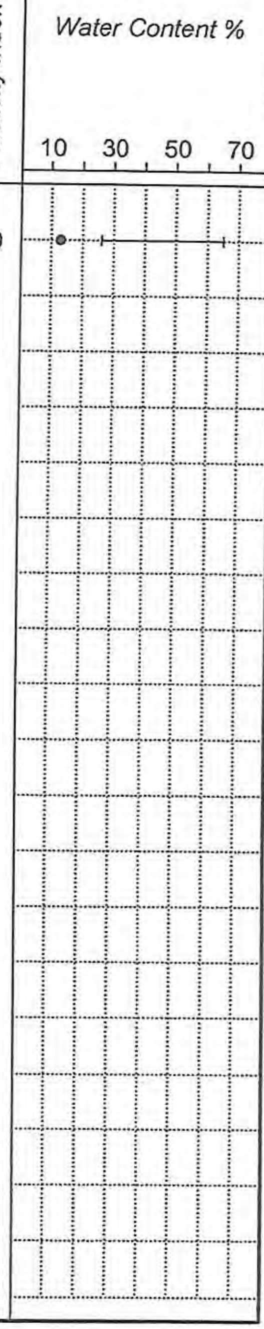
LOG OF BORING # B-4

PROJECT: Preliminary - Cabins at Gruene Subdivision **DATE:** August 30, 2015

LOCATION: See Figure 1 **PROJECT #:** A151216

SUBSURFACE PROFILE

DEPTH	SYMBOL	SAMPLES	SOIL DESCRIPTION Surf. Elev.	PP (tsf)	% Fines	Moisture Content (%)	THD (blows per foot)	Vertical Swell (%)	Liquid Limit (LL)	Plasticity Index (PI)
			FAT CLAY, hard, moist, brown, (CH)							
		THD	LIMESTONE			13	33		65	39
		THD					50/2" 50/0"			
5		A					50/0" 50/0"			
			End of Borehole							
10										
15										
20										



Completion Depth: Refusal at 6' Ground Water Observed: None Date:

THD - TxDOT Cone Penetrometer
PP - Pocket Penetrometer
RC - Rock Core

SS - Split Spoon Sample
ST - Shelby Tube Sample
A - Auger Sample

LL - Liquid Limit
PL - Plastic Limit
NP - Non-Plastic

Figure 5

InTEC

STANDARD REFERENCE NOTES FOR BORING LOGS

I. Sampling & Testing Symbols or Abbreviations:

ST	SS	RC	TC	A	SPT	PT
Shelby Tube	Split-Spoon Sampler	Rock core	Texas Cone	Auger	Standard Penetration Test	Percussion Tube

II. Correlations of Penetration Resistance to Soil Properties:

Relative Density of Sand and Sandy Silt		Consistency of Clay and Clayey Silt		
Relative Density	SPT N-value	Stiffness	SPT N-value (qualitative measure)	Unconfined Compressive Strength (tsf)
Very loose	0 to 4	Very soft	0 to 3	Under 0.25
Loose	5 to 10	Soft	4 or 5	0.25 – 0.5
Medium dense	11 to 30	Medium stiff	6 to 10	0.5 – 1.0
Dense	31 to 50	Stiff	11 to 15	1.0 – 2.0
Very Dense	> 50	Very stiff	16 to 30	2.0 – 4.0
		Hard	> 30	4.0 – 8.0

III. Unified Soil Classification Symbols:

GP - Poorly Graded Gravel
GW - Well Graded Gravel
GM - Silty Gravel
GC - Clayey Gravel
OH - High Plasticity Organics

SP - Poorly Graded Sand
SW - Well Graded Sand
SM - Silty Sand
SC - Clayey Sand
OL - Low Plasticity Organics

ML - Low Plasticity Silt
MH - High Plasticity Silt
CL - Low to Medium Plasticity Clay
CH - High Plasticity Clay

IV. Rock Quality Designation index (RQD):

RQD:	Description of Rock Quality: (if all natural fractures)
0-25 %	Very poor
25-50 %	Poor
50-75 %	Fair
75-90 %	Good
90-100%	Excellent

V. Natural moisture content:

"Dry" No apparent moisture, crumbles easily
"Moist" Damp but no visible water
"Wet" Visible water

VI. Grain size terminology:

Cobble: 3-inches to 12-inches
Gravel: #4 sieve size (4.75 mm) to 3-inches
Coarse sand: #10 to #4 sieve size
Medium sand: #40 to #10 sieve size
Fine sand: #200 to #40 sieve size
Silt or clay: smaller than #200 sieve size

