

Geotechnical Engineering Report

Old Boerne Road Reconstruction
Between Bulverde Crossing and Hwy 46
Bulverde, Texas

August 27, 2021
Terracon Project No. 90215174
Halff Project No. 32308.002

Prepared for:
Halff Associates, Inc.
San Antonio, Texas

Prepared by:
Terracon Consultants, Inc.
San Antonio, Texas

terracon.com

Terracon

Environmental



Facilities



Geotechnical



Materials



August 27, 2021

Halff Associates, Inc.
100 NE Loop 410, Suite 200
San Antonio, TX 78216

Attn: Mr. Sam Edwards, P.E., CFM
Senior Project Manager

Re: Geotechnical Engineering Report
Old Boerne Road Reconstruction
Between Bulverde Crossing and Hwy 46
Bulverde, Texas
Terracon Project Number: 90215174

Dear Mr. Edwards:

We have completed the Geotechnical Engineering services for the above referenced project. This report presents the findings of the subsurface exploration and provides geotechnical recommendations for the proposed project.

We appreciate the opportunity to work with you on this project and look forward to contributing to the ongoing success of this project by providing **Materials Testing and Special Inspection** services during construction. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
(Firm Registration: TX F3272)

Tariqul Anwar, P.E.
Project Engineer

TA/GPS/mhb – 90215174

Mike T. Ghazawi, P.E.
Senior Principal

Terracon Consultants, Inc. 6911 Blanco Road San Antonio, Texas 78216
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**GEOTECHNICAL ENGINEERING REPORT
 OLD BOERNE ROAD RECONSTRUCTION
 BETWEEN BULVERDE CROSSING AND HWY 46
 BULVERDE, TEXAS
 Terracon Project No. 90215174
 August 27, 2021**

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) is pleased to submit our Geotechnical Engineering Report for the Old Boerne Road Reconstruction will be re-constructed between Bulverde Crossing and Hwy 46 in Bulverde, Texas. The project was authorized by issuing a Standard Subcontract for Subsurface/Underground Services. This study was performed in general accordance with Terracon Proposal Number P90215174. dated July 1, 2021. The geotechnical engineering scope of services for this project included the advancement of two test borings to depths ranging from approximately 9 to 10 feet below existing site grades.

The purposes of this report are to describe the subsurface conditions observed at the borings drilled for this study, analyze and evaluate the test data, and provide recommendations with respect to:

- subsurface soil conditions
- earthwork
- groundwater conditions
- pavement design and construction

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-1 and A-2: Site Location Plan and Boring Location Plan, respectively.
Roadways	The project scope includes design and reconstruction of Old Boerne Road approximately 785 linear feet.
Pavement	Flexible pavement will be considered.
Traffic Load	Based on the provided traffic data by Halff Associates, Inc. via an email dated August 26, 2021 and Code of Ordinances of City of Bulverde (Ordinance 643 adopted 4/13/21) the roadway will be designed for a collector type road which corresponds 6 million ESALs for a flexible (asphalt) pavement.

2.2 Site Location and Description

Item	Description
Location	This project will be along Old Boerne Road between Bulverde Crossing and Hwy 46 in Bulverde, Texas.
Existing improvements	Existing roadway.
Current ground cover	Asphalt.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the borings subsurface conditions on the project site can be generalized as follows:

Approximate Depth Below Existing Grade (feet)	Material Encountered	Consistency/Density
PAVEMENT SECTION: 1" to 1½" Asphalt over 2" to 7½" Flexible Base Material		
¾ to 8	CLAYEY GRAVEL (GC) ¹ ; light brown	Medium Dense to Very Dense
¼ to 10	LEAN CLAY (CL) ² ; with gravel, light brown, tan	Stiff to Hard
¹	The CLAYEY GRAVEL materials could undergo low volumetric changes (shrink/swell) should they experience changes in their in-place moisture content. These materials are considered volumetrically stable with regards to change in moisture content due to their granular nature.	
²	The LEAN CLAY (CL) materials could undergo low volumetric changes (shrink/swell) should they experience changes in their in-place moisture content.	

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.2 Groundwater

Groundwater generally appears as either a permanent or temporary water source. Permanent groundwater is generally present year round, which may or may not be influenced by seasonal and climatic changes. Temporary groundwater water is also referred to as a "perched" water source, which generally develops as a result of seasonal and climatic conditions.

Borings were drilled to their full depths using dry drilling techniques to aid in the observation of groundwater. Groundwater was not encountered in the borings. Groundwater levels are

influenced by seasonal and climatic conditions which generally result in fluctuations in the elevation of the groundwater level over time. Additionally, the gravel zone may become water bearing after a precipitation event and can readily transmit water. Therefore, the contractor should check the groundwater conditions just before excavation activities.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The recommendations, comments, and suggestions in this section are provided so project drawings, documents, and specifications can be prepared and to make certain the intent of our design recommendations are achieved. Details regarding excavation, dewatering, selection of equipment/machinery, trafficability, project site safety, shoring, and other similar construction techniques requiring “means and methods” to accomplish the work is the sole responsibility of the project contractor. Our comments and opinions do not relieve the contractor’s responsibility to establish and maintain all aspects of site safety.

4.1.1 Potential Vertical Rise (PVR) Consideration

Based on the field exploration results and the laboratory test results, the subsurface soils at this site generally exhibit a low expansion potential. Based on the information developed from our field and laboratory programs and on method TEX-124-E in the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, we estimate that the subgrade soils at the site exhibit a Potential Vertical Rise (PVR) of about 1 inch in its present condition. The actual movements could be greater than the values presented in this report if inadequate drainage, ponded water, and/or other sources of moisture are allowed to infiltrate beneath the pavement after construction.

4.1.2 Sulfate Considerations

Sulfate tests were performed on selected sample collected from the borings to check for possible adverse reactions with lime or cement treatment. Testing was not performed on all borings nor at all depths. Sulfate content concentrations test results are as follows:

Boring No.	Approximate Depth, feet	Sulfate Content, ppm
B-1	2½ – 4	76.5
B-2	0 – 1½	80.6

Based on the test results, the sulfate effect at this site is considered to be low. Using the criteria from ACI 201.2R, the test results were classified as Class 0. The soluble sulfate test results do not indicate a concern related to the use of calcium-based soil modifier such as hydrated lime in the upper clay soil.

4.1.3 California Bearing Ratio (CBR) Test Results

To evaluate the subgrade CBR value at this site, we tested a bulk sample of the anticipated predominate subgrade soil type collected in the upper 2 to 3 feet of soil. Based on the CBR test result, an average CBR value of about 4 percent is estimated for the untreated soil subgrade for 95% compaction. The results of the CBR test and the moisture-density relationships are presented on Exhibits B-2 and B-3.

4.1.4 Lime Series and Soluble Sulfate Content Tests Results

Lime series tests were performed on the subgrade soils. Based on the lime series testing results, lime treatment of onsite soil is not necessary. The results are presented in Exhibits B-4 and B-5 in this report.

4.2 Earthwork

The following presents recommendations for general site preparation and placement of engineered fills on the project. The recommendations presented for design and construction of pavements are contingent upon following the recommendations outlined in this section. Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, and other geotechnical conditions exposed during the construction of the project.

4.2.1 Site Preparation

Construction operations may encounter difficulties due to the wet or soft surface soils becoming a general hindrance to equipment due to rutting and pumping of the soil surface, especially during and soon after periods of wet weather. If the subgrade cannot be adequately compacted to minimum densities as described in the **Compaction Requirements** section of this report, one of the following measures may be required: 1) removal and replacement with select fill, or 2) drying by natural means if the schedule allows.

Prior to placing any fill, existing pavement, any vegetation, loose topsoil, and any otherwise unsuitable materials should be removed from the proposed road alignment. The stripped materials consisting of vegetation and organic materials should be wasted from the site, or used to revegetate landscaped areas or exposed slopes after completion of grading operations. Wet or dry material should either be removed or moisture conditioned and recompacted. After stripping and grubbing, the subgrade should be proof-rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a fully loaded dump truck or comparable pneumatic tired vehicle. Soft, dry and low-density soil should be removed or compacted in place prior to placing fill.

4.2.2 Grading and Drainage

Pavements will be subject to post-construction movement. Maximum grades practical should be used for paving to prevent water from ponding. Allowances in final grades should also consider post-construction movement of pavement, particularly if such movement would be critical. Positive drainage should be provided during construction and maintained throughout the life of the pavement. Utility trenches are a common source of water infiltration and migration. Infiltration of water into utility trenches should be prevented during construction.

4.2.3 Material Requirements

Fill Type ¹	USCS Classification	Acceptable Location for Placement
Granular Base Course ²	varies	Pavement areas.
Imported Select fill	CL, SC (7≤PI≤20)	Can be used for site grading if grades are to be raised.
On-site soils	CL, GC	The on-site soils appear suitable for use within the pavement areas, provided they are free of organics and debris maximum particle size of about 2 inches.

¹ Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

² Granular select fill should consist of 2014 TxDOT Item 247, Type A, Grade 1-2 crushed limestone material.

4.2.4 Compaction Requirements

Item	Description
Fill Lift Thickness	All fill should be placed in thin, loose lifts not to exceed 8 inches, with compacted thickness of about exceed 6 inches.
Compaction of On-Site Soil, Select Fill	At least 95 percent of the material's standard Proctor maximum dry density (ASTM D698).
Compaction of Granular Base Course	At least 95 percent of the maximum dry density as determined by the modified moisture-density relation (ASTM D1557).
Moisture Content of Select Fill; Granular Base Course and On-Site Soil	The materials should be moisture conditioned between -2 and +3 percentage points of the optimum moisture content.

4.2.5 Earthwork Construction Considerations

The ground conditions may become wet and very soft after a precipitation event. The stability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. Over-excavation of wet and soft zones and replacement with more competent materials may be necessary.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards. OSHA Safety and Health Standards (29 CFR Part 1926 Revised, 1989) require that all trenches in excess of 5 feet deep be shored or appropriately sloped unless the trench sidewalls are comprised of “solid” rock. “Solid” rock was not encountered in the soil borings drilled at this site. State of Texas legislation requires that detailed plans and specifications for trench retention systems meet OSHA standards for a safe construction environment during utilities installation.

4.3 Pavements

Flexible pavement systems will be considered for the project. Pavement designs were based on the American Association of State Highway and Transportation Officials' (AASHTO) *Guide for Design of Pavement Structures* (1993).

Based on the provided traffic data by Half via an email dated August 26, 2021 and Code of Ordinances of City of Bulverde (Ordinance 643 adopted 4/13/21) the roadway was designed for a collector type road which corresponds to 6 million ESALs for a flexible (asphalt) pavement.

4.3.1 Design Considerations

The near-surface clayey soil is anticipated to be the predominate subgrade for the pavements at this site. The thickness of each course is a function of subgrade strength, anticipated traffic volume, design life, serviceability factors, and frost susceptibility.

Flexible pavement sections are typically designed using a CBR value. We have collected bulk samples from the upper 3 feet of onsite soil below existing pavement section. CBR and moisture density relationship tests were conducted on the bulk samples. Based on the results from the tests, an average CBR value of 4.0 for the design was used.

Proper perimeter drainage is very important and should be provided so infiltration of surface water from unpaved areas surrounding the pavement is minimized. Water penetration usually results in degradation of the pavement section with time as vehicular traffic traverses the affected area.

Curbs should extend through the base and at least 3 inches into the soil subgrade below the base course. This will help reduce migration of subsurface water into the pavement base course from adjacent areas.

4.3.2 Design Parameters

The 1993 AASHTO pavement design method is typically used in this locale. The AASHTO design parameters include the following:

AASHTO Design Parameters	
18-kip Equivalent Single Axle Loads (ESAL),	W_{18}
Reliability,	R
Standard Deviation,	S_o
Environmental Effects,	$\Delta PSI_{ENV} = \Delta PSI_{SW} + \Delta PSI_{FH}$
Loss in Serviceability Index Due to Swelling Soils,	ΔPSI_{SW}
Loss in Serviceability Index Due to Frost Heave,	ΔPSI_{FH}
Initial Serviceability Index,	p_o
Minimum Serviceability Index,	p_t
Total Change in Serviceability Index,	$\Delta PSI = p_o - p_t$
Effective Road Bed Soil Resilient Modulus,	M_r
Pavement Service Life,	T

Flexible pavement design parameters for 2 million ESAL are presented below.

Design Parameter	Collector Road
	Flexible Pavement
R	95 percent
ΔPSI	2.5
p_t	2.0
T	30 year design life
S_o	0.39
W_{18}	6,000,000
p_o	4.5
Minimum Structural Number (SN)	2.92
Maximum Structural Number (SN)	5.08

Pavement sections are typically designed using a California Bearing Ratio (CBR) value for flexible pavements. The resilient modulus value, M_r , is based on the most common subgrade soil condition encountered in our borings. The CBR is often used to aid in approximating M_r . Generally, the CBR and M_r can be related as follows:

$$M_r = 2555 * CBR^{0.64}$$

with M_r given in pounds per square inch (psi).

Based on the test results, a CBR value of 4 was considered for design of the pavement. The next step in the AASHTO method is the determination of the Structural Number (SN), which can either be calculated using formulae in the AASHTO Guide or by using a nomograph contained in the guide. The total required pavement thickness is then based on the following equation:

$$SN = a_1 \cdot D_1 \cdot m_1 + a_2 \cdot D_2 \cdot m_2 + a_3 \cdot D_3 \cdot m_3 + \dots + a_n \cdot D_n \cdot m_n$$

Where:

- a_n = structural coefficient of material "n",
- D_n = thickness of material "n", inches
- m_n = drainage coefficient for material "n"

Generally, the most cost effective pavement section can be obtained by maximizing the thicknesses of the materials with the lowest structural coefficient where applicable. Recommended minimum compacted layer thicknesses, approximate structural coefficients, and drainage coefficients are as follows:

Pavement Components	Minimum Thickness	Structural Coefficient	Drainage Coefficient
Type D HMAC Surface	1½ inches	0.44	1.00
Type C HMAC Surface	2½ inches	0.44	1.00
Type A or B HMAC Base	4 inches	0.38	1.00
Untreated Flexible Base Material	6 inches	0.14	1.00
Stabilized Subgrade	6 inches	0.08	1.00

The drainage coefficient, m, is dependent on the quality of drainage in the untreated base and modified subgrade (i.e. lime treated clay) layer of the flexible pavement section. Good drainage (i.e. Drainage Coefficient, m = 1) corresponds to water being removed from each layer in one day; and the pavement structure is exposed to moisture levels approaching saturation from 5 to 25 percent of time. If improper materials are used or standing water can develop due to construction or design deficiencies, the quality of drainage would be fair to very poor, which would reduce the drainage coefficient, m, and ultimately the structural capacity of the pavement. The AASHTO design procedure provides more guidance and discussion regarding this issue.

4.3.3 Pavement Thickness Design Recommendations

Asphalt pavement design recommendations for the provided traffic loading category are outlined in the following table. The recommendations for pavement thickness are based on the borings drilled in the existing road alignment. Any deviations below subsurface from the encountered soil conditions in borings during the construction need to be notified to Terracon and design recommendations may need to be modified.

6 Million ESAL (Collector Road)		
Components	Option 1	Option 2
Warm Mix Asphaltic Concrete (Type D), inches	2.0	2.0
Warm Mix Asphaltic Concrete (Type B) - Base, inches	3.0	6.0
Granular Base Material, inches	17.0	9.0
Moisture Conditioned Subgrade, inches	6.0	6.0
Required Structural Number	4.79	
Actual Structural Number	4.83	4.85

4.3.4 Pavement Section Materials

Presented below are selection and preparation guidelines for various materials that may be used to construct the pavement sections. Submittals should be made for each pavement material. The submittals should be reviewed by the Geotechnical Engineer and appropriate members of the design team and should provide test information necessary to verify compliance with the recommended or specified material properties.

- **Hot Mix Asphaltic Concrete Surface Course** - The asphaltic concrete surface course should be plant mixed, hot laid Type D Surface. Each mix should meet the master specifications requirements of 2014 TXDOT Standard Specifications Item 341, Item SS 3224 (2011) and specific criteria for the job mix formula. The mix should be compacted between 91 and 95 percent of the maximum theoretical density as measured by TEX-227-F. The asphalt cement content by percent of total mixture weight should fall within a tolerance of ±0.3 percent asphalt cement from the specific mix. In addition, the mix should be designed so 75 to 85 percent of the voids in the mineral aggregate (VMA) are filled with asphalt cement. The grade of the asphalt cement should be PG 70-22 or higher performance grade. Aggregates known to be prone to stripping should not be used in the hot mix. If such aggregates are used measures should be taken to mitigate this concern. The mix should have at least 70 percent strength retention when tested in accordance with TEX-531-C.

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 pavement specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required pavement specimens at their expense and in a manner and at locations selected by the Engineer.

- **Asphaltic Base Course** - The asphaltic base material should meet the specification requirements of 2014 TxDOT Standard Specification Item 340, Type A or B.

- **Granular Base Material** - Base material may be composed of crushed limestone base or crushed concrete meeting all of the requirements of 2014 TxDOT Item 247, Type A, Grade 1-2; including triaxial strength. The material should be compacted to at least 95 percent of the maximum dry density as determined in accordance with ASTM D1557 at moisture contents ranging from -2 and +3 percentage points of the optimum moisture content.

- **Moisture Conditioned Subgrade** - The subgrade should be scarified to a depth of 6 inches and clay subgrade should be moisture conditioned between -2 and +3 percentage points of the optimum moisture content. The subgrade should then be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D698.

Details regarding subgrade preparation and fill placement and compaction are presented in the subsections titled **Earthwork** and **Pavement**.

4.4.5 Pavement Drainage and Maintenance

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventative maintenance. The following recommendations should be implemented to help promote long-term pavement performance:

- The subgrade and the pavement surface should be designed to promote proper surface drainage, preferably at a minimum grade of 2 percent;
- Install joint sealant and seal cracks immediately;
- Extend curbs into the treated subgrade for a depth of at least 4 inches to help reduce moisture migration into the subgrade soils beneath the pavement section; and
- Place compacted, low permeability clayey backfill against the exterior side of the curb and gutter.
- Slope subgrade in landscape islands to low points should drain to an appropriate outlet.
- Edge drains are recommended along pavement/ landscape borders.

4.4.6 Pavement Reuse

A pulverized, uniform mixture of the existing asphaltic concrete and coarse aggregate base may also be used as a modified subgrade (subbase). The material should have particles no larger than 2 inches, and be moisture conditioned to between -2 and +3 percentage points of optimum. The material should be placed in loose lifts of no more than 8 inches in thickness, and be compacted to at least 95 percent of the maximum density determined in accordance with ASTM D1557 to achieve compacted lifts of about 6 inches. The existing base material may also be

reused in the pavement provided that it is tested and meets the requirements in the “Granular Base Material” section of this report.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, pavement construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided. Prospective contractors should familiarize themselves with the conditions at the site and retain their own experts to interpret the data in this report and perform additional testing and/or inspection as they deem necessary prior to bidding.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A FIELD EXPLORATION

EXHIBIT A-1: SITE LOCATION PLAN

Old Boerne Road Reconstruction ■ Bulverde, Texas

August 26, 2021 ■ Terracon Project No. 90215174

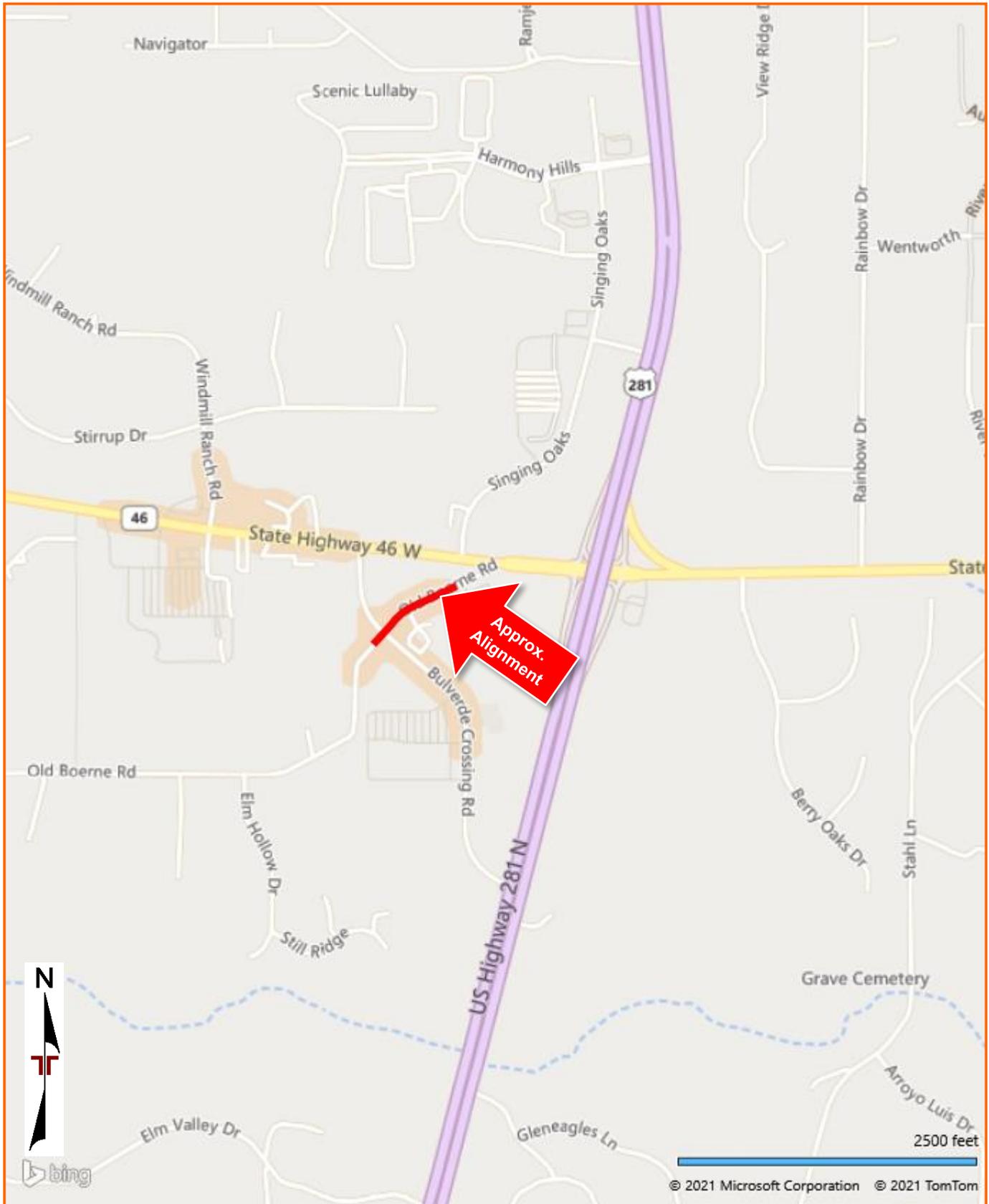


EXHIBIT A-2: BORING LOCATION PLAN

Old Boerne Road Reconstruction ■ Bulverde, Texas

August 26, 2021 ■ Terracon Project No. 90215174



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES
AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Geotechnical Engineering Report

Old Boerne Road Reconstruction ■ Bulverde, Texas

August 27, 2021 ■ Terracon Project No. 90215174



Field Exploration Description

We use handheld GPS equipment to locate borings with an estimated horizontal accuracy of +/- 20 feet. The location of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

A truck-mounted drill rig was used to advance the boreholes. Soil samples were obtained by split-barrel sampling procedures. In the split barrel sampling procedure, a standard 2-inch outer diameter split barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths.

Our field representative prepared the field logs as part of the drilling operations. The field logs included visual classifications of the materials encountered during drilling and our field representative interpretation of the subsurface conditions between samples. Each boring log included with this report represents the engineer's/geologist's interpretation of the field logs and include modifications based on visual observations and testing of the samples in the laboratory.

The scope of services for our geotechnical engineering services does not include addressing any environmental issues pertinent to the site.

BORING LOG NO. B-1

PROJECT: Old Boerne Road Reconstruction

CLIENT: Halff Associates, Inc.
San Antonio, Texas

SITE: Between Bulverde Crossing and Hwy 46
Bulverde, Texas

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_ 90215174 OLD BOERNE ROAD R.GPJ TERRACON_DATATEMPLATE.GDT 8/26/21

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 29.7972° Longitude: -98.4232°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS		PERCENT FINES
							LL-PL-PI		
	DEPTH								
	0.3 PAVEMENT SECTION: 1" Asphalt over 2" Base Material LEAN CLAY (CL) , with gravel and sand, tan, stiff to hard			X	9-15-8 N=23	12.4	35-20-15		
				X	7-10-9 N=19	17.8	26-19-7	56	
		5		X	7-4-5 N=9	19.6			
				X	5-14-12 N=26	15.3	28-15-13		
	- gravelly below 8 feet			X	50/5"	15.2			
	9.0 Boring Terminated at 9 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method: Flight auger		Notes:	
Abandonment Method:			
WATER LEVEL OBSERVATIONS No free water observed	<p style="font-size: 0.8em; margin-top: 5px;">6911 Blanco Rd San Antonio, TX</p>	Boring Started: 07-29-2021 Drill Rig: CME 75 Project No.: 90215174	Boring Completed: 07-29-2021 Driller: Ramco Exhibit: A-1

BORING LOG NO. B-2

PROJECT: Old Boerne Road Reconstruction

CLIENT: Halff Associates, Inc.
San Antonio, Texas

SITE: Between Bulverde Crossing and Hwy 46
Bulverde, Texas

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 90215174 OLD BOERNE ROAD R.GPJ TERRACON.DATATEMPLATE.GDT 8/26/21

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 29.7966° Longitude: -98.4246°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS		PERCENT FINES
							LL-PL-PI		
	PAVEMENT SECTION: 1.5" Asphalt over 7.5" Base Material								
0.8	CLAYEY GRAVEL (GC) , with sand, light brown, medium dense to very dense			X	5-4-9 N=13	14.3			42
				X	30-41-50/4"	11.8	27-19-8		
		5		X	26-30-14 N=44	13.0	26-15-11		50
	- Gravelly Lean Clay (CL) at 6 feet			X	50/5"	14.9			
8.0	LEAN CLAY (CL) , tan, very stiff			X	10-10-19 N=29	23.8	36-14-22		
10.0	Boring Terminated at 10 Feet	10							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Flight auger

Abandonment Method:

Notes:

WATER LEVEL OBSERVATIONS

No free water observed



Boring Started: 07-29-2021

Boring Completed: 07-29-2021

Drill Rig: CME 75

Driller: Ramco

Project No.: 90215174

Exhibit: A-2

APPENDIX B LABORATORY TESTING

Geotechnical Engineering Report

Old Boerne Road Reconstruction ■ Bulverde, Texas
August 27, 2021 ■ Terracon Project No. 90215174



Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in this Appendix. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples and the test results are presented in this appendix. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Moisture Content
- Atterberg Limits
- Soils Finer than No. 200 Mesh Sieve
- Laboratory Standard Proctor Test
- California Bearing Ratio
- Sulfate Content
- Lime Series

Sample Disposal

All samples were returned to our laboratory. The samples not tested in the laboratory will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless other arrangements are made prior to the disposal period.

Laboratory Compaction Characteristics of Soil

Sample Information

Sample Number: ---
 Boring Number: ---
 Sample Location: Bulk Sample
 Depth (ft): 1 to 3

Material Designation: CL
 Test Method: ASTM D698
 Test Procedure: A
 Sample Preparation: Wet
 Rammer: Mechanical X
 Manual

Sample Description: Lean Clay with Gravel

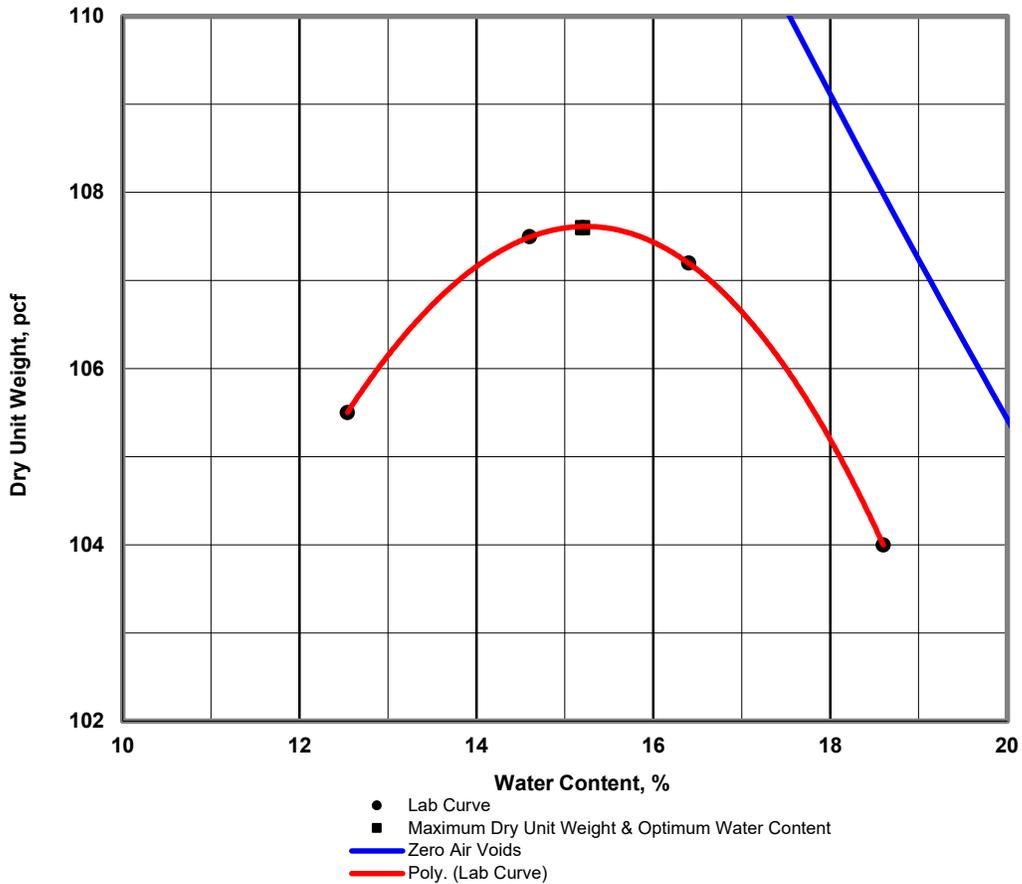
Atterberg Limits:

Liquid Limit: 29
 Plastic Limit: 18
 Plasticity Index: 11
 Natural Moisture (%): 8.7

TEST RESULTS

Maximum Dry Unit Wt.: 107.6 pcf
 Optimum Water Content: 15.2 %

Zero air voids for specific gravity of 2.55



Project Mngr. TA
 Drawn By: TA
 Checked By: TA
 Approved By: MTG

Project No. 90215174
 Scale As Shown
 File No. 90215174
 Date: 8/5/2021

Terracon
 Consulting Engineers and Scientists
 6911 Blanco Rd
 San Antonio, TX 78216
 210-641-2112

Laboratory Standard Proctor Test
 Old Boerne Road Reconstruction
 Between Bulverde Crossing and Hwy 46
 Bulverde, Texas

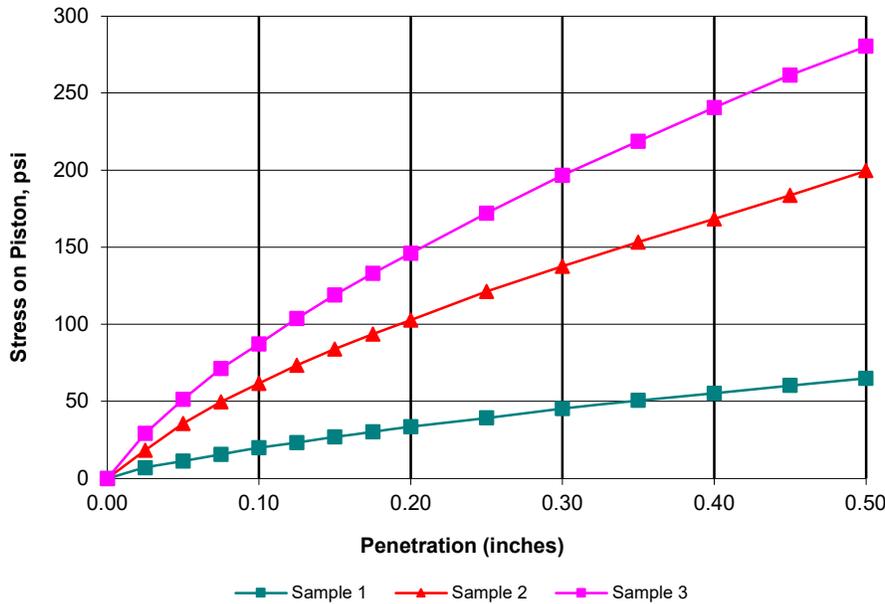
EXHIBIT
 B-2

California Bearing Ratio of Laboratory-Compacted Soils

Sample Information

Sample Number: _____	---	Proctor Method: _____	D698
Boring Number: _____	---	Maximum Dry Density (pcf): _____	107.6
Sample Location: _____	Bulk Sample	Optimum Moisture (%): _____	15.2
Depth: _____	1 to 3	Liquid Limit: _____	29
		Plasticity Index: _____	11

Material Description: Lean Clay with Gravel



Test information

Surcharge Wgt (lbs): _____	10
Soaked: _____	X
Unsoaked: _____	
Length of Soak (hrs): _____	48
Load Penetration Curve _____	

Test Results

Test Sample No. _____	5% Soaked (S-1)	5% Unsoaked (S-2)	7% Soaked (S-3)	7% Unsoaked (S-4)
-----------------------	-----------------	-------------------	-----------------	-------------------

Density Data

Dry Density before Soaking, (pcf)	97.2	105.8	108.5	
Degree of Compaction, (%)	90.3	98.3	100.9	
Dry Density after Soaking, (pcf)	97.9	105.8	109.5	

Moisture Content, (%)

Before Compaction	15.5	15.2	14.4	
After Compaction	15.1	14.9	15.5	
Top 1" After Soaking	22.6	20.9	18.3	
Average After Soaking	19.9	16.9	15.2	

Swell, (%)

0.5	0.4	0.4	0.0
-----	-----	-----	-----

Bearing Ratio

@ 0.100 inch	2.0	6.2	8.7	
@ 0.200 inch	2.2	6.8	9.7	

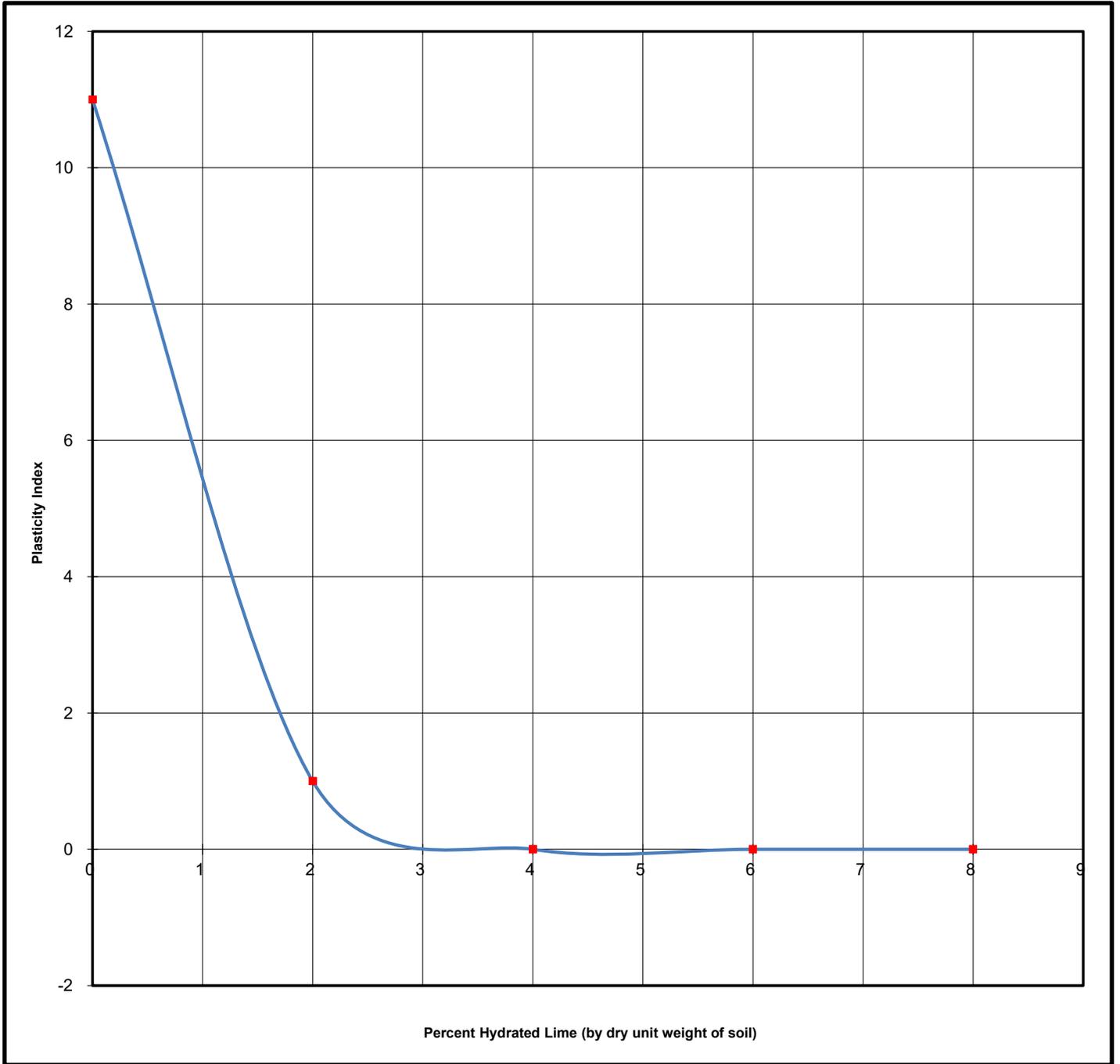
Project Mngr. TA	Project No. 90215174
Drawn By: _____	Scale As Shown
Checked By: TA	File No. 90215174
Approved By: MTG	Date: 8/5/2021

Terracon
Consulting Engineers and Scientists
6911 Blanco Rd
San Antonio, TX
210-641-2112

CBR of Lab Compacted Soils
Old Boerne Road Reconstruction
Between Bulverde Crossing and Hwy 46
Bulverde, Texas

EXHIBIT
B-3

SOIL-LIME MIXTURE DESIGN USING PLASTICITY INDEX (TEX-112-E)



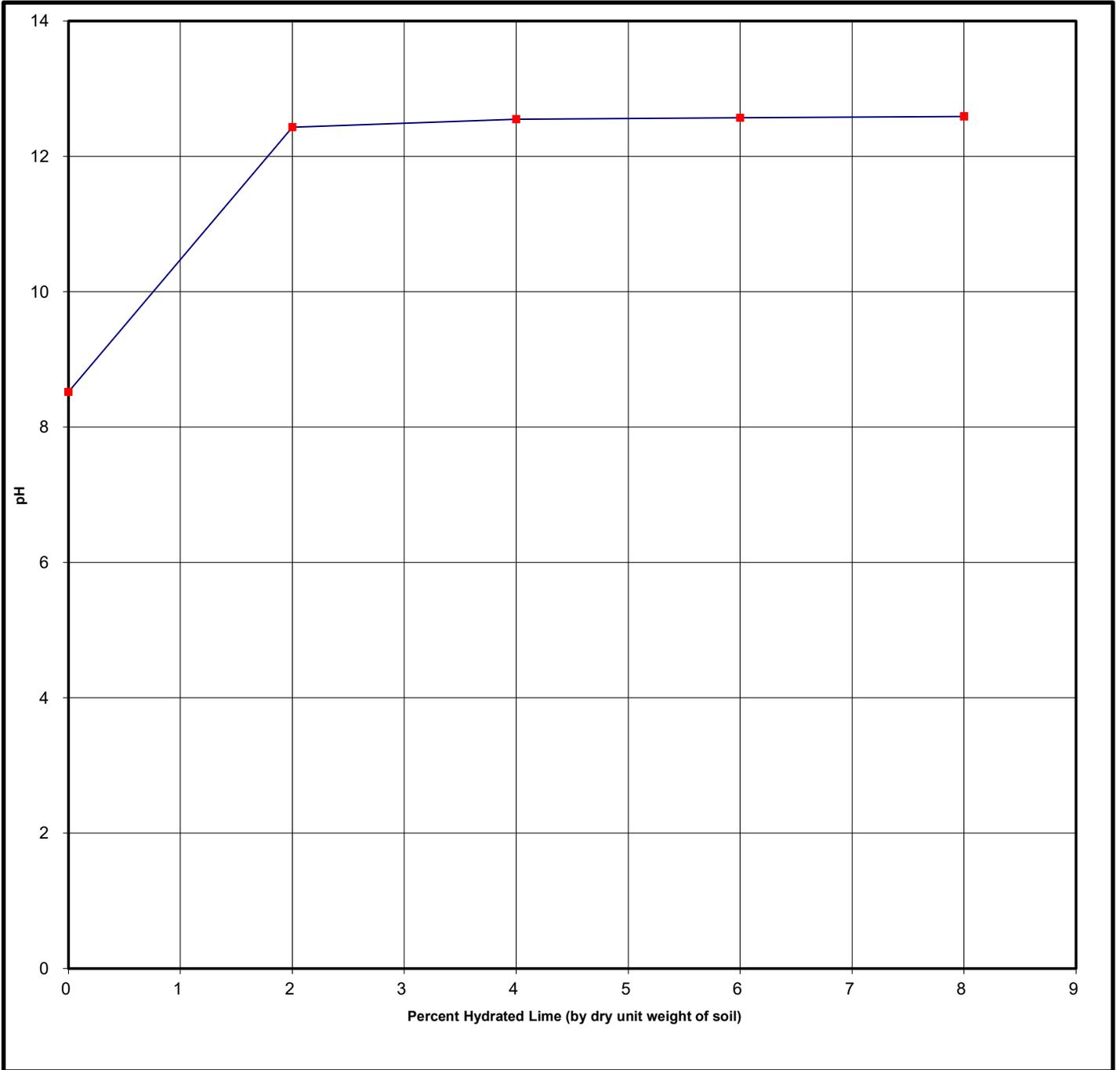
Project No. 90215174

Date 08/14/21

Exhibit B-4

TERRACON CONSULTANTS, INC.

HYDRATED LIME FOR SOIL STABILIZATION USING pH (ASTM C 977)



Project No. 90215174

Date 08/14/21

Exhibit B-5

TERRACON CONSULTANTS, INC.

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING			WATER LEVEL		Water Initially