PAVEMENT DESIGN STUDY

FOR

WINDING CREEK RANCH UNITS 5 THROUGH 8 - PAVEMENTS
NEW BRAUNFELS, TEXAS

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Project No. ANA23-010-00
April 21, 2023

Ms. Leslie Ostrander
DR Horton
5419 North Loop 1604 East
San Antonio, Texas 78247

RE: Pavement Design Study
Winding Creek Ranch Units 5 through 8 – Pavements
New Braunfels, Texas

Dear Ms. Ostrander:

RABA KISTNER Inc. (RKI) is pleased to submit the report of our Pavement Design Study for the above-referenced project. This study was performed in accordance with RKI proposal PNA23-013-00, dated February 23, 2023. The purpose of this study was to drill borings within the proposed subdivision roadways, to perform laboratory testing to classify and characterize subsurface conditions, and to provide pavement design and construction guidelines.

The following report contains our design recommendations and considerations based on our current understanding of the project information provided to us. There may be alternatives for value engineering of the pavement systems, and RKI recommends that a meeting be held with the Owner and design team to evaluate these alternatives.

We appreciate the opportunity to be of service to you on this project. Should you have any questions about the information presented in this report, or if we may be of additional assistance with value engineering or on the materials testing-quality control program during construction, please call.

Very truly yours,

RABA KISTNER INC.

Ryan M. DeWees
Graduate Engineer

Isaac Molina, P.E.
Project Manager

STATE OF TEXAS
ISAAC MOLINA
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LICENSED
PROFESSIONAL ENGINEER

RMD/IM/mmd

Attachments

Copies Submitted: (1) Electronic

PAVEMENT DESIGN STUDY

For

WINDING CREEK RANCH UNITS 5 THROUGH 8 - PAVEMENTS
NEW BRAUNFELS, TEXAS

Prepared for

DR HORTON
San Antonio, Texas

Prepared by

RABA KISTNER, INC.
New Braunfels, Texas

PROJECT NO. ANA23-010-00

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TABLE OF CONTENTS

TABLE OF CONTENTS

ATTACHMENTS

The following figures are attached and complete this report:

INTRODUCTION

RABA KISTNER Inc. (RKI) has completed the authorized subsurface exploration for the proposed pavements for Units 5 through 8 in the Winding Creek Ranch Subdivision. This report briefly describes the procedures utilized during this study and presents our findings along with our recommendations for pavement design and construction guidelines.

PROJECT DESCRIPTION

To be considered in this study are the roadways within Units 5 through 8 of the Winding Creek Ranch subdivision in New Braunfels, Texas. The Winding Creek Ranch subdivision is located approximately 1/2 mile south of W. Klein Road on FM 1044.

The roadways will be designed using guidance from the City of San Antonio Pavement Design Guidance Manual. It is our understanding that proposed roadway classifications include Local Type A Streets (with and without bus traffic), Local Type B Streets, and Collectors.

LIMITATIONS

This engineering report has been prepared in accordance with accepted Geotechnical Engineering practices in the region of south/central Texas and for the use of DR Horton (CLIENT) and its representatives for design purposes. This report may not contain sufficient information for purposes of other parties or other uses. This report is not intended for use in determining construction means and methods.

The recommendations submitted in this report are based on the data obtained from 13 borings drilled within the proposed roadways and our understanding of the project information provided to us. If the project information described in this report is incorrect, is altered, or if new information is available, we should be retained to review and modify our recommendations.

This report may not reflect the actual variations of the subsurface conditions across the site. The nature and extent of variations across the site may not become evident until construction commences. The construction process itself may also alter subsurface conditions. If variations appear evident at the time of construction, it may be necessary to reevaluate our recommendations after performing on-site observations and tests to establish the engineering impact of the variations.

The scope of our Geotechnical Engineering Study does not include an environmental assessment of the air, soil, rock, or water conditions either on or adjacent to the site. No environmental opinions are presented in this report.

BORINGS AND LABORATORY TESTS

Subsurface conditions at the site were evaluated by 13 borings drilled along the proposed roadways at the locations shown on the Boring Location Map, Figure 1. These locations are approximate and distances were measured using a recreational-grade, hand-held GPS locator. The borings were drilled to an approximate depth of 10 ft below the existing ground surface using a truck-mounted drilling rig. During drilling operations, split-spoon (with standard penetration test (SPT)) and auger grab samples were collected.

Each sample was visually classified in the laboratory by a member of our Geotechnical Engineering staff. The geotechnical engineering index properties of the strata were evaluated by moisture content, Atterberg limits testing, as well as grain size analyses.

The laboratory test results are presented in graphical or numerical form on the boring logs illustrated on Figures 2 through 14. A key to classification terms and symbols used on the logs is presented on Figure 15. The results of the laboratory and field testing are also tabulated on Figure 16 for ease of reference.

SPT results are noted as “blows per ft” on the boring logs and Figure 16, where “blows per ft” refers to the number of blows by a falling hammer required for 1 ft of penetration into the soil/weak rock (N-value). Where hard or dense materials were encountered, the tests were terminated at 50 blows even if one foot of penetration had not been achieved.

In addition to the above listed testing and sampling, a bulk samples of anticipated subgrade soils near Boring B-2 and B-11 were collected for use in the CBR ,PI-Lime Series, pH-lime series, sulfate content tests, and lime series stabilization testing. The results of the moisture-density relationship, pH-lime series, and PI-lime series tests are presented in Figures 17, 18, and 19, respectively. The results of the pH-lime series test indicated that a 6% lime addition increased the pH to 12.4. Sulfate testing was conducted on 13 samples taken during our field study. The sulfate results along with the results of the soil lime testing are discussed in the *Pavement Recommendations* section of this report. DCP field testing was conducted at/adjacent to all boring locations and the results of that testing are presented in Figure 20.

Samples will be retained in our laboratory for 30 days after submittal of this report. Other arrangements may be provided at the request of the Client.

FINDINGS AND TEST RESULTS

GEOLOGY

A review of the *Geologic Atlas of Texas, San Antonio Sheet*, indicates that this site is naturally underlain with the soils/rock of the Pecan Gap Chalk. This formation mainly consists of chalk and chalky marl. Light yellow to yellowish brown in color. The Pecan Gap Chalk weathers to form moderately deep soil that typically consists of clays, marly clays, and marl grading to chalk at depth. Exogyra ponderosa fossils are common. Thin seams of bentonite and/or bentonitic clays are also often encountered in this formation. Because such seams are typically thin and random, they are often difficult to locate and identify with standard geotechnical sampling methods and sampling intervals. Key geotechnical engineering concerns for development supported on this formation are expansive, soil-related movement.

STRATIGRAPHY

The natural subsurface stratigraphy at this site can generally be described as surficial dark brown clays overlying tan and gray clays. Each stratum has been designated by grouping soils that possess similar physical and engineering characteristics. The boring logs should be consulted for more specific stratigraphic information. Unless noted on the boring logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials may be gradual or may occur between recovered samples. The stratification given on the boring logs, or described herein, is for use by RKI in its analyses and should not be used as the basis of design or construction cost estimates without realizing that there can be variation from that shown or described. The boring logs and related information depict subsurface conditions only at the specific location and time where sampling was conducted. The passage of time may result in changes in conditions, interpreted to exist, at or between the locations where sampling was conducted.

GROUNDWATER

Groundwater was not observed in the borings either during or immediately upon completion of the drilling operations. However, it is possible for groundwater to exist beneath this site at shallow depths on a transient basis, particularly following periods of precipitation. Fluctuations in groundwater levels occur due to variation in rainfall and surface water run-off. The construction process itself may also cause variations in the groundwater level.

PAVEMENT RECOMMENDATIONS

SWELL/HEAVE POTENTIAL

The subgrade soils at this site are classified as plastic to highly plastic, and the potential exists for the soils to expand or heave when water is introduced, causing the pavement to become rough or uneven over time. Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also fuel consumption as well as vehicle maintenance costs. Pavement heave can be reduced through various measures but cannot be totally eliminated without full removal of the problematic soil. Measures available for reducing heave include:

- Soil Treatment with Lime or Other Chemicals
- Removal and Replacement of Moderate to High PI Soils
- Drains or Barriers to Collect or Inhibit Moisture Infiltration

Soil treatment with lime (or other chemicals) is typically used to reduce the swelling potential of the upper portion of the pavement subgrade containing plastic soils. Lime and water are mixed with the top 6 to 12 inches (or possibly more) of the subgrade and allowed to mellow or cure for a period of time. After mellowing, the soil-lime mixture is compacted to form a relatively strong soil matrix that can improve pavement performance and potentially reduce soil heave. However, the chemical reaction between the calcium-based additives and the sulfates and/or sulfide minerals in the soil can create a heaving problem on the pavement. If the soil soluble sulfate content exceeds 3,000 ppm, the use of calcium-based additives to treat the soils will need to be reconsidered. Sulfate testing was conducted on 13 samples taken from bulk samples or auger cuttings during drilling operations, the table below summarizes the results of that testing.

Sulfate Content Results		
Boring	**Depth (ft)[1]**	**Sulfate Content (ppm)**
B-1	2.5 - 4	100 or Less
B-2	0 - 2	100 or Less
B-3	0 – 1.5	100 or Less
B-4	0 – 1.5	100 or Less
B-5	0 – 1.5	100 or Less
B-6	2.5 - 4	360
B-7	5 - 6	100 or Less
B-8	0 – 1.5	100 or Less
B-9	2.5 - 4	560
B-10	0 – 1.5	100 or Less
B-11	0 - 2	100 or Less
B-12	0 – 1.5	100 or Less
B-13	0 – 1.5	100 or Less

[1]From existing surface at time of study.

Furthermore, in highly plastic soils, lime treatment of only the top portion of the expansive subgrade may not provide an acceptable reduction in PVR. For a more substantial reduction in PVR, removal and replacement or treatment of the high plasticity index (PI) soil may be the only method available to reduce the potential vertical rise of the pavement to an acceptable level. As stated previously though, it must be recognized that partial removal of expansive clay soil only reduces the potential (or risk) of the damage swell can cause to a pavement and does not completely eliminate this risk.

In addition, capturing water infiltration via French drains, pavement edge drains, or horizontal/vertical moisture barriers would reduce the potential for heave since one important component of the heaving mechanism, water, would be reduced. Geogrid is also another tool available that may help reduce the damage that heaving subgrades cause to flexible pavements and may be considered in addition to or as an alternative to other mitigation techniques.

It should be noted that the pavement sections recommended in subsequent sections of this report are structurally adequate for the given traffic levels and subgrade strength, but do not consider the long-term effects of pavement roughness due to heave, which can only be addressed by the measures discussed in this section.

DESIGN PARAMETERS

The proposed roadways were evaluated in general accordance with the City of San Antonio's Design Guidance Manual. We understand that the proposed roadways will be classified as Local A with and without Bus Traffic, Local B, and Collector. Based on information provided by the City of San Antonio, we understand that the following design parameters are required for use in the design of pavement sections for this street classification:

City of San Antonio Design Parameters		
Pavement Design Parameters	Design Input	
	Flexible Pavement	Rigid Pavement
18-kip ESALs Local A without Bus Traffic Local A with Bus Traffic Local B Collector	 100,000 1,000,000 2,000,000 2,000,000	 150,000 1,500,000 3,000,000 3,000,000
CBR	3.0[(1)]	
Initial Serviceability Index	4.2	4.5
Terminal Serviceability Index Local A with and without Bus Traffic Local B Collector	 2.0 2.0 2.5	
Overall Standard Deviation	0.45	0.35
Reliability Local A with and without Bus Traffic Local B and Collector	 70% 90%	
Modulus of Subgrade reaction (k-value)	-	300 pci
28-day Concrete Modulus of Rupture	-	600 psi
28-day Concrete Elastic Modulus	-	4,000,000 psi
Load Transfer Coefficient Local A without Bus Traffic Local A with Bus Traffic Local B Collector	-	 3.7[(2)] 3.7[(2)] 2.9[(3)] 2.9[(3)]
Drainage Coefficient	-	1.02
Roadbed Soil Resilient Modulus	4,500[(1)]	-
Minimum Asphalt Pavement Structural Number Local A without Bus Traffic Local A with Bus Traffic Local B and Collector	 2.02 2.58 2.92	-
Maximum Asphalt Pavement Structural Number Local A without Bus Traffic Local A with Bus Traffic Local B and Collector	 3.18 4.20 5.08	-
Minimum Rigid Pavement Thickness Local A without Bus Traffic Local A with Bus Traffic Local B and Collector	-	 5.0 6.0 7.0
Maximum Rigid Pavement Thickness Local A without Bus Traffic Local A with Bus Traffic Local B and Collector	-	 6.0 8.0 9.0

(1)The design CBR and corresponding Soil Resilient Modulus values were estimated based on the DCP results, laboratory CBR results, and experience with similar soils in the area.
(2)Assumes the use of Jointed Plain Concrete Pavement (JPCP) without load transfer devices and with tied shoulders, curbs, and/or gutters

(3)Assumes the use of JPCP with load transfer devices or Continuously Reinforced Concrete Pavement (CRCP) with tied shoulders, curbs, and/or gutters

The required structural number (SN) is related to the CBR value of the pavement subgrade and the amount of traffic that the pavement will carry over its service life. The required structural number for flexible pavement design was calculated to be 2.48, 3.53, 4.36, and 4.66 for Local A without Bus Traffic, Local A with Bus Traffic, Local B, and Collector Streets, respectively. The CBR provides an estimate of the relative strength of the subgrade and consequently indicates the ability of the pavement section to carry load. If clay soils are imported for the purpose of constructing the roadbed then imported materials must be selected that have a CBR value of at least 3.0. If lower quality clay fill materials are utilized, the pavement sections will have to be increased based on the quality (tested CBR value) of the clays imported. The selected design CBR value was utilized in conjunction with the above specified parameters to determine the required SN for use in the design of the pavement section.

Concrete slab support is characterized by the k-value (modulus of subgrade/subbase reaction). The selected k-value for the subgrade material at this site was estimated based our experience with similar soils, the DCP results, and laboratory CBR results. The k-value for the subbase material was selected based on the *City of San Antonio's Design Guidance Manual* recommended subbase layer options for rigid pavement design.

We recommend that subgrade soils with a plasticity index (PI) greater than 20 be treated with lime or other proven methods of treatment to reduce the PI of the soil to less than 20. **Based on the results of our Atterberg limits testing performed in the upper 5 ft of our borings, the PI values of the subgrade materials are generally above 20.**

PAVEMENT SECTIONS

Recommendations for new pavements are presented in this section of the report. These pavement section options apply for the street classifications listed in the following table. Soil lime testing (Tex-121-E) was conducted on a bulk samples from an areas near Borings B-2 and B-11. The testing showed that at a 6 percent lime mixture would yield a PI of at most 14, a pH of at least 12.4, and a compressive strength of at least 68 psi. These results meet or exceed the standards of the City of San Antonio to qualify for structural credit. Utilizing the design SN values and minimum layer thicknesses, optional pavement sections are presented in the following tables.

Street Classification	Options	Layer Description	Layer Thickness[1]	Recommended SN Coeff.	SN Extension
Local A without Bus Traffic	**Rigid Pavement Option 1**	Concrete[2] HMA Bond Breaker Cement Treated Base Lime Treated Subgrade **Combined Total**	5.0 in. 1.0 in. 6.0 in. 6.0 in. **18.0 in.**	-	-
	Rigid Pavement Option 2	Concrete[2] HMA Bond Breaker Cement Treated Base Compacted Low PI Material **Combined Total**	5.0 in. 1.0 in. 6.0 in. 6.0 in. **18.0 in.**	-	-
	Rigid Pavement Option 3	Concrete[2] HMA Type B Base Course Lime Treated Subgrade **Combined Total**	5.0 in. 4.0 in. 6.0 in. **15.0 in.**	-	-
	Flexible Base Option	HMA Type C or D Surface Course Flexible (Granular) Base Lime Treated Subgrade **Combined Total**	2.0 in. 8.0 in. 6.0 in. **16.0 in.**	0.44 0.14 0.08	0.88 1.12 0.48 **2.48**
	Flexible Base Option w/o Treated Subgrade	HMA Type C or D Surface Course Flexible (Granular) Base Compacted Low PI Material **Combined Total**	2.0 in. 12.0 in. 6.0 in. **20.0 in.**	0.44 0.14 0.00	0.88 1.68 0.00 **2.56**
	Mechanically Stabilized Option	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Lime Treated Subgrade **Combined Total**	2.0 in. 6.0 in. N/A 8.0 in. **16.0 in.**	0.44 0.17 N/A 0.08	0.88 1.02 N/A 0.64 **2.54**
	Mechanically Stabilized Option w/o treated subgrade	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Compacted Low PI Material **Combined Total**	2.0 in. 10.0 in. N/A 6.0 in. **18.0 in.**	0.44 0.17 N/A 0.00	0.88 1.70 N/A 0.00 **2.58**
	Full Depth Asphalt Option	HMA Type C or D Surface Course HMA Type B Base Course Lime Treated Subgrade **Combined Total**	2.0 in. 3.0 in. 6.0 in. **11.0 in.**	0.44 0.38 0.08	0.88 1.14 0.48 **2.50**
	Full Depth Asphalt Option w/o Treated Subgrade	HMA Type C or D Surface Course HMA Type B Base Course Compacted Low PI Material **Combined Total**	2.5 in. 4.0 in. 6.0 in. **12.5 in.**	0.44 0.38 0.00	1.10 1.52 0.00 **2.62**

(1)Alternative layer thicknesses are available and can be provided upon request.
(2)Concrete pavement should consist of JPCP.

Street Classification	Options	Layer Description	Layer Thickness[1]	Recommended SN Coeff.	SN Extension
Local A with Bus Traffic	**Rigid Pavement Option 1**	Concrete[2] HMA Bond Breaker Cement Treated Base Lime Treated Subgrade **Combined Total**	7.0 in. 1.0 in. 6.0 in. 6.0 in. **20.0 in.**	-	-
	Rigid Pavement Option 2	Concrete[2] HMA Bond Breaker Cement Treated Base Compacted Low PI Material **Combined Total**	7.0 in. 1.0 in. 6.0 in. 6.0 in. **20.0 in.**	-	-
	Rigid Pavement Option 3	Concrete[2] HMA Type B Base Course Lime Treated Subgrade **Combined Total**	7.0 in. 4.0 in. 6.0 in. **17.0 in.**	-	-
	Flexible Base Option	HMA Type C or D Surface Course Flexible (Granular) Base Lime Treated Subgrade **Combined Total**	3.0 in. 9.0 in. 12.0 in. **24.0 in.**	0.44 0.14 0.08	1.32 1.26 0.96 **3.54**
	Flexible Base Option w/o Treated Subgrade	HMA Type C or D Surface Course Flexible (Granular) Base Compacted Low PI Material **Combined Total**	5.0 in. 10.0 in. 6.0 in. **21.0 in.**	0.44 0.14 0.00	2.20 1.40 0.00 **3.60**
	Mechanically Stabilized Option	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Lime Treated Subgrade **Combined Total**	4.0 in. 6.0 in. N/A 10.0 in. **20.0 in.**	0.44 0.17 N/A 0.08	1.76 1.02 N/A 0.80 **3.58**
	Mechanically Stabilized Option w/o Treated Subgrade	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Compacted Low PI Material **Combined Total**	5.0 in. 8.0 in. N/A 6.0 in. **19.0 in.**	0.44 0.17 N/A 0.00	2.20 1.36 N/A 0.00 **3.56**
	Full Depth Asphalt Option	HMA Type C or D Surface Course HMA Type B Base Course Lime Treated Subgrade **Combined Total**	4.0 in. 4.0 in. 6.0 in. **14.0 in.**	0.44 0.38 0.08	1.76 1.52 0.48 **3.76**
	Full Depth Asphalt Option w/o Treated Subgrade	HMA Type C or D Surface Course HMA Type B Base Course Compacted Low PI Material **Combined Total**	4.0 in. 5.0 in. 6.0 in. **15.0 in.**	0.44 0.38 0.00	1.76 1.90 0.00 **3.66**

[1]Alternative layer thicknesses are available and can be provided upon request.
[2]Concrete pavement should consist of JPCP.

Street Classification	Options	Layer Description	Layer Thickness[1]	Recommended SN Coeff.	SN Extension
Local B	**Rigid Pavement Option 1**	Concrete[2] HMA Bond Breaker Cement Treated Base Lime Treated Subgrade **Combined Total**	7.5 in. 1.0 in. 6.0 in. 6.0 in. **20.5 in.**	-	-
	Rigid Pavement Option 2	Concrete[2] HMA Bond Breaker Cement Treated Base Compacted Low PI Material **Combined Total**	7.5 in. 1.0 in. 6.0 in. 6.0 in. **20.5 in.**	-	-
	Rigid Pavement Option 3	Concrete[2] HMA Type B Base Course Lime Treated Subgrade **Combined Total**	7.5 in. 4.0 in. 6.0 in. **17.5 in.**	-	-
	Flexible Base Option	HMA Type C or D Surface Course Flexible (Granular) Base Lime Treated Subgrade **Combined Total**	5.0 in. 10.0 in. 10.0 in. **25.0 in.**	0.44 0.14 0.08	2.20 1.40 0.80 **4.40**
	Flexible Base Option w/o Treated Subgrade	HMA Type C or D Surface Course Flexible (Granular) Base Compacted Low PI Material **Combined Total**	6.0 in. 13.0 in. 6.0 in. **25.0 in.**	0.44 0.14 0.00	2.64 1.82 0.00 **4.46**
	Mechanically Stabilized Option	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Lime Treated Subgrade **Combined Total**	5.0 in. 8.0 in. N/A 10.0 in. **23.0 in.**	0.44 0.17 N/A 0.08	2.20 1.36 N/A 0.80 **4.36**
	Mechanically Stabilized Option w/o Treated Subgrade	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Compacted Low PI Material **Combined Total**	6.0 in. 11.0 in. N/A 6.0 in. **23.0 in.**	0.44 0.17 N/A 0.00	2.64 1.87 N/A 0.00 **4.51**
	Full Depth Asphalt Option	HMA Type C or D Surface Course HMA Type B Base Course Lime Treated Subgrade **Combined Total**	4.0 in. 5.0 in. 9.0 in. **18.0 in.**	0.44 0.38 0.08	1.76 1.90 0.72 **4.38**
	Full Depth Asphalt Option w/o Treated Subgrade	HMA Type C or D Surface Course HMA Type B Base Course Compacted Low PI Material **Combined Total**	5.0 in. 6.0 in. 6.0 in. **17.0 in.**	0.44 0.38 0.00	2.20 2.28 0.00 **4.48**

[1]Alternative layer thicknesses are available and can be provided upon request.
[2]Concrete pavement should consist of CRCP, or JPCP with load transfer devices at control joints.

Street Classification	Options	Layer Description	Layer Thickness[1]	Recommended SN Coeff.	SN Extension
Collector	**Rigid Pavement Option 1**	Concrete[2] HMA Bond Breaker Cement Treated Base Lime Treated Subgrade **Combined Total**	8.0 in. 1.0 in. 6.0 in. 6.0 in. **21.0 in.**	-	-
	Rigid Pavement Option 2	Concrete[2] HMA Bond Breaker Cement Treated Base Compacted Low PI Material **Combined Total**	8.0 in. 1.0 in. 6.0 in. 6.0 in. **21.0 in.**	-	-
	Rigid Pavement Option 3	Concrete[2] HMA Type B Base Course Lime Treated Subgrade **Combined Total**	8.0 in. 4.0 in. 6.0 in. **18.0 in.**	-	-
	Flexible Base Option	HMA Type C or D Surface Course Flexible (Granular) Base Lime Treated Subgrade **Combined Total**	7.0 in. 7.0 in. 8.0 in. **22.0 in.**	0.44 0.14 0.08	3.08 0.98 0.64 **4.70**
	Flexible Base Option w/o Treated Subgrade	HMA Type C or D Surface Course Flexible (Granular) Base Compacted Low PI Material **Combined Total**	7.0 in. 12.0 in. 6.0 in. **25.0 in.**	0.44 0.14 0.00	3.08 1.68 0.00 **4.76**
	Mechanically Stabilized Option	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Lime Treated Subgrade **Combined Total**	7.0 in. 6.0 in. N/A 7.0 in. **20.0 in.**	0.44 0.17 N/A 0.08	3.08 1.02 N/A 0.56 **4.66**
	Mechanically Stabilized Option w/o Treated Subgrade	HMA Type C or D Surface Course Mechanically Stabilized Flexible Base XXXXX Geogrid XXXXX Compacted Low PI Material **Combined Total**	7.0 in. 10.0 in. N/A 6.0 in. **23.0 in.**	0.44 0.17 N/A 0.00	3.08 1.70 N/A 0.00 **4.78**
	Full Depth Asphalt Option	HMA Type C or D Surface Course HMA Type B Base Course Lime Treated Subgrade **Combined Total**	5.0 in. 5.0 in. 7.0 in. **17.0 in.**	0.44 0.38 0.08	2.20 1.90 0.56 **4.66**
	Full Depth Asphalt Option w/o Treated Subgrade	HMA Type C or D Surface Course HMA Type B Base Course Compacted Low PI Material **Combined Total**	5.0 in. 7.0 in. 6.0 in. **18.0 in.**	0.44 0.38 0.00	2.20 2.66 0.00 **4.86**

(1)Alternative layer thicknesses are available and can be provided upon request.
(2)Concrete pavement should consist of CRCP, or JPCP with load transfer devices at control joints.

PAVEMENT CONSTRUCTION CONSIDERATIONS

SITE PREPARATION

The roadways and all areas to support fill should be stripped of all vegetation, organic topsoil, and rootmass. Exposed subgrades should be thoroughly proofrolled in order to locate and densify any weak, compressible zones. A fully-loaded dump truck or a similar heavily-loaded piece of construction equipment should be used for planning purposes. Proofrolling operations should be observed by the Geotechnical Engineer or his representative to document subgrade condition and preparation. Weak or soft areas identified during proofrolling should be removed and replaced with a suitable, compacted backfill.

After completion of the proofrolling operations and just prior to treated or flexible base placement, the exposed subgrade should be moisture conditioned by scarifying to a minimum depth of 6 in. and recompacting to a minimum of 95 percent of the maximum density determined from the Texas Department of Transportation Compaction Test (TxDOT, Tex-114-E). The moisture content of the subgrade should be maintained within the range of optimum moisture content to 3 percentage points above optimum until permanently covered.

DRAINAGE CONSIDERATIONS

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

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

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

ON-SITE SOIL FILL

As discussed previously, the pavement recommendations presented in this report were prepared assuming that on-site soils will be used for fill grading in proposed pavement areas. If used, we recommend that on-site soils be placed in loose lifts not exceeding 8 in. in thickness and compacted to at least 95 percent of the maximum density as determined by TxDOT, Tex-114-E. The moisture content of the fill should be maintained within the range of optimum water content to 3 percentage points above the optimum water content until permanently covered. We recommend that fill materials be free of roots and other organic or degradable material. We also recommend that the maximum particle size not exceed 4 in. or one half the lift thickness, whichever is smaller.

TREATMENT OF SUBGRADE

Lime or cement treatment of the subgrade soils, if utilized, should be in accordance with the TxDOT Standard Specifications, Item 260 or Item 275, respectively. A sufficient quantity of hydrated lime should be mixed with the subgrade soils to reduce the soil plasticity index to 20 or less. Based on the results of the pH-lime series and soil lime testing, we recommend that at least 6 percent hydrated lime treatment by weight be used, which decreased the soil subgrade plasticity index to 14 in our laboratory test. Based on the results of the CBR tests performed on the subgrade soils, we estimate a total density of approximately 98 pcf for the natural subgrade soil. For construction purposes, we recommend that the optimum cement content of the subgrade soils be determined by laboratory testing with representative samples of the subgrade materials being used for this project. Treated subgrade soils should be compacted to a minimum of 95 percent of the maximum density at a moisture content within the range of optimum moisture content to 3 percentage points above the optimum moisture content as determined by Tex-113-E.

PRIME COAT

A prime coat should be placed on top of any compacted base course and should be a MC-30 or AE-P conforming to TxDOT Standard Specifications 2014, Item 300 – Asphalts, Oils or Emulsions. Prime coat application rates are generally dependent upon the absorption rate of the granular base and other environmental conditions at the time of placement. For construction, the application rate shall not exceed 0.2 gal/yd^2.

TACK COAT

A tack coat should be placed between asphaltic concrete base and/or surface lifts and should be a PG binder with a minimum high-temperature grade of PG 58, SS-1H, CSS-1H, or EAP&T conforming to the TxDOT Standard Specifications 2014, Item 300 – Asphalts, Oils or Emulsions. For construction, the application rate shall not exceed 0.1 gal/yd^2.

FLEXIBLE BASE COURSE

The flexible base course should be crushed limestone conforming to TxDOT 2014 Standard Specifications, Item 247, Type A, Grade 1-2. The base course should be placed in lifts with a maximum compacted thickness of 8 in. (10 in. loose) and compacted to a minimum of 95 percent of maximum dry density as determined by TxDOT Tex-113-E Compaction Test. The moisture content of the material should be maintained within the range of 2 percentage points below to 2 percentage points above the optimum moisture content until final compaction.

CEMENT TREATED BASE COURSE

The cement treated base course should conform to TxDOT 2014 Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, Item 275 or 276. For estimating purposes we estimate a total density of approximately 145 pcf for cement treated base material. In our experience, cement percentages typically range from 2 to 5 percent, but should be verified with laboratory testing. For estimating purposes we estimate 5% cement be included. We recommend microcracking be performed approximately 1 - 3 days after placement.

ASPHALTIC CONCRETE SURFACE AND/OR BINDER COURSES

The asphaltic concrete surface and/or binder courses should conform to TxDOT Standard Specifications 2014, 341 – Dense Graded Hot-Mix Asphalt, Types C or D, and Type B for the base, if the full depth asphalt section is selected for construction. Recycled asphalt pavement (RAP) should be limited to 20 percent of the total weight of the mix for Types C and D mixes, and 30 percent for Type B mixes. Higher percentages of RAP may be permissible depending on the material source. If higher percentages of RAP are desired, contact RKI for consideration. Asphalt cement grades should conform to the table shown below.

<table>
<tr><th rowspan="2">Street Classification</th><th colspan="3">Minimum PG Asphalt Cement Grade</th></tr>
<tr><th>Surface Courses</th><th>Binder & Level Up Courses</th><th>Base Courses</th></tr>
<tr><td>Collector and Local Type B Streets</td><td rowspan="2">PG 70-22</td><td>PG 70-22</td><td rowspan="3">PG 64-22</td></tr>
<tr><td>Local Type A Street with Bus Traffic</td><td rowspan="2">PG64-22</td></tr>
<tr><td>Local Type A Street without Bus Traffic</td><td>PG 64-22</td></tr>
</table>

The asphaltic concrete should be compacted on the roadway to contain from 5 to 9 percent air voids computed using the maximum theoretical specific gravity (Rice) of the mixture determined according to Test Method Tex-227-F. Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method Tex-207-F. The nuclear-density gauge or other methods which correlate satisfactorily with results obtained from project roadway specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required roadway specimens at their expense and in a manner and at locations selected by the Engineer.

It is recommended that the hot mix asphalt concrete pavement be placed with a paving machine only and not with a motor grader unless prior approval is granted by the Engineer for special circumstances.

HOT-MIX ASPHALT BOND BREAKER

The hot-mix asphalt bond breaker should be in accordance with the TxDOT 2014 Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, Item 340, Dense-Graded Hot-Mix Asphalt (Small Quantity), Type D, a Performance Graded Binder 76-22 (PG-76-22), and designed with a laboratory density target of 97.5 percent.

PORTLAND CEMENT CONCRETE

The Portland cement concrete should be in accordance with Class P concrete of the TxDOT 2014 Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, Item 421, Portland Cement Concrete. Requirements include concrete designed to meet a minimum average compressive strength of 3,500 psi at 7-days or a minimum average compressive strength of 4,400 psi at 28-days in accordance with TxDOT standard laboratory test procedure Tex-448-A or Tex-418-A. Liquid membrane-forming curing compound should be applied as soon as practical after broom finishing the concrete surface. The curing compound will help reduce the loss of water from the concrete. The reduction in the rapid loss in water will help reduce shrinkage cracking of the concrete.

MISCELLANEOUS PAVEMENT RELATED CONSIDERATIONS

Longitudinal Cracking

It should be understood that asphalt pavement sections in highly expansive soil environments, can develop longitudinal cracking along unprotected pavement edges. In the semi-arid climate of south central Texas this condition typically occurs along the unprotected edges of pavements where moisture fluctuation is allowed to occur over the lifetime of the pavements.

Pavements that do not have a protective barrier to reduce moisture fluctuation of the highly expansive clay subgrade between the exposed pavement edge and that beneath the pavement section tend to develop longitudinal cracks 1 to 4 ft from the edge of the pavement. Once these cracks develop, further degradation and weakening of the underlying granular base may occur due to water seepage through the cracks. The occurrence of these cracks can be more prevalent in the absence of lateral restraint and embankments. This problem can best be addressed by providing either a horizontal or vertical moisture barrier at the unprotected pavement edge.

At a minimum, we recommend that the curbs are constructed such that the depth of the curb extends through the entire depth of the granular base material and into the subgrade to act as a protective barrier against the infiltration of water into the granular base.

In most cases, a longitudinal crack does not immediately compromise the structural integrity of the pavement system. However, if left unattended, infiltration of surface water runoff into the crack will result in isolated saturation of the underlying base. This will result in pumping of the flexible base, which could lead to rutting, cracking, and pot-holes. For this reason, we recommend that the owner of the facility immediately seal the cracks and develop a periodic sealing program.

Utilities

Our experience indicates that significant settlement of backfill can occur in utility trenches, particularly when trenches are deep, when backfill materials are placed in thick lifts with insufficient compaction, and when water can access and infiltrate the trench backfill materials. The potential for water to access the backfill is increased where water can infiltrate flexible base materials due to insufficient penetration of curbs, and at sites where geological features can influence water migration into utility trenches. It is our belief that another factor which can significantly impact settlement is the migration of fines within the backfill into the open voids in the underlying free-draining bedding material.

To reduce the potential for settlement in utility trenches, we recommend that consideration be given to the following:

- All backfill materials should be placed and compacted in controlled lifts appropriate for the type of backfill and the type of compaction equipment being utilized and all backfilling procedures should be tested and documented.
- Consideration should be given to wrapping free-draining bedding gravels with a geotextile fabric (similar to Mirafi 140N) to reduce the infiltration and loss of fines from backfill material into the interstitial voids in bedding materials.

Pavement Maintenance

Regular pavement maintenance is critical in maintaining pavement performance over a period of several years. All cracks that develop in asphalt pavements should be regularly sealed. Areas of moderate to severe fatigue cracking (also known as alligator cracking) should be sawcut and removed. The underlying base should be checked for contamination or loss of support and any insufficiencies fixed or removed and the entire area patched. All cracks that develop in concrete pavements should be routed and sealed regularly. Joints in concrete pavements should be maintained to reduce the influx of incompressible materials that restrain joint movement and cause spalling and/or cracking. Other typical TxDOT or City of San Antonio maintenance techniques should be followed as required.

Construction Traffic

Construction traffic on prepared subgrade and base layers should be restricted as much as possible until the protective surface pavement is applied. Significant damage to the underlying layers resulting in weakening may occur if heavily loaded vehicles are allowed to use these areas.

CONSTRUCTION RELATED SERVICES

CONSTRUCTION MATERIALS TESTING AND OBSERVATION SERVICES

As presented in the attachment to this report, *Important Information About Your Geotechnical Engineering Report*, subsurface conditions can vary across a project site. The conditions described in this report are based on interpolations derived from a limited number of data points. Variations will be encountered during construction, and only the geotechnical design engineer will be able to determine if these conditions are different than those assumed for design.

Construction problems resulting from variations or anomalies in subsurface conditions are among the most prevalent on construction projects and often lead to delays, changes, cost overruns, and disputes. These variations and anomalies can best be addressed if the geotechnical engineer of record, RKI is retained to perform construction observation and testing services during the construction of the project. This is because:

- RKI has an intimate understanding of the geotechnical engineering report's findings and recommendations. RKI understands how the report should be interpreted and can provide such interpretations on site, on the client's behalf.
- RKI knows what subsurface conditions are anticipated at the site.
- RKI is familiar with the goals of the owner and project design professionals, having worked with them in the development of the geotechnical workscope. This enables RKI to suggest remedial measures (when needed) which help meet the owner's and the design teams' requirements.
- RKI has a vested interest in client satisfaction, and thus assigns qualified personnel whose principal concern is client satisfaction. This concern is exhibited by the manner in which contractors' work is tested, evaluated and reported, and in selection of alternative approaches when such may become necessary.
- RKI cannot be held accountable for problems which result due to misinterpretation of our findings or recommendations when we are not on hand to provide the interpretation which is required.

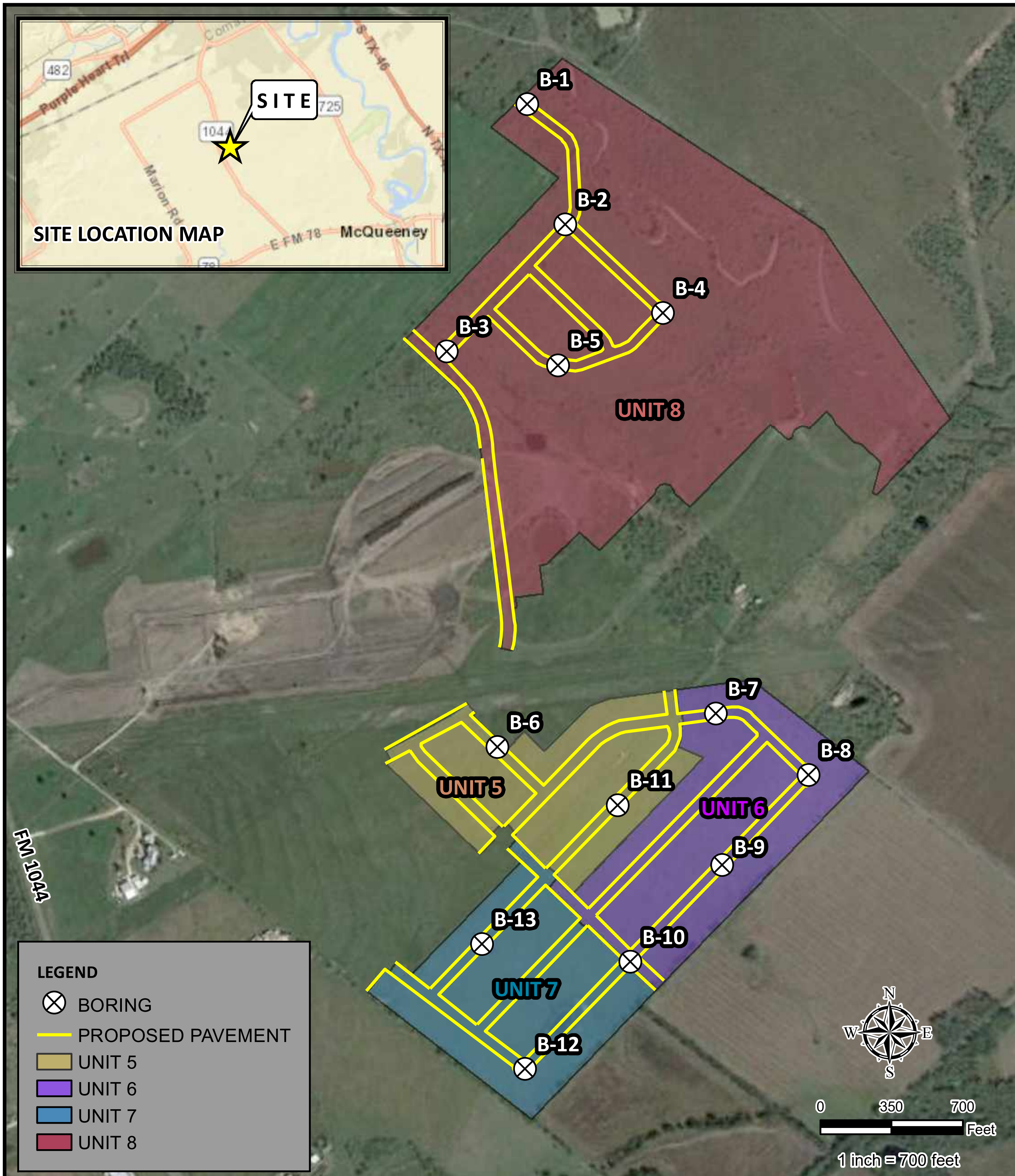
BUDGETING FOR CONSTRUCTION TESTING

Appropriate budgets need to be developed for the required construction testing and observation activities. At the appropriate time before construction, we advise that RKI and the project designers meet and jointly develop the testing budgets, as well as review the testing specifications as it pertains to this project.

Once the construction testing budget and scope of work are finalized, we encourage a preconstruction meeting with the selected contractor to review the scope of work to make sure it is consistent with the construction means and methods proposed by the contractor. RKI looks forward to the opportunity to provide continued support on this project, and would welcome the opportunity to meet with the Project Team to develop both a scope and budget for these services.

* * * * * * * * * * * * * * * * * *

ATTACHMENTS



RABA KISTNER

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TBPE Firm Number 3257

SOURCE: Aerial imagery from Google Earth Pro - 2021

BORING LOCATION MAP

WINDING CREEK RANCH
UNITS 5 THROUGH 8 - PAVEMENTS
NEW BRAUNFELS, TEXAS

PROJECT No.:	ANA23-010-00
ISSUE DATE:	03/07/2023
DRAWN BY:	BM
CHECKED BY:	RD
REVIEWED BY:	IM

FIGURE

1

NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

LOG OF BORING NO. B-1

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.63097; W 98.17701

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0	FAT CLAY, Stiff to Very Stiff, Dark Brown				
		10		49	92
		16			
5		22			
6	FAT CLAY, Very Stiff, Tan and Gray				
		25			
		29			
10	Boring Terminated				
15					

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 10.0 ft
DATE DRILLED: 3/10/2023
DEPTH TO WATER: Dry
DATE MEASURED: 3/10/2023
PROJ. No.: ANA23-010-00
FIGURE: 2

LOG OF BORING NO. B-2

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62938; W 98.11712

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT^2 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT 10 20 30 40 50 60 70 80	PLASTICITY INDEX	% -200
			FAT CLAY, Firm to Very Stiff, Dark Brown	6				
				14				
5			FAT CLAY, Very Stiff, Tan and Gray, with calcareous material	24				
				22			37	
				28				
10			Boring Terminated					
15								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	3

LOG OF BORING NO. B-3

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62772; W 98.11893

SHEAR STRENGTH, TONS/FT²: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10, 20, 30, 40, 50, 60, 70, 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0	FAT CLAY, Soft to Very Stiff, Dark Brown				
		4			
		13		52	
5	FAT CLAY, Very Stiff, Tan and Gray	20			
		17			
		19			
10	Boring Terminated				
15					

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 10.0 ft	**DEPTH TO WATER:** Dry	**PROJ. No.:** ANA23-010-00
DATE DRILLED: 3/10/2023	**DATE MEASURED:** 3/10/2023	**FIGURE:** 4

LOG OF BORING NO. B-4

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62815; W 98.11564

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			FAT CLAY, Firm to Very Stiff, Dark Brown to Brown	6			
				22			
5			FAT CLAY, Hard, Tan and Gray	50/11"			
				39			
				32		38	
10			Boring Terminated				
15							

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	5

LOG OF BORING NO. B-5

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62743; W 98.11727

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			FAT CLAY, Soft to Very Stiff, Dark Brown to Brown	4			
				19			
5				16			
			FAT CLAY, Stiff to Very Stiff, Tan and Gray	14		39	
				24			98
10			Boring Terminated				
15							

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	6

LOG OF BORING NO. B-6

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62229; W 98.11824

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			FAT CLAY, Soft to Stiff, Dark Brown	4		92	69	
				12				
			FAT CLAY, Stiff to Very Stiff, Tan and Gray - with calcareous material from 3.5 ft to 6.5 ft.					
5				23				
				15				
				17				
10			Boring Terminated					
15								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	7

LOG OF BORING NO. B-7

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62271; W 98.11486

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0	FAT CLAY, Firm to Very Stiff, Dark Brown	6			
		8		55	
5	FAT CLAY, Very Stiff, Tan and Gray	28			
		22			
		25			
10	Boring Terminated				
15					

SHEAR STRENGTH, TONS/FT^2: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10, 20, 30, 40, 50, 60, 70, 80

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	8

LOG OF BORING NO. B-8

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62186; W 98.11345

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			FAT CLAY, Soft to Very Stiff, Dark Brown				
				4			
				24			
			LEAN CLAY, Very Stiff, Tan and Gray				
5				27		31	
				28			
				26			
10			Boring Terminated				
15							

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	9

LOG OF BORING NO. B-9

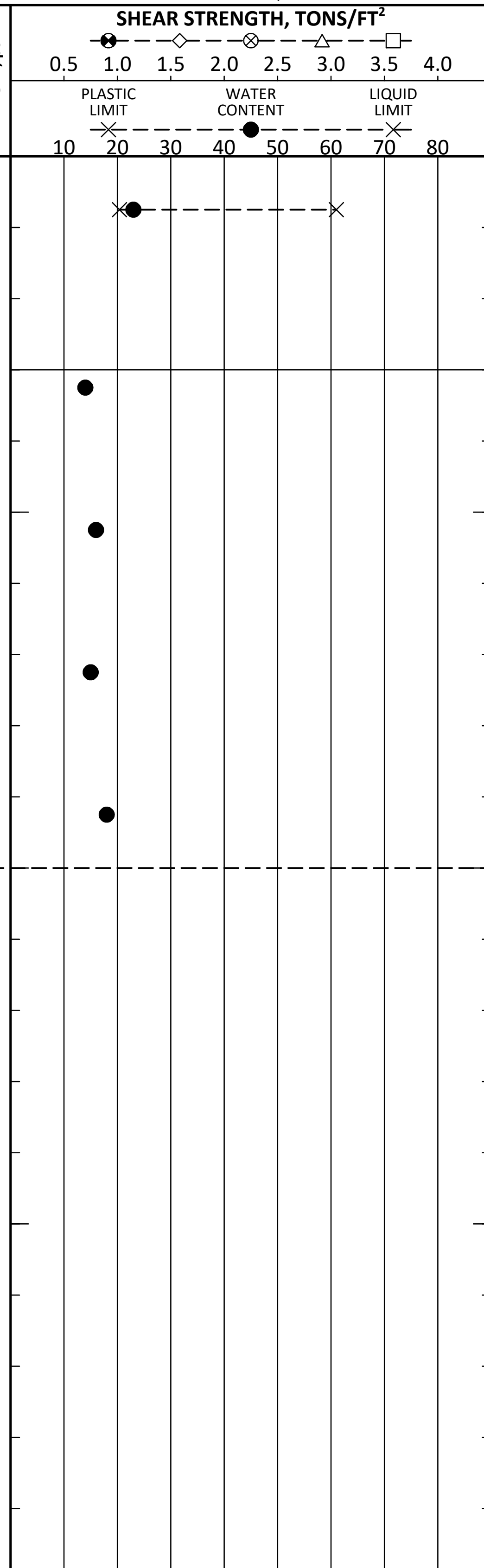
Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62067; W 98.11480

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0–3	FAT CLAY, Firm to Very Stiff, Dark Brown	6		41	
3–10	FAT CLAY, Very Stiff, Tan and Gray	19			
		26			
		22			
		28			
10	Boring Terminated				



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 10.0 ft	**DEPTH TO WATER:** Dry	**PROJ. No.:** ANA23-010-00	
DATE DRILLED: 3/10/2023	**DATE MEASURED:** 3/10/2023	**FIGURE:** 10	

LOG OF BORING NO. B-10

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.61937; W 98.11623

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0	FAT CLAY, Firm to Very Stiff, Dark Brown				
		6			
		17			
4	FAT CLAY, Hard to Very Stiff, Tan and Gray				
5		33			
		21		44	
		26			
10	Boring Terminated				
15					

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	11

LOG OF BORING NO. B-11

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.62150; W 98.11640

DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
FAT CLAY, Firm to Very Stiff, Dark Brown	8			
	26			
FAT CLAY, Hard to Very Stiff, Tan and Gray	46			
	28			
	23		39	99
Boring Terminated				

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT: 5, 10, 15

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 10.0 ft
DATE DRILLED: 3/10/2023
DEPTH TO WATER: Dry
DATE MEASURED: 3/10/2023
PROJ. No.: ANA23-010-00
FIGURE: 12

LOG OF BORING NO. B-12

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.61793; W 98.11782

SHEAR STRENGTH, TONS/FT^2: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10, 20, 30, 40, 50, 60, 70, 80

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0			FAT CLAY, Soft to Very Stiff, Dark Brown				
				4			
				12		58	94
5				27			
			FAT CLAY, Very Stiff, Tan and Gray				
				23			
				25			
10			Boring Terminated				
15							

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-010-00
DATE DRILLED:	3/10/2023	**DATE MEASURED:**	3/10/2023	**FIGURE:**	13

LOG OF BORING NO. B-13

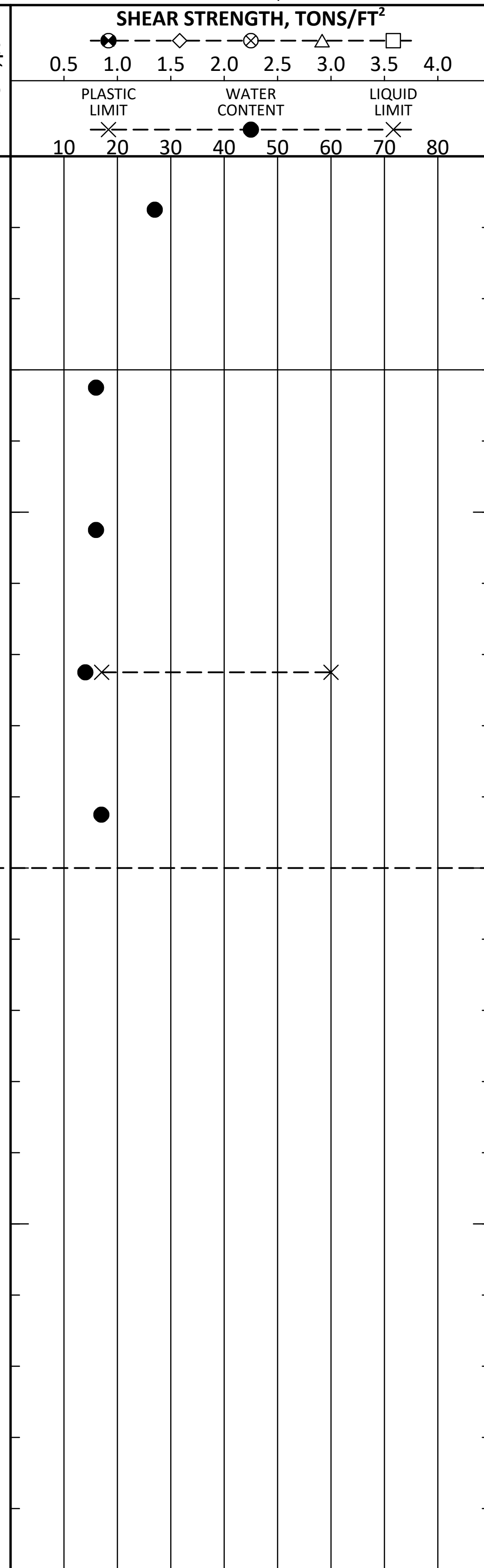
Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.61963; W 98.11852

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT²; PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT	PLASTICITY INDEX	% -200
			FAT CLAY, Firm to Very Stiff, Dark Brown	6				
			FAT CLAY, Very Stiff, Tan and Gray	28				
5				19				
				23			43	
				17				
10			Boring Terminated					
15								



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 10.0 ft
DATE DRILLED: 3/10/2023
DEPTH TO WATER: Dry
DATE MEASURED: 3/10/2023
PROJ. No.: ANA23-010-00
FIGURE: 14

KEY TO TERMS AND SYMBOLS

MATERIAL TYPES

SOIL TERMS

- CALCAREOUS
- CALICHE
- CLAY
- CLAYEY
- GRAVEL
- GRAVELLY
- PEAT
- SAND
- SANDY
- SILT
- SILTY
- FILL

ROCK TERMS

- CHALK
- CLAYSTONE
- CLAY-SHALE
- CONGLOMERATE
- DOLOMITE
- IGNEOUS
- LIMESTONE
- MARL
- METAMORPHIC
- SANDSTONE
- SHALE
- SILTSTONE

OTHER

- ASPHALT
- BASE
- CONCRETE/CEMENT
- BRICKS / PAVERS
- WASTE
- NO INFORMATION

WELL CONSTRUCTION AND PLUGGING MATERIALS

- BLANK PIPE
- SCREEN
- BENTONITE
- CEMENT GROUT
- BENTONITE & CUTTINGS
- CONCRETE/CEMENT
- CUTTINGS
- GRAVEL
- SAND
- VOLCLAY

SAMPLE TYPES

- AIR ROTARY
- GRAB SAMPLE
- CORE
- GEOPROBE SAMPLER
- ROTOSONIC -DAMAGED
- MUD ROTARY
- NO RECOVERY
- NX CORE
- PITCHER
- ROTOSONIC -INTACT
- SHELBY TUBE
- SPLIT BARREL
- SPLIT SPOON
- TEXAS CONE PENETROMETER
- DISTURBED

STRENGTH TEST TYPES

- POCKET PENETROMETER
- TORVANE
- UNCONFINED COMPRESSION
- TRIAXIAL COMPRESSION UNCONSOLIDATED-UNDRAINED
- TRIAXIAL COMPRESSION CONSOLIDATED-UNDRAINED

NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

PROJECT NO. ANA23-010-00

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D2487-06 and D2488-00, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 2005.

The depths shown on the boring logs are not exact, and have been estimated to the nearest half-foot. Depth measurements may be presented in a manner that implies greater precision in depth measurement, i.e 6.71 meters. The reader should understand and interpret this information only within the stated half-foot tolerance on depth measurements.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
> 50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0 - 2	Very Soft	0 - 0.125
2 - 4	Soft	0.125 - 0.25
4 - 8	Firm	0.25 - 0.5
8 - 15	Stiff	0.5 - 1.0
15 - 30	Very Stiff	1.0 - 2.0
> 30	Hard	> 2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0 - 5	None
5 - 10	Low
10 - 20	Moderate
20 - 40	Plastic
> 40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
NR = Not Recorded/No Recovery
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qam, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace Deposits
Qao = Seymour Formation
Qle = Leona Formation
Q-Tu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Mc = Catahoula Formation
El = Laredo Formation
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kft = Fort Terrett Member
Kgt = Georgetown Formation
Kep = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kew = Walnut Formation
Kgr = Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kh = Hensell Sand

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

SAMPLING METHODS

RELATIVELY UNDISTURBED SAMPLING

Cohesive soil samples are to be collected using three-inch thin-walled tubes in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587) and granular soil samples are to be collected using two-inch split-barrel samplers in general accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). Cohesive soil samples may be extruded on-site when appropriate handling and storage techniques maintain sample integrity and moisture content.

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-in.-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

FILE NAME: ANA23-010-00.GPJ 4/20/2023

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-1	0.0 to 1.5	10	22	71	22	49	CH		92		
	2.5 to 4.0	16	13								
	4.5 to 6.0	22	12								
	6.5 to 8.0	25	14								
	8.5 to 10.0	29	14								
B-2	0.0 to 1.5	6	29								
	2.5 to 4.0	14	19								
	4.5 to 6.0	24	13								
	6.5 to 8.0	22	14	51	14	37	CH				
	8.5 to 10.0	28	13								
B-3	0.0 to 1.5	4	19								
	2.5 to 4.0	13	17	71	19	52	CH				
	4.5 to 6.0	20	11								
	6.5 to 8.0	17	12								
	8.5 to 10.0	19	14								
B-4	0.0 to 1.5	6	19								
	2.5 to 4.0	22	12								
	4.5 to 5.9	50/11"	12								
	6.5 to 8.0	39	14								
	8.5 to 10.0	32	16	52	14	38	CH				
B-5	0.0 to 1.5	4	28								
	2.5 to 4.0	19	15								
	4.5 to 6.0	16	13								
	6.5 to 8.0	14	12	53	14	39	CH				
	8.5 to 10.0	24	14						98		
B-6	0.0 to 1.5	4	31	92	23	69	CH				
	2.5 to 4.0	12	16								
	4.5 to 6.0	23	15								
	6.5 to 8.0	15	15								
	8.5 to 10.0	17	17								
B-7	0.0 to 1.5	6	28								
	2.5 to 4.0	8	21	75	20	55	CH				
	4.5 to 6.0	28	16								
	6.5 to 8.0	22	13								
	8.5 to 10.0	25	16								
B-8	0.0 to 1.5	4	25								
	2.5 to 4.0	24	11								
	4.5 to 6.0	27	12	45	14	31	CL				
	6.5 to 8.0	28	12								

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

FILE NAME: ANA23-010-00.GPJ 4/20/2023

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-8	8.5 to 10.0	26	14								
B-9	0.0 to 1.5	6	23	61	20	41					
	2.5 to 4.0	19	14								
	4.5 to 6.0	26	16								
	6.5 to 8.0	22	15				CH				
	8.5 to 10.0	28	18								
B-10	0.0 to 1.5	6	25								
	2.5 to 4.0	17	14								
	4.5 to 6.0	33	14								
	6.5 to 8.0	21	14	61	17	44	CH				
	8.5 to 10.0	26	18								
B-11	0.0 to 1.5	8	26								
	2.5 to 4.0	26	12								
	4.5 to 6.0	46	12								
	6.5 to 8.0	28	15								
	8.5 to 10.0	23	16	56	17	39	CH		99		
B-12	0.0 to 1.5	4	32								
	2.5 to 4.0	12	27	80	22	58	CH		94		
	4.5 to 6.0	27	17								
	6.5 to 8.0	23	15								
	8.5 to 10.0	25	17								
B-13	0.0 to 1.5	6	27								
	2.5 to 4.0	28	16								
	4.5 to 6.0	19	16								
	6.5 to 8.0	23	14	60	17	43	CH				
	8.5 to 10.0	17	17								

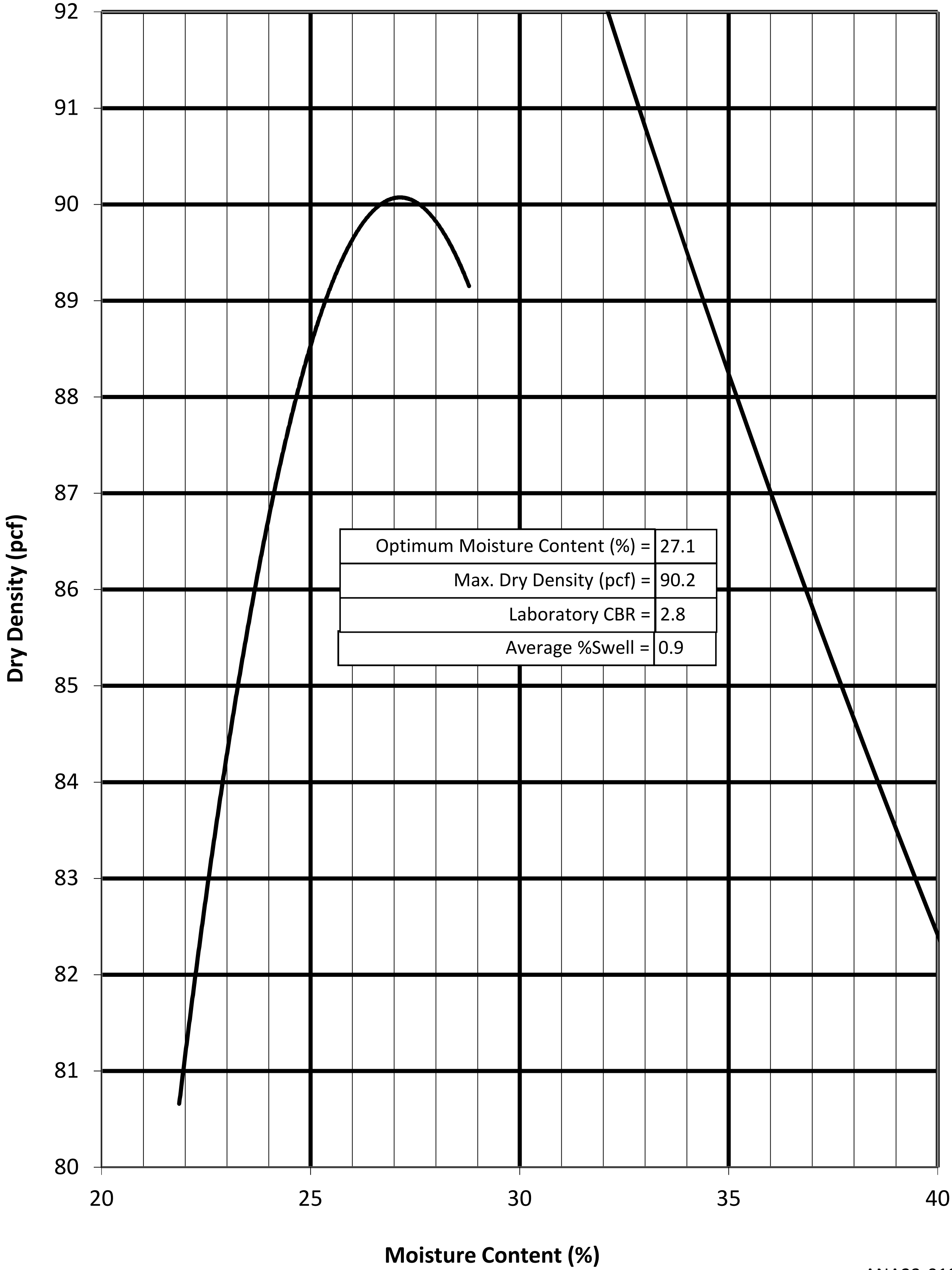
PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. ANA23-010-00

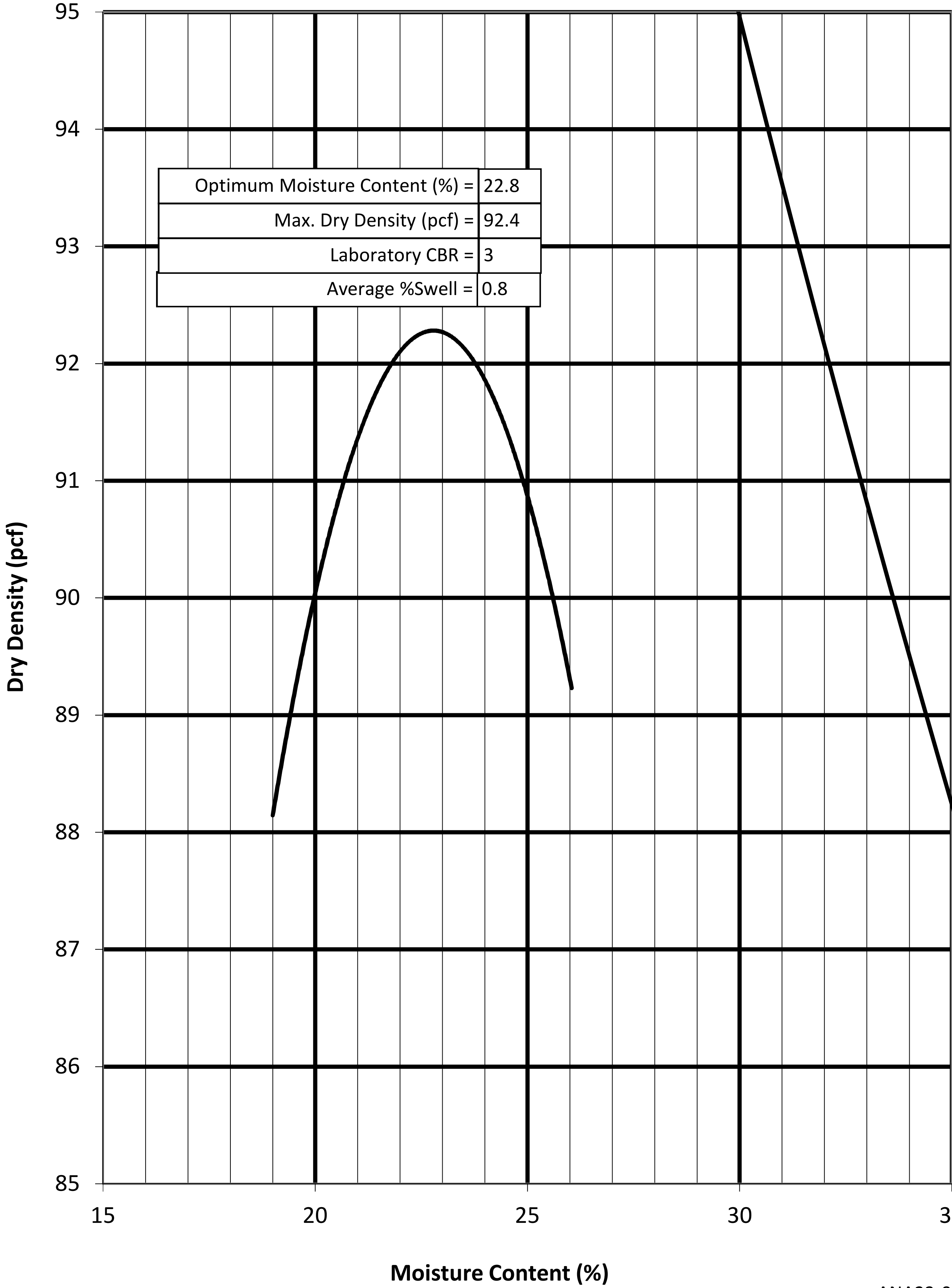
MOISTURE DENSITY RELATIONSHIP CURVE (TEX-114-E)

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas
Boring B-2, 0 - 2 ft.



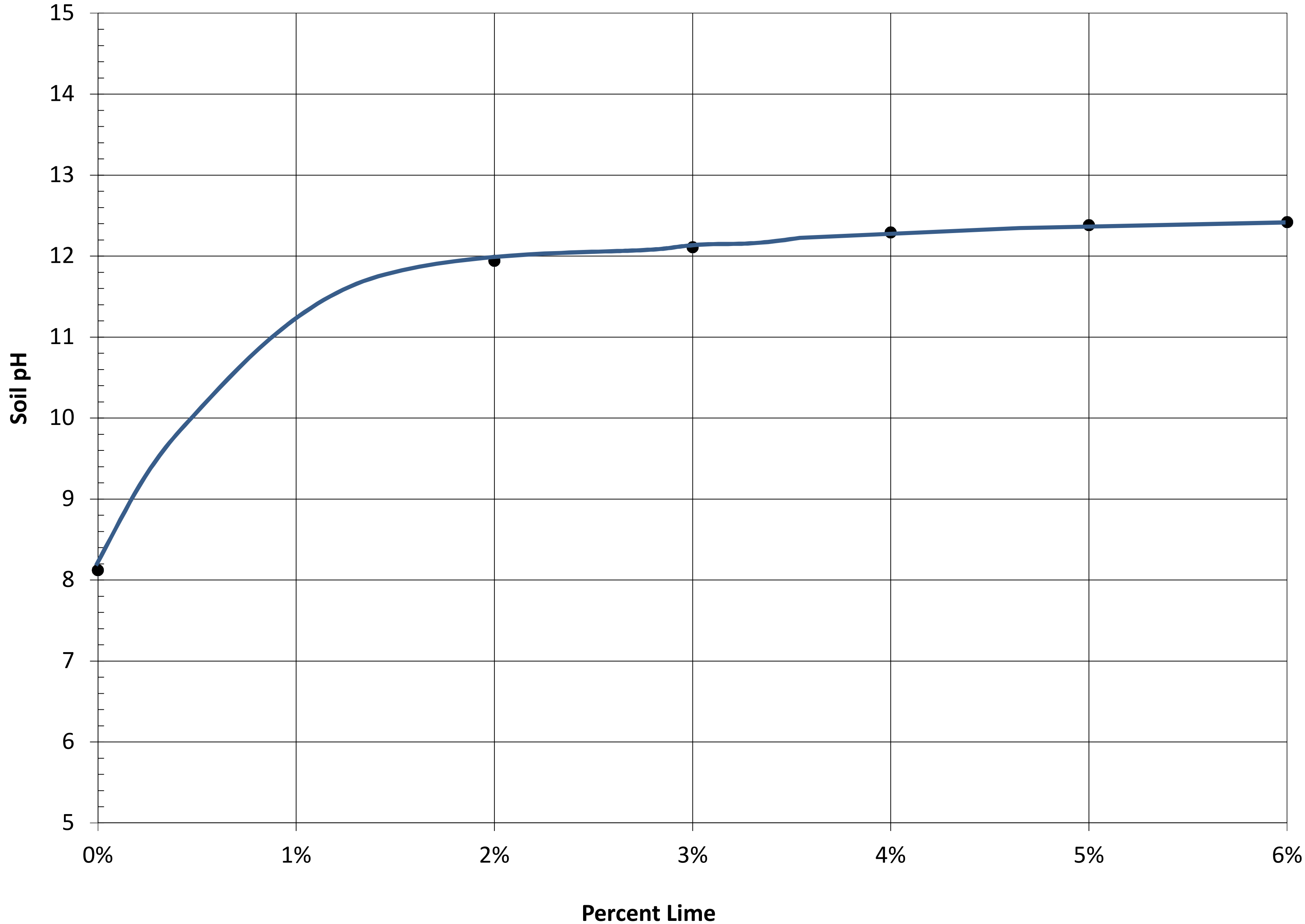
MOISTURE DENSITY RELATIONSHIP CURVE (TEX-114-E)

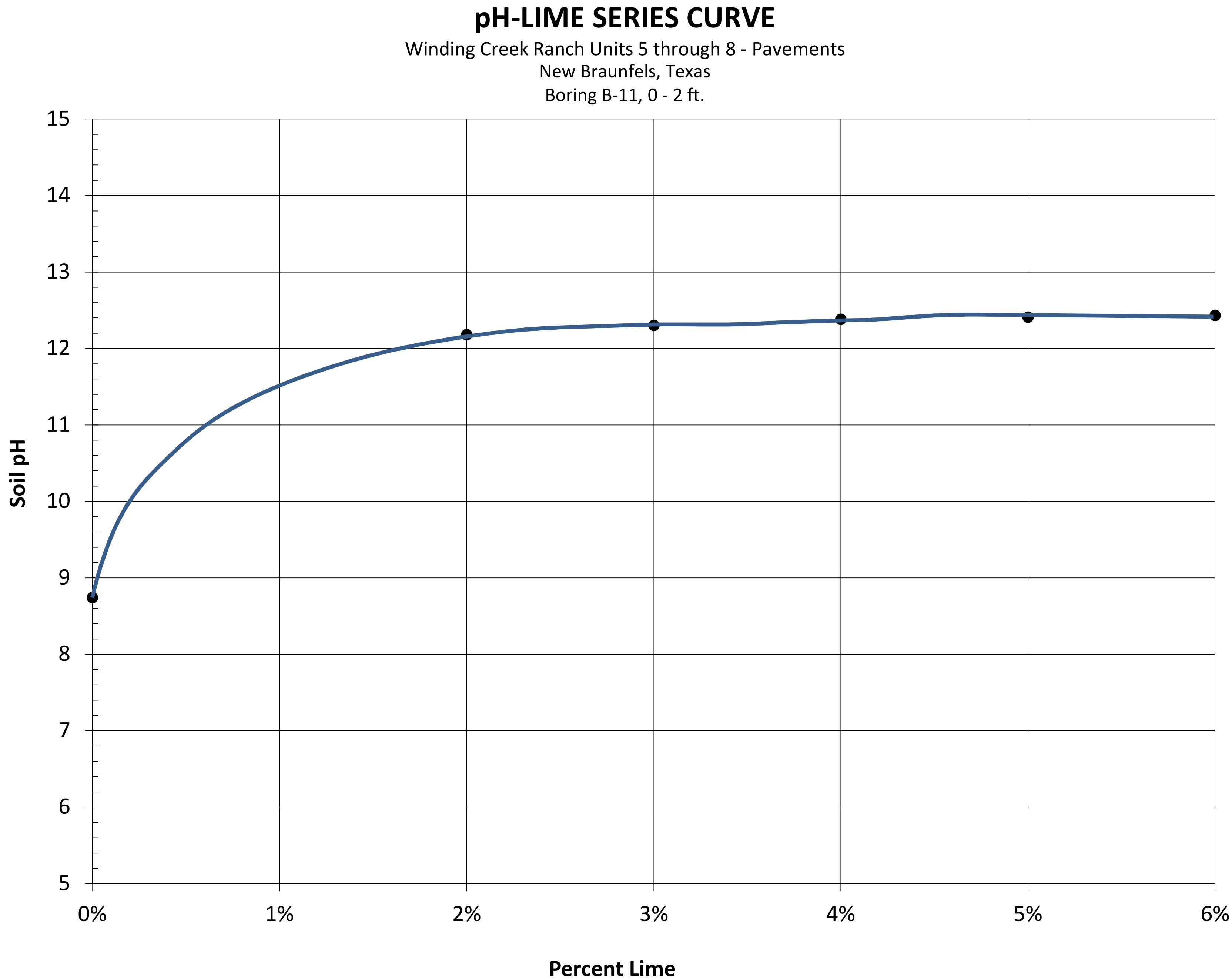
Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas
Boring B-11, 0 - 2 ft.



pH-LIME SERIES CURVE

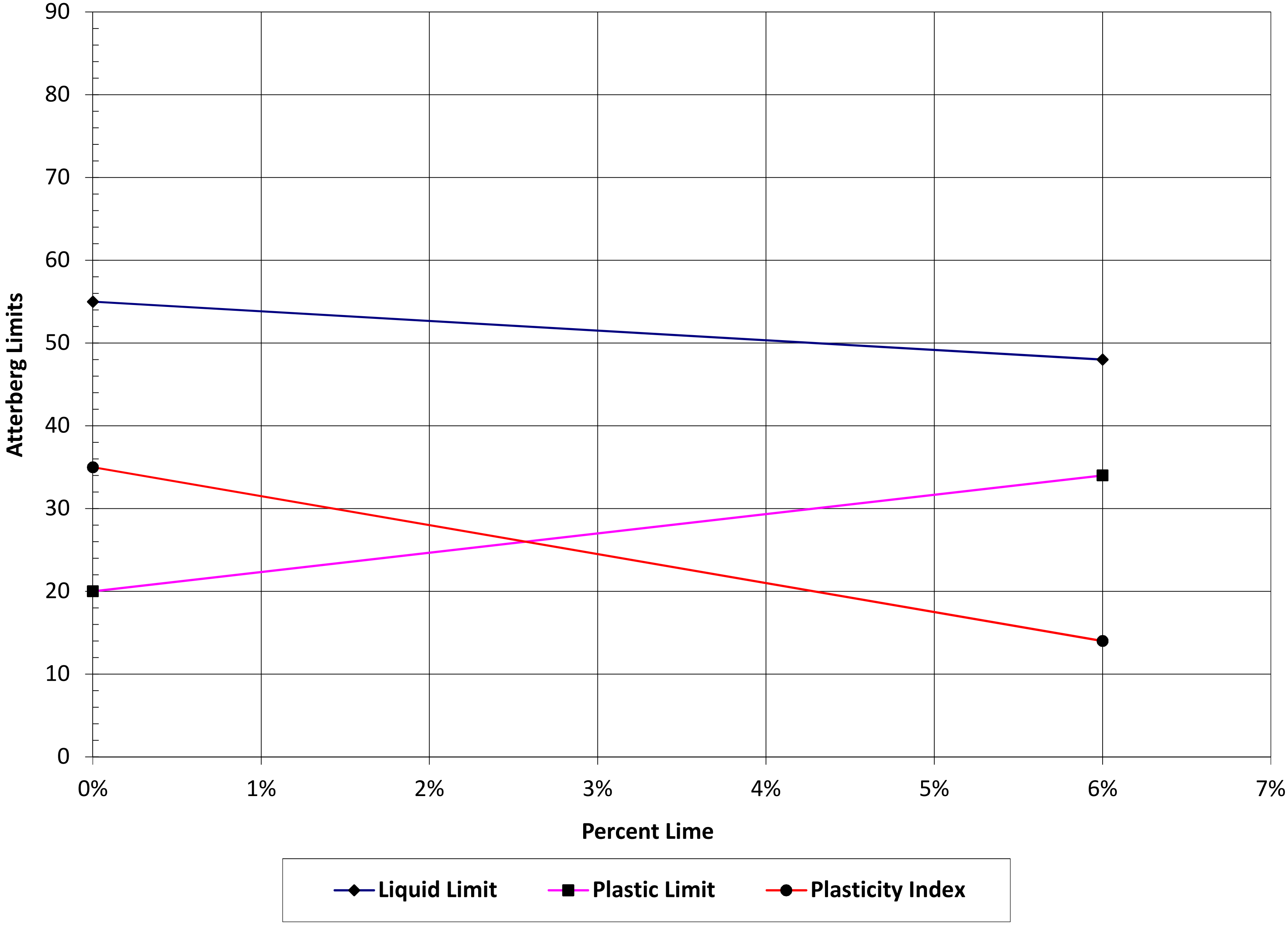
Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas
Boring B-2, 0 - 2 ft.




pH-LIME SERIES CURVE
Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas
Boring B-11, 0 - 2 ft.
15
14
13
12
11
10
9
8
7
6
5
Soil pH
0%
1%
2%
3%
4%
5%
6%
Percent Lime

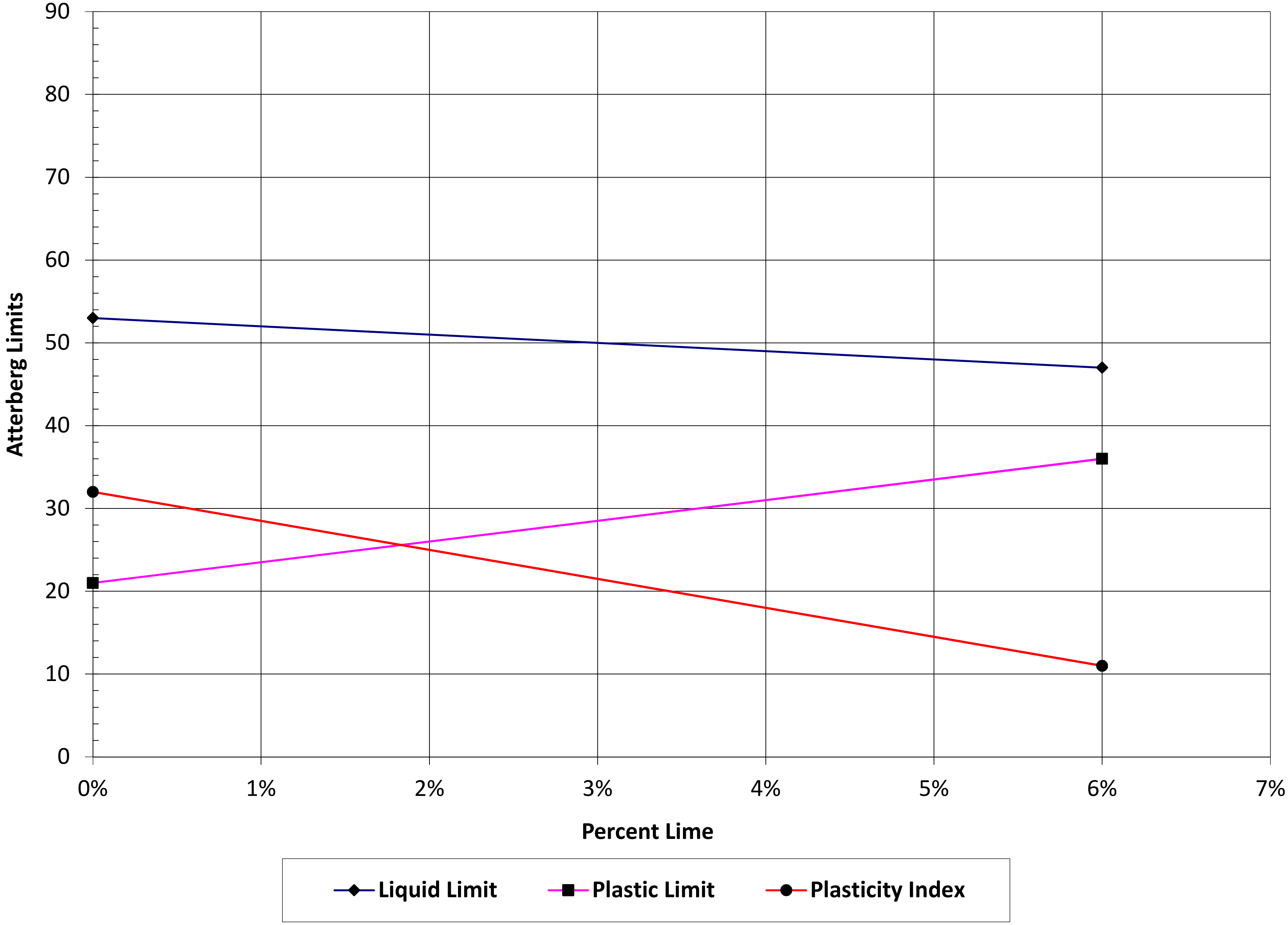
PI-LIME SERIES CURVE

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas
Boring B-2, 0 - 2 ft.



PI-LIME SERIES CURVE

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas
Boring B-11, 0 - 2 ft.



Project Number: ANA23-010-00
Test Date: March 13, 2023

DCP TEST DATA

B-1

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	60	2.4	3	4.5	1.13
1	1	20	3.1	10	15	2.52
1	1	25	4.1	8	12	2.17
1	1	25	5.1	8	12	2.17
1	1	20	5.9	10	15	2.52
1	1	30	7.1	6	9	1.80
1	1	30	8.3	6	9	1.80
1	1	30	9.4	6	9	1.80
1	1	35	10.8	5	7.5	1.59
1	1	30	12	6	9	1.80
1	1	35	13.4	5	7.5	1.59
1	1	45	15.2	4	6	1.37
1	1	35	16.5	5	7.5	1.59
1	1	30	17.7	6	9	1.80
1	1	25	18.7	8	12	2.17
1	1	20	19.5	10	15	2.52
1	1	25	20.5	8	12	2.17
1	2	35	21.9	12	18	2.84
1	2	25	22.8	17	25.5	3.59
1	2	25	23.8	17	25.5	3.59
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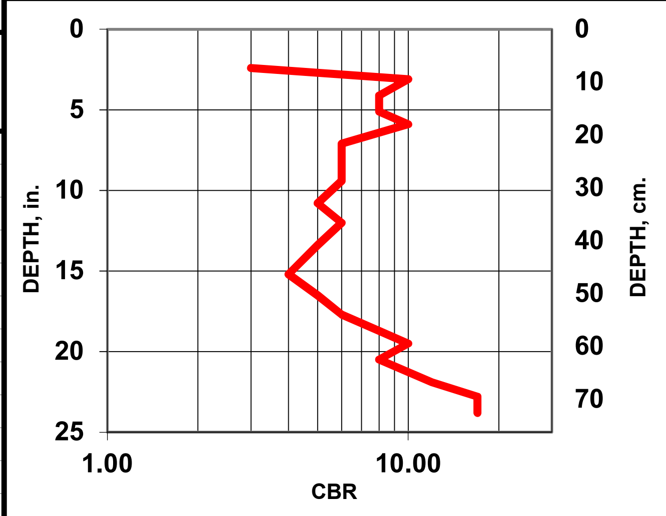
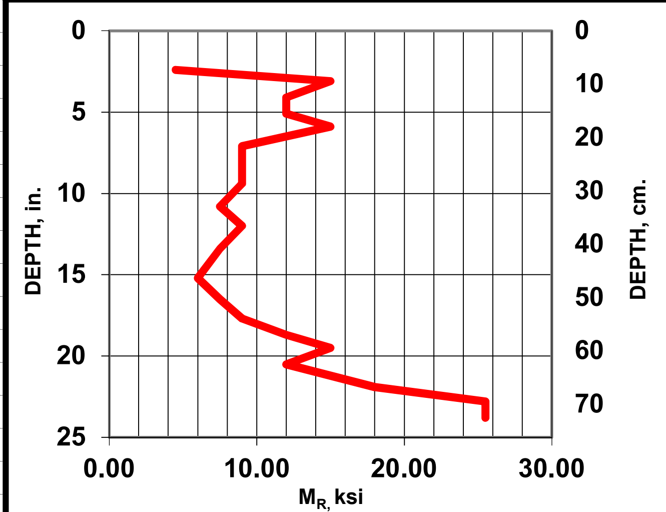
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





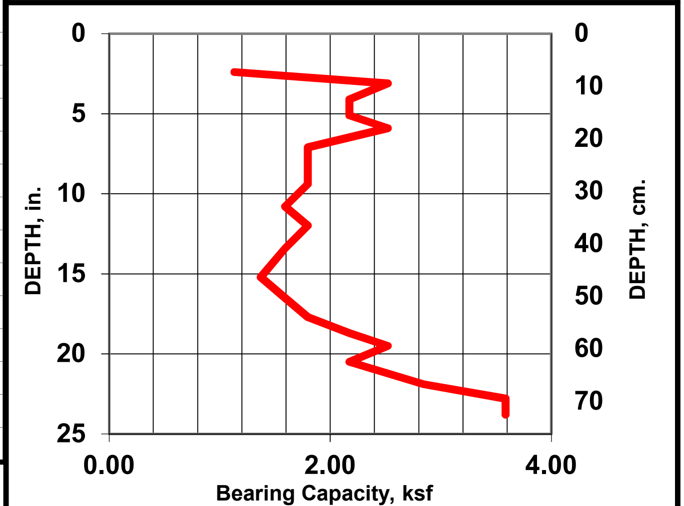


Figure 20a

Project Number: ANA23-010-00

Test Date: March 13, 2023

DCP TEST DATA

B-2

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	80	3.1	2	3	0.87
1	1	70	5.9	3	4.5	1.13
1	1	75	8.9	2	3	0.87
1	1	70	11.6	3	4.5	1.13
1	1	60	14	3	4.5	1.13
1	1	60	16.3	3	4.5	1.13
1	1	55	18.5	3	4.5	1.13
1	1	45	20.3	4	6	1.37
1	1	40	21.9	5	7.5	1.59
1	1	45	23.6	4	6	1.37
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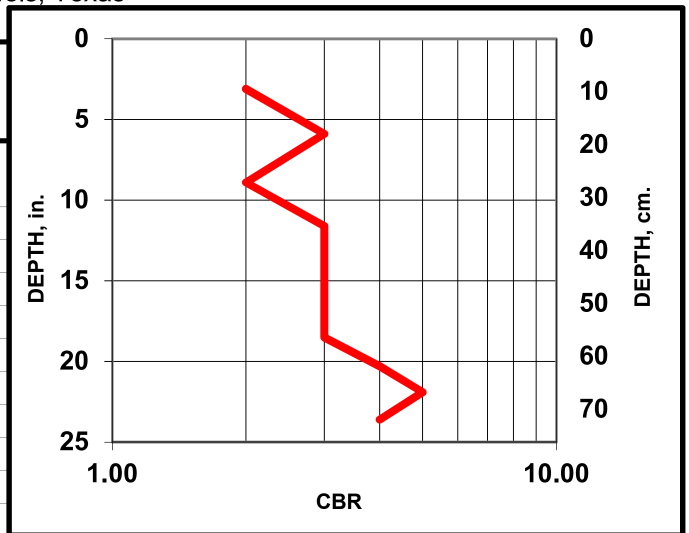
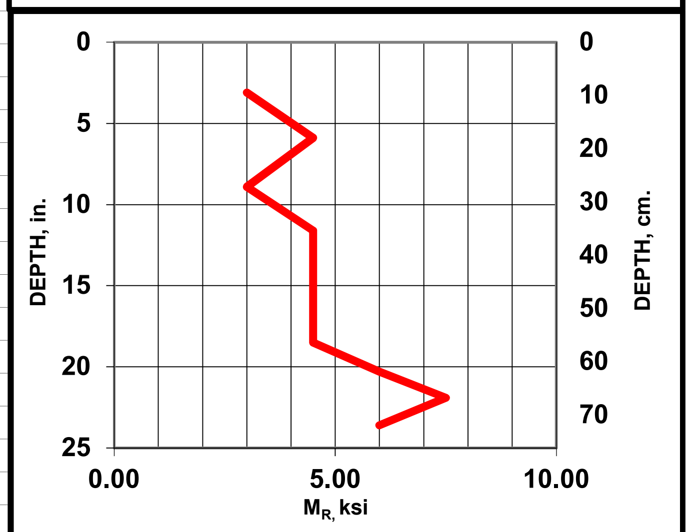
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





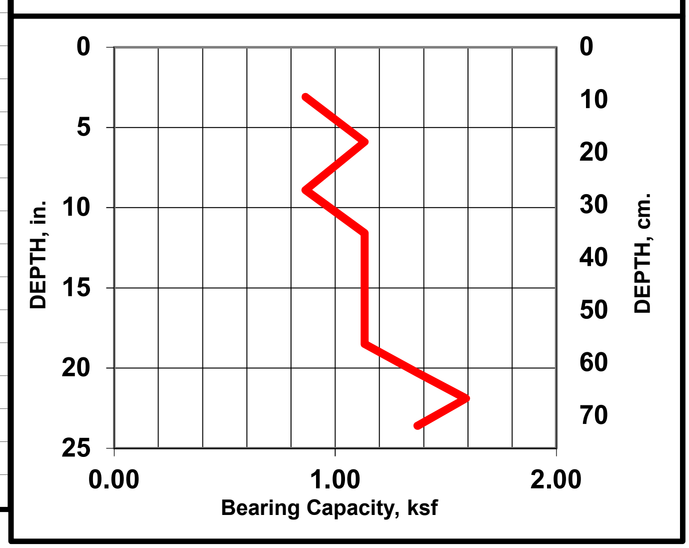


Figure 20b

Project Number: ANA23-010-00

Test Date: March 13, 2023

DCP TEST DATA

B-3

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	45	1.8	4	6	1.37
1	1	55	3.9	3	4.5	1.13
1	1	65	6.5	3	4.5	1.13
1	1	70	9.3	3	4.5	1.13
1	1	65	11.8	3	4.5	1.13
1	1	65	14.4	3	4.5	1.13
1	1	65	16.9	3	4.5	1.13
1	1	55	19.1	3	4.5	1.13
1	1	60	21.5	3	4.5	1.13
1	1	60	23.8	3	4.5	1.13
-	-	-	-	-	-	-
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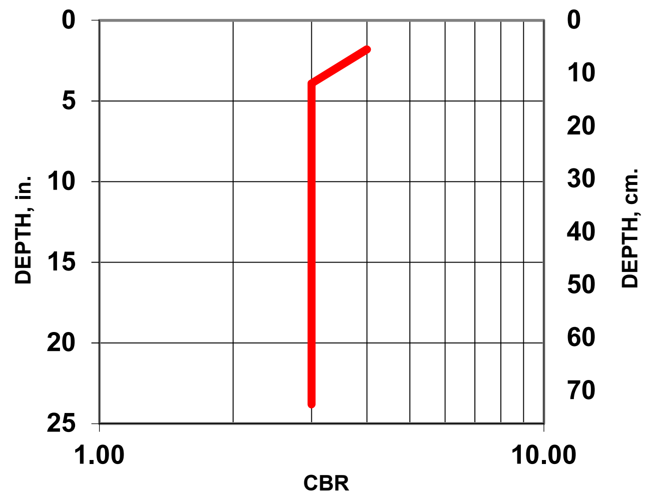
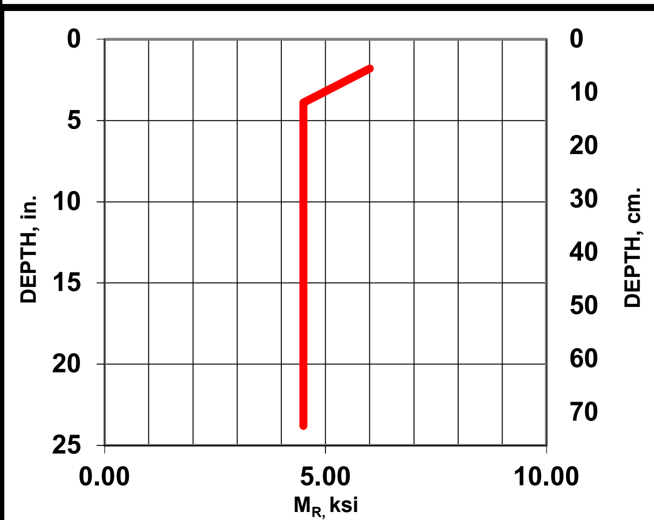
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





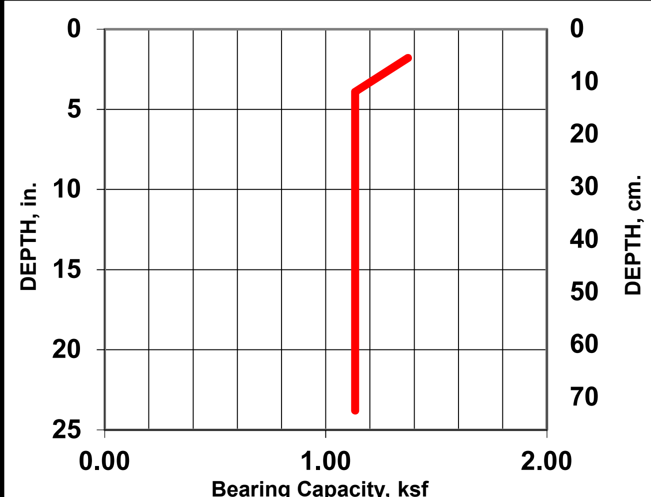


Figure 20c

Project Number: ANA23-010-00

Test Date: March 13, 2023

DCP TEST DATA

B-4

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	65	2.6	3	4.5	1.13
1	1	55	4.7	3	4.5	1.13
1	1	55	6.9	3	4.5	1.13
1	1	55	9.1	3	4.5	1.13
1	1	60	11.4	3	4.5	1.13
1	1	55	13.6	3	4.5	1.13
1	1	45	15.4	4	6	1.37
1	1	55	17.5	3	4.5	1.13
1	1	40	19.1	5	7.5	1.59
1	1	40	20.7	5	7.5	1.59
1	1	40	22.2	5	7.5	1.59
1	1	40	23.8	5	7.5	1.59
-	-	-	-	-	-	-
-	-	-	-	-	-	-
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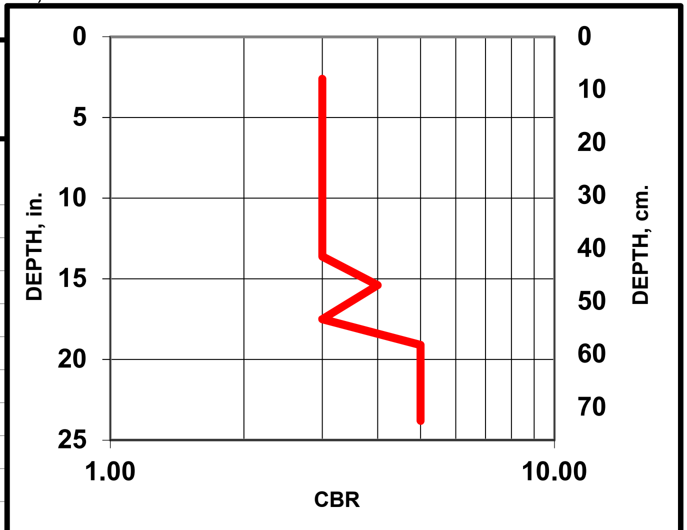
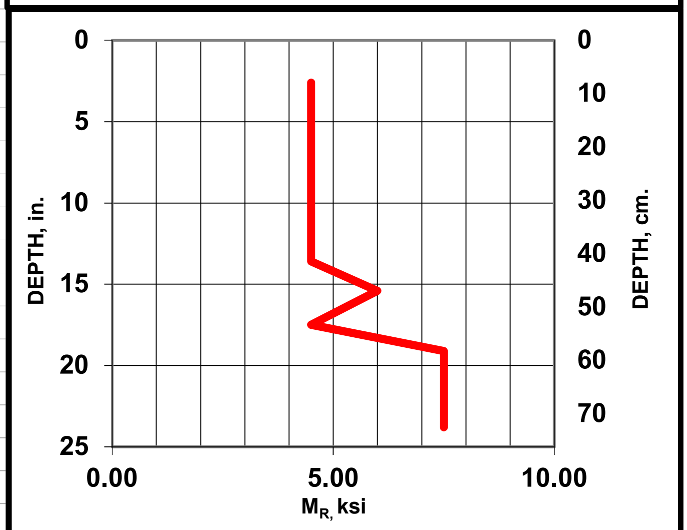
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





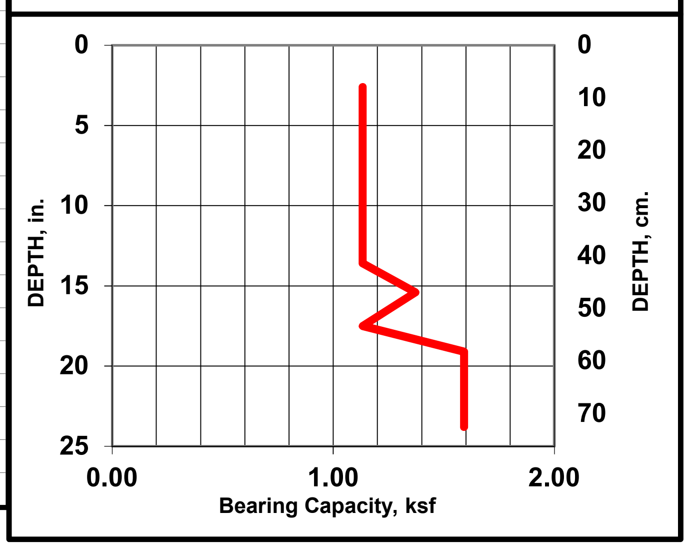


Figure 20d

Project Number: ANA23-010-00

Test Date: March 13, 2023

DCP TEST DATA

B-5

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration		CBR (%)	M_R (ksi)	q_{ult} (ksf)
		Incre. (mm)	Cumm. (in)			
1	1	25	1	8	12	2.17
1	1	50	3	4	6	1.37
1	1	50	4.9	4	6	1.37
1	1	70	7.7	3	4.5	1.13
1	1	100	11.6	2	3	0.87
1	1	90	15.2	2	3	0.87
1	1	80	18.3	2	3	0.87
1	1	80	21.5	2	3	0.87
1	1	60	23.8	3	4.5	1.13
1	1	35	25.2	5	7.5	1.59
1	1	25	26.2	8	12	2.17
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NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2

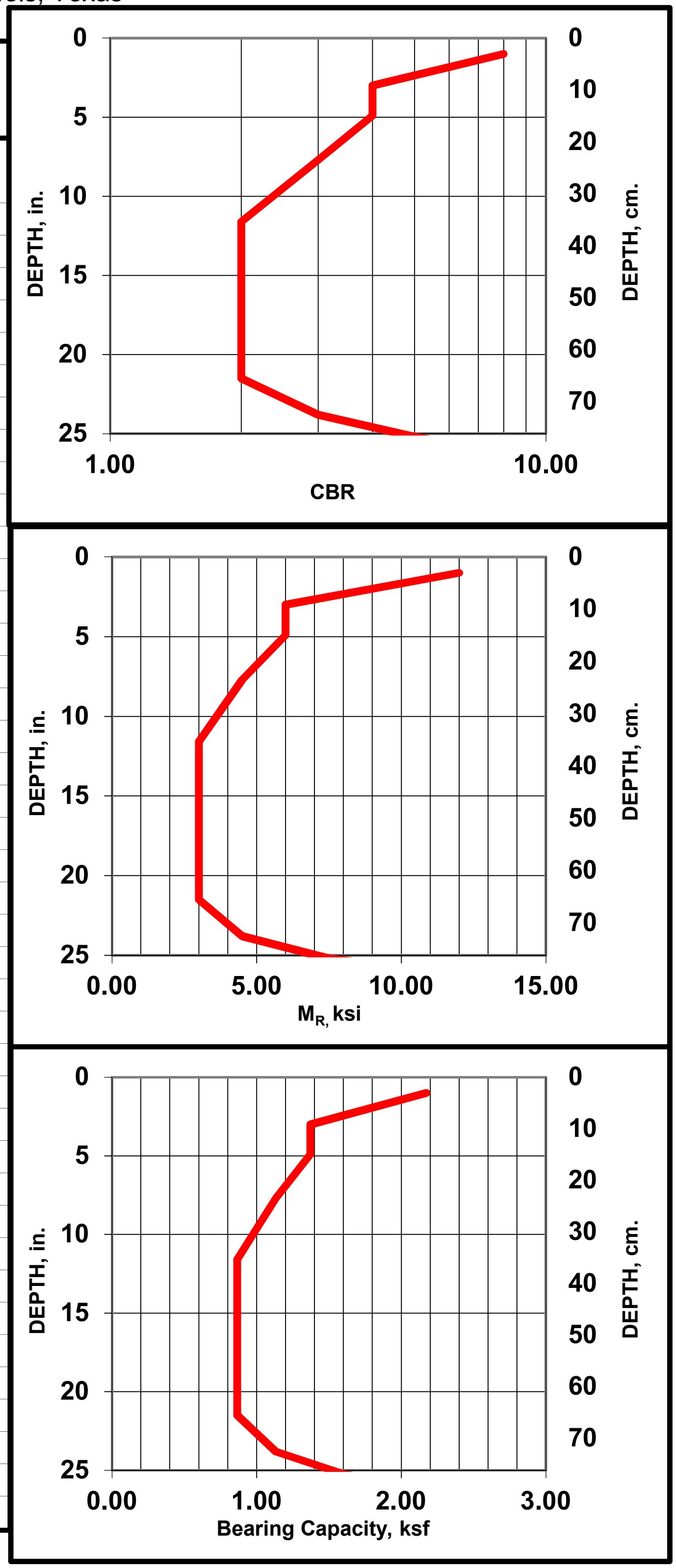

Figure 20e

Project Number: ANA23-010-00

Test Date: March 13, 2023

DCP TEST DATA

B-6

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration		CBR	M_R	q_{ult}
		Incre. (mm)	Cumm. (in)	(%)	(ksi)	(ksf)
1	1	20	0.8	10	15	2.52
1	1	60	3.1	3	4.5	1.13
1	1	50	5.1	4	6	1.37
1	1	70	7.9	3	4.5	1.13
1	1	55	10	3	4.5	1.13
1	1	65	12.6	3	4.5	1.13
1	1	60	15	3	4.5	1.13
1	1	60	17.3	3	4.5	1.13
1	1	40	18.9	5	7.5	1.59
1	1	25	19.9	8	12	2.17
1	1	25	20.9	8	12	2.17
1	1	30	22	6	9	1.80
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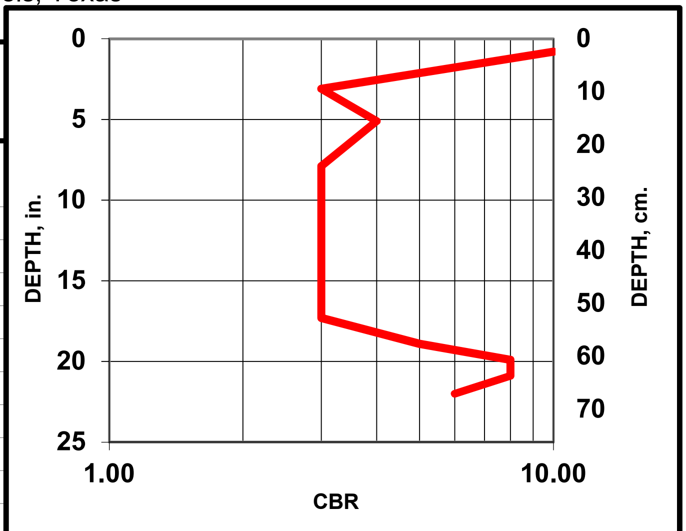
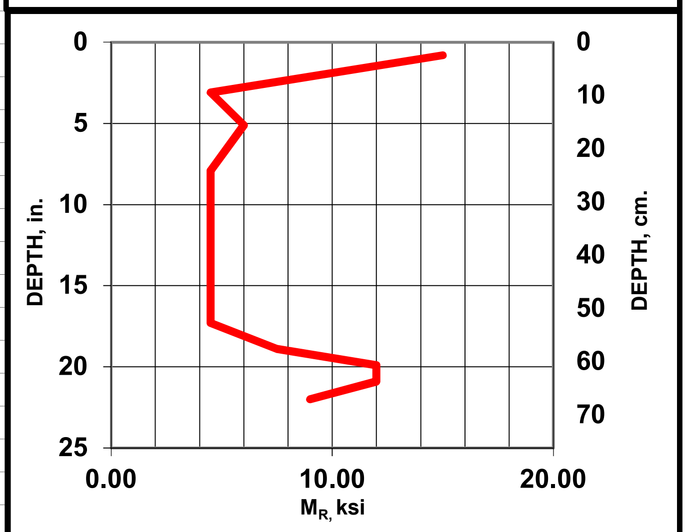
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





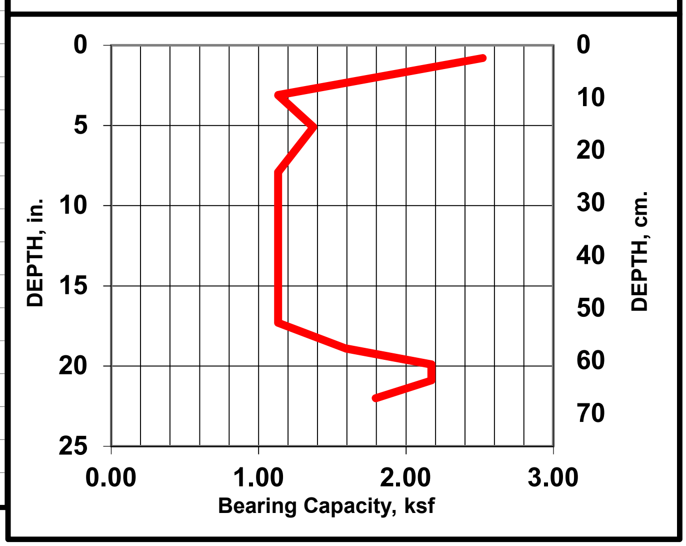


Figure 20f

Project Number: ANA23-010-00
Test Date: March 13, 2023

DCP TEST DATA

B-7

Winding Creek Ranch Units 5 through 8 - Pavements
New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration		CBR	M_R	q_{ult}
		Incre. (mm)	Cumm. (in)	(%)	(ksi)	(ksf)
1	1	70	2.8	3	4.5	1.13
1	1	80	5.9	2	3	0.87
1	1	85	9.3	2	3	0.87
1	1	95	13	2	3	0.87
1	1	85	16.3	2	3	0.87
1	1	70	19.1	3	4.5	1.13
1	1	60	21.5	3	4.5	1.13
1	1	60	23.8	3	4.5	1.13
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NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2

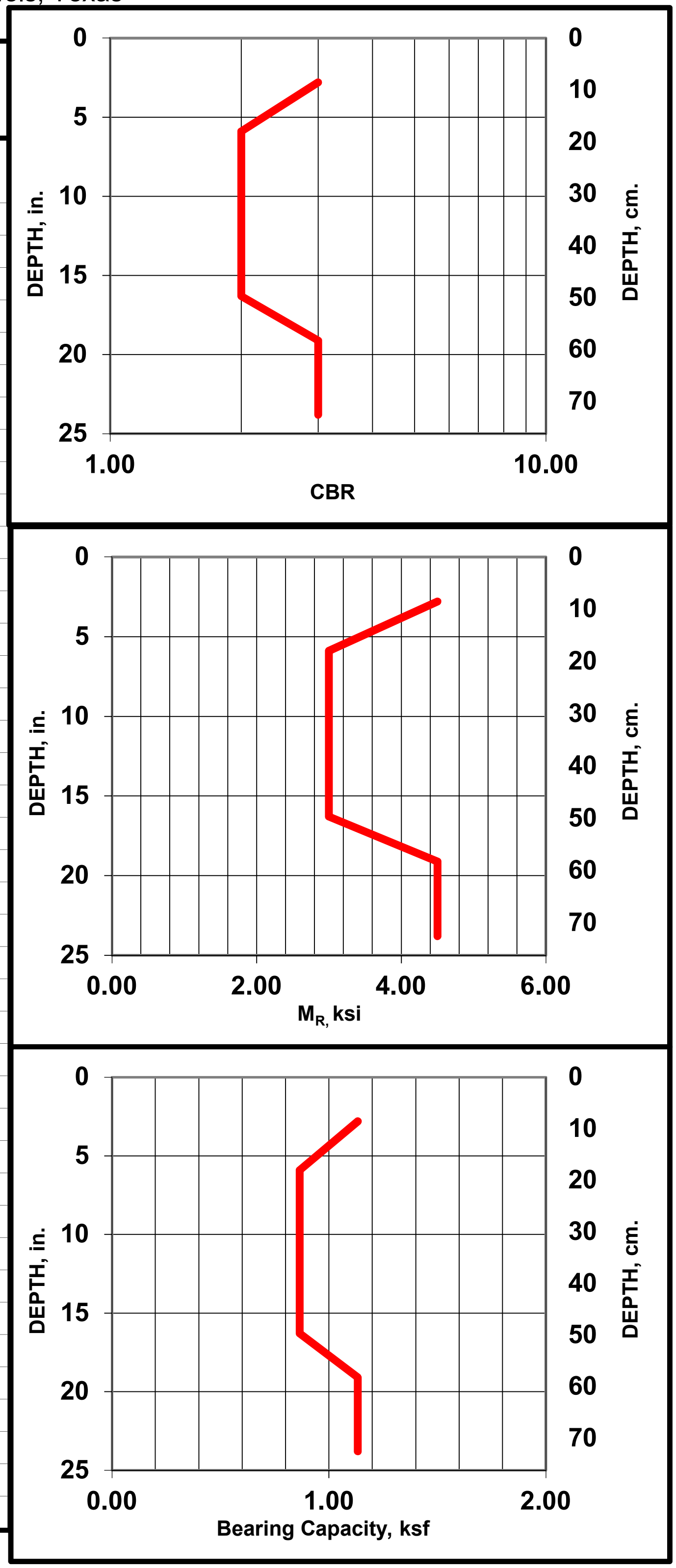

Figure 20g

Project Number: ANA23-010-00

Test Date: March 13, 2023

DCP TEST DATA

B-8

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration		CBR (%)	M_R (ksi)	q_{ult} (ksf)
		Incre. (mm)	Cumm. (in)			
1	1	80	3.1	2	3	0.87
1	1	70	5.9	3	4.5	1.13
1	1	45	7.7	4	6	1.37
1	1	45	9.4	4	6	1.37
1	1	40	11	5	7.5	1.59
1	1	35	12.4	5	7.5	1.59
1	1	45	14.2	4	6	1.37
1	1	50	16.1	4	6	1.37
1	1	50	18.1	4	6	1.37
1	1	50	20.1	4	6	1.37
1	1	45	21.9	4	6	1.37
1	1	35	23.2	5	7.5	1.59
1	1	25	24.2	8	12	2.17
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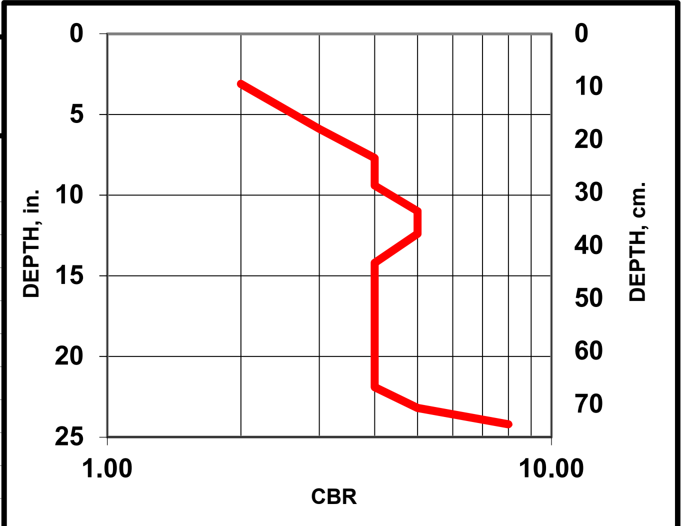
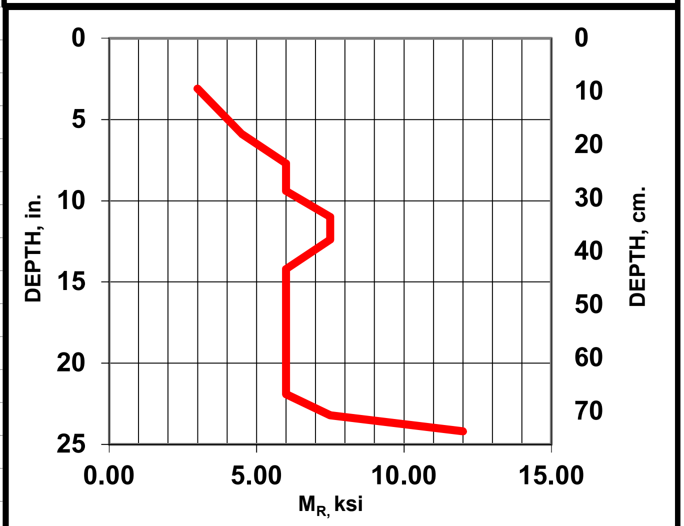
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





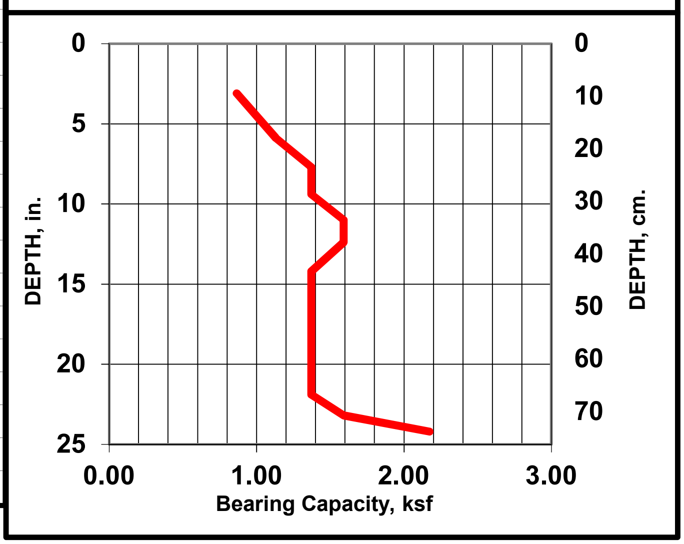


Figure 20h

Project Number: ANA23-010-00

Test Date: March 14, 2023

DCP TEST DATA

B-9

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration		CBR (%)	M_R (ksi)	q_{ult} (ksf)
		Incre. (mm)	Cumm. (in)			
1	1	55	2.2	3	4.5	1.13
1	1	50	4.1	4	6	1.37
1	1	55	6.3	3	4.5	1.13
1	1	55	8.5	3	4.5	1.13
1	1	60	10.8	3	4.5	1.13
1	1	65	13.4	3	4.5	1.13
1	1	70	16.1	3	4.5	1.13
1	1	55	18.3	3	4.5	1.13
1	1	45	20.1	4	6	1.37
1	1	55	22.2	3	4.5	1.13
1	1	60	24.6	3	4.5	1.13
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-	-	-	-	-	-	-
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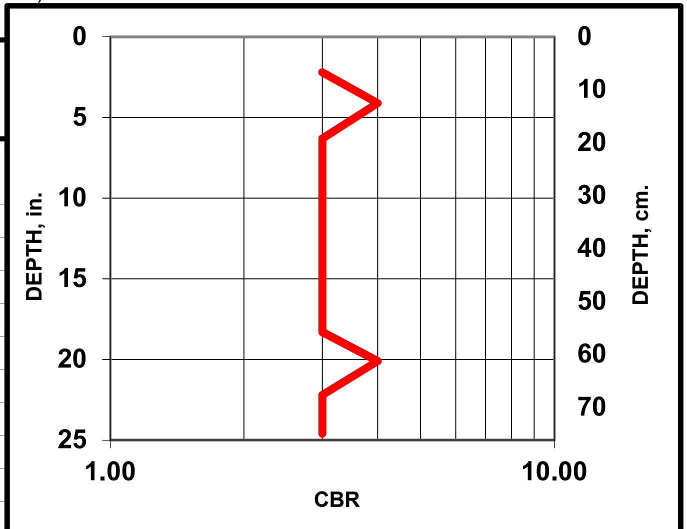
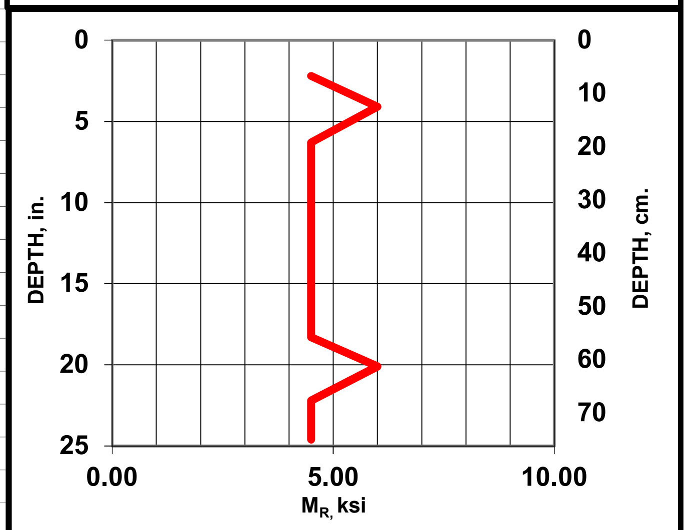
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





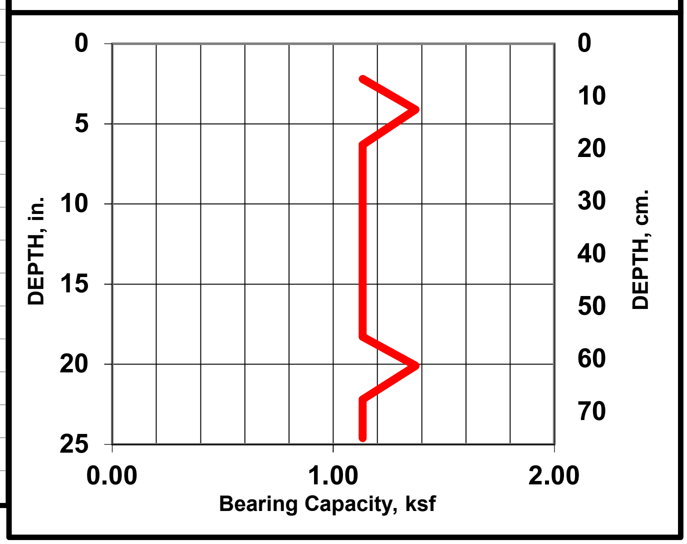


Figure 20i

Project Number: ANA23-010-00

Test Date: March 14, 2023

RABA KISTNER

DCP TEST DATA

B-10

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	45	1.8	4	6	1.37
1	1	55	3.9	3	4.5	1.13
1	1	55	6.1	3	4.5	1.13
1	1	55	8.3	3	4.5	1.13
1	1	60	10.6	3	4.5	1.13
1	1	50	12.6	4	6	1.37
1	1	100	16.5	2	3	0.87
1	1	45	18.3	4	6	1.37
1	1	50	20.3	4	6	1.37
1	1	40	21.9	5	7.5	1.59
1	1	40	23.4	5	7.5	1.59
1	1	30	24.6	6	9	1.80
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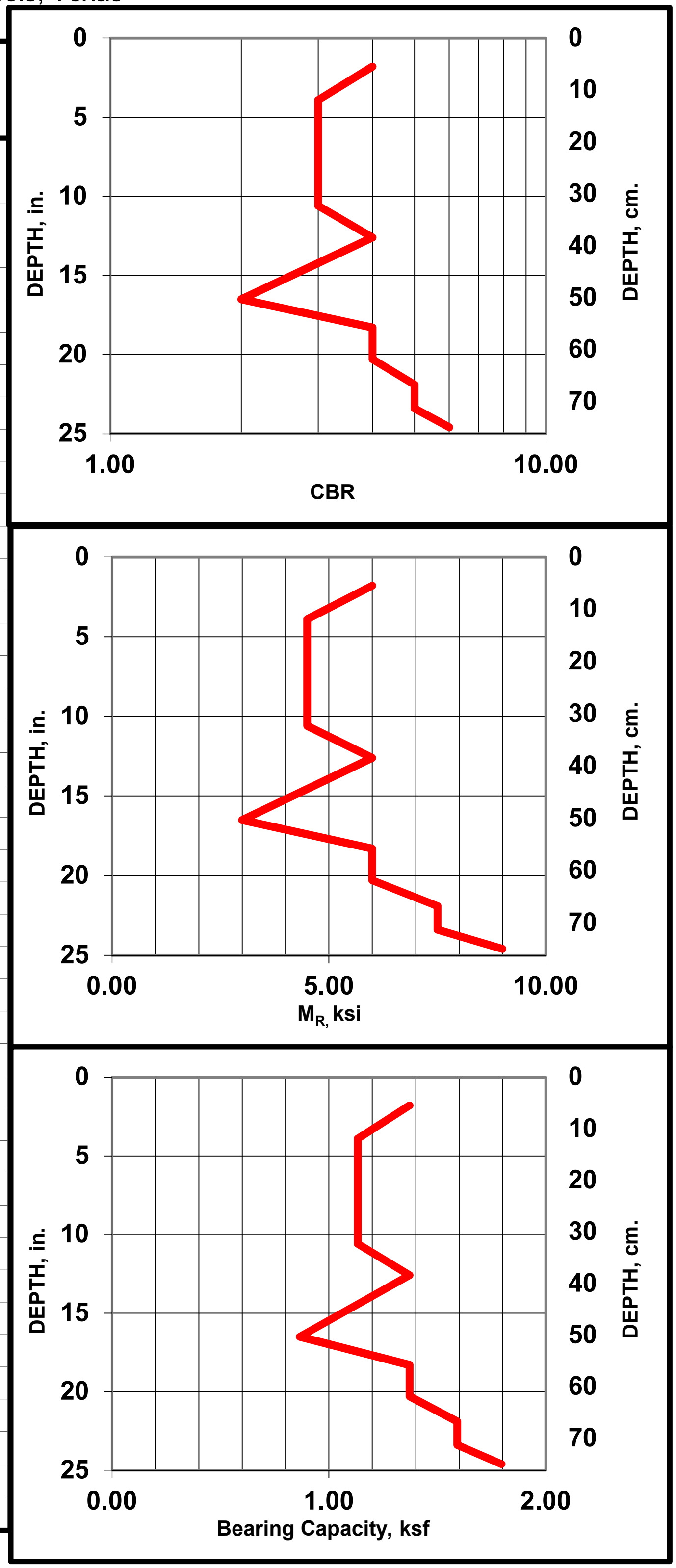

NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2

Figure 20j

Project Number: ANA23-010-00

Test Date: March 14, 2023

DCP TEST DATA

B-11

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	60	2.4	3	4.5	1.13
1	1	50	4.3	4	6	1.37
1	1	55	6.5	3	4.5	1.13
1	1	55	8.7	3	4.5	1.13
1	1	60	11	3	4.5	1.13
1	1	55	13.2	3	4.5	1.13
1	1	50	15.2	4	6	1.37
1	1	60	17.5	3	4.5	1.13
1	1	50	19.5	4	6	1.37
1	1	45	21.3	4	6	1.37
1	1	40	22.8	5	7.5	1.59
1	1	45	24.6	4	6	1.37
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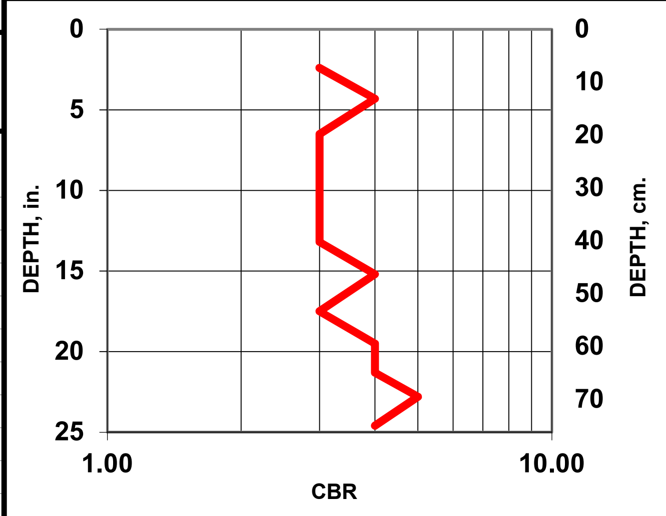
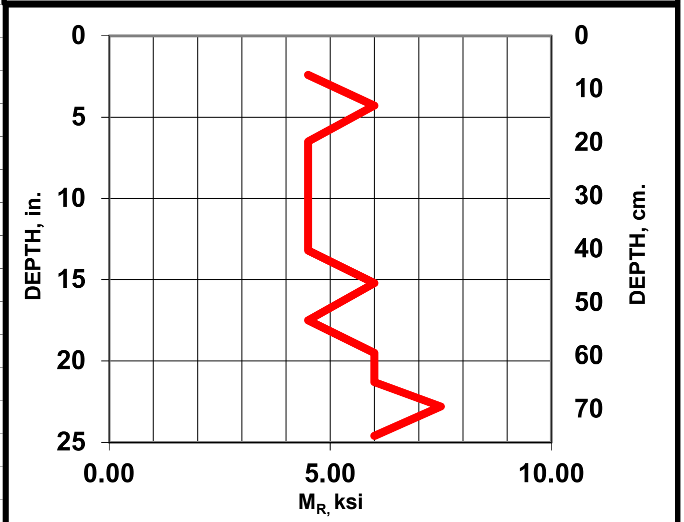
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





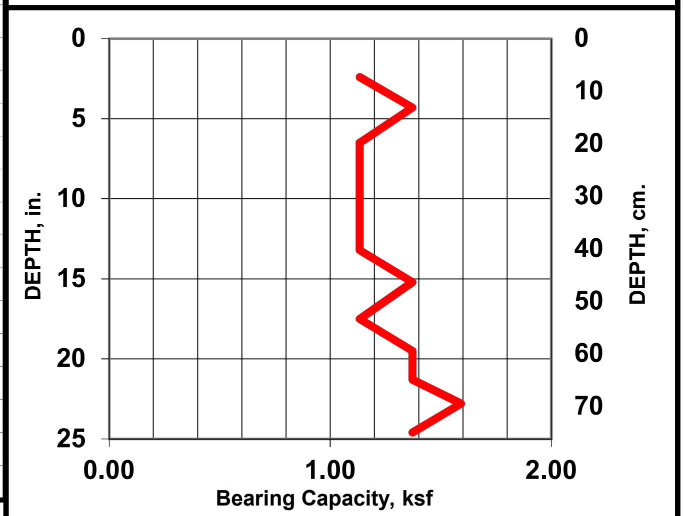


Figure 20k

Project Number: ANA23-010-00

Test Date: March 14, 2023

DCP TEST DATA

B-12

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration		CBR (%)	M_R (ksi)	q_{ult} (ksf)
		Incre. (mm)	Cumm. (in)			
1	1	55	2.2	3	4.5	1.13
1	1	70	4.9	3	4.5	1.13
1	1	75	7.9	2	3	0.87
1	1	80	11	2	3	0.87
1	1	90	14.6	2	3	0.87
1	1	65	17.1	3	4.5	1.13
1	1	55	19.3	3	4.5	1.13
1	1	50	21.3	4	6	1.37
1	1	60	23.6	3	4.5	1.13
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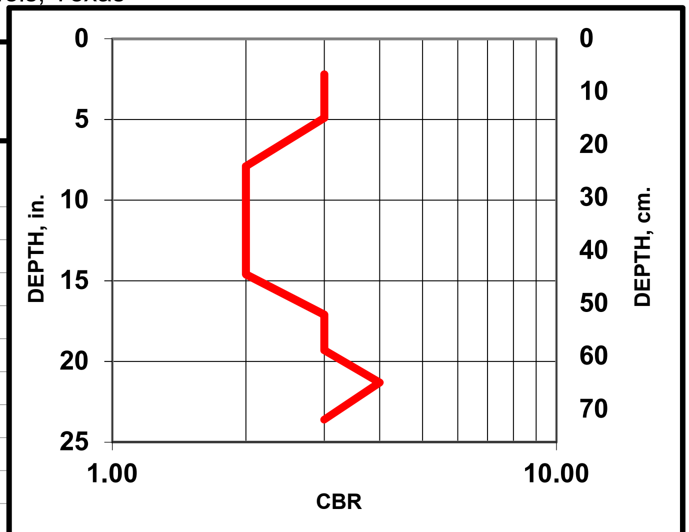
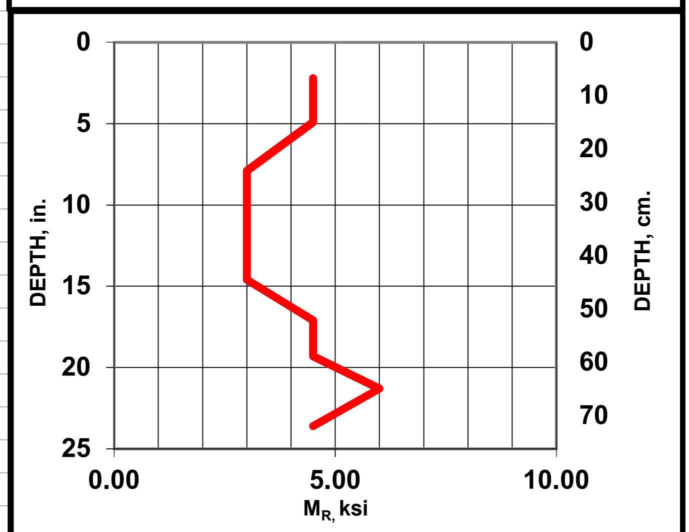
NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2





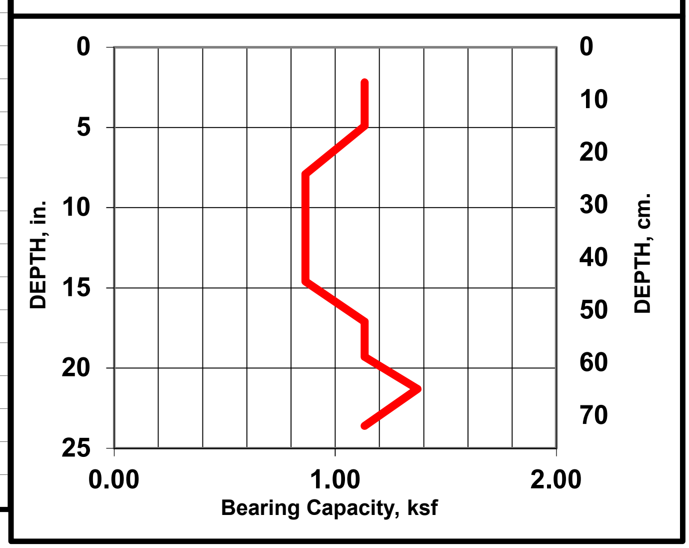


Figure 20l

Project Number: ANA23-010-00

Test Date: March 14, 2023

RABA KISTNER

DCP TEST DATA

B-13

Winding Creek Ranch Units 5 through 8 - Pavements

New Braunfels, Texas

Type of Ham.	No. of Blows	Penetration Incre. (mm)	Penetration Cumm. (in)	CBR (%)	M_R (ksi)	q_{ult} (ksf)
1	1	30	1.2	6	9	1.80
1	1	30	2.4	6	9	1.80
1	1	45	4.1	4	6	1.37
1	1	55	6.3	3	4.5	1.13
1	1	65	8.9	3	4.5	1.13
1	1	70	11.6	3	4.5	1.13
1	1	80	14.8	2	3	0.87
1	1	80	17.9	2	3	0.87
1	1	85	21.3	2	3	0.87
1	1	65	23.8	3	4.5	1.13
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
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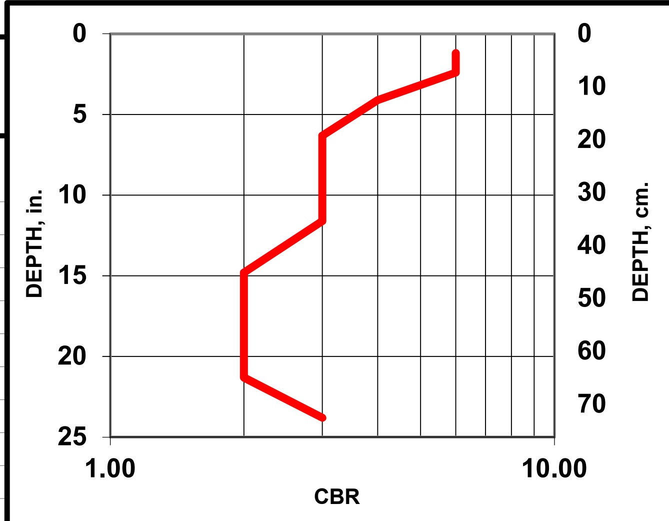

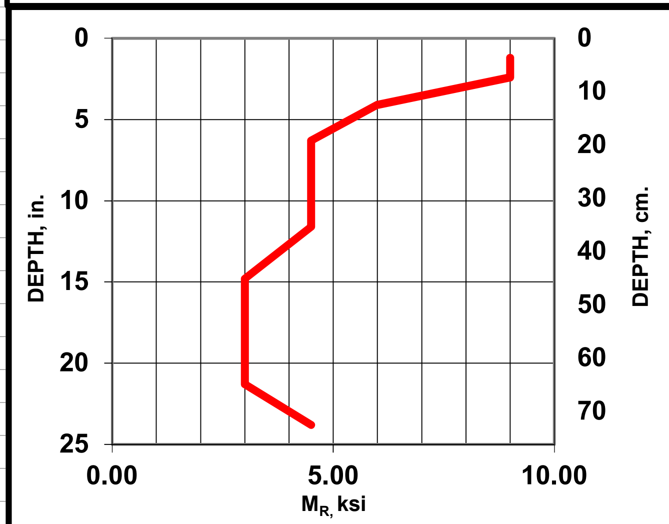

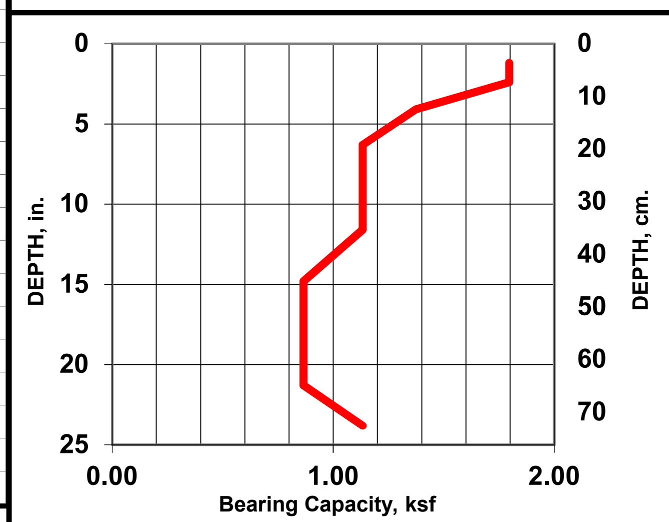

NOTES: Hammer 17.6 lbs = 1 Hammer 10.1 lbs = 2

Figure 20m

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

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RABA KISTNER