VIII. Descriptive terms or symbols:

"Mottled": occasional/spotted presence of that color
"- [...]": identifies change in soil characteristics
LL: Liquid Limit (moisture content as % of dry weight)
PL: Plastic Limit (moisture content as % of dry weight)
WOH: Weight of hammer
"with [...]": item identified within that sample only
"REC": Rock core recovery %

VII. Descriptive terms for soil composition:

"Trace" . . . . 1 to 9%
"Some" . . . . 10 to 29%
(with suffix –y, e.g. sandy, clayey ...) . . . . 30 to 49%

IX. Plasticity of cohesive soil:

(function of PI and clay mineral types)

Plasticity Index (PI):	*Plasticity*:
0 to 20	Low
20 to 30	Medium
30 +	High

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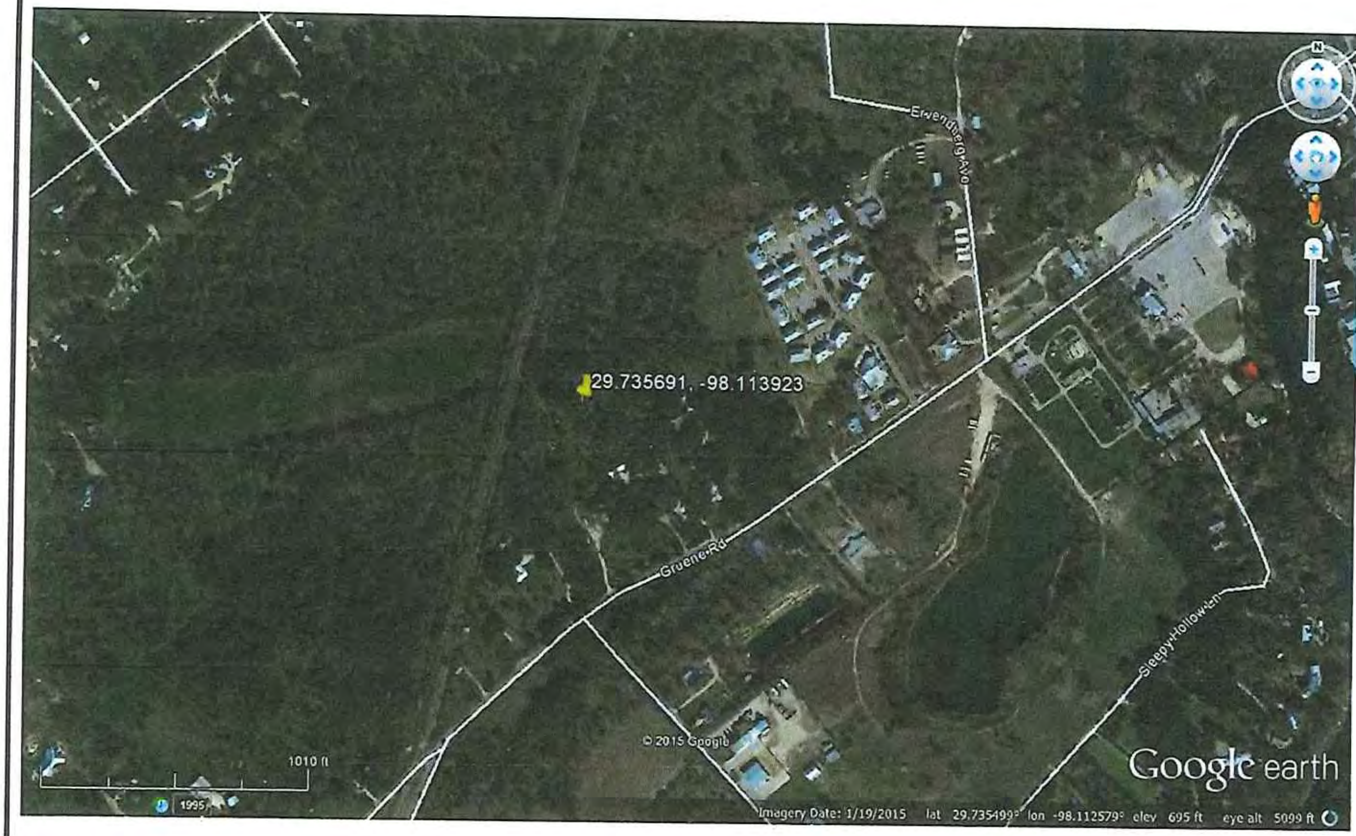

Site Latitude and Longitude Cabins at Gruene Subdivision New Braunfels Comal County, Texas	TERRADYNE Engineers Geologists & Environmental Scientists	TERRADYNE AUSTIN, TEXAS	
	Prepared By: AMT	Scale: See Scale Bar	Project # A151216
	Verified By:	Date: September 2015	Figure # 7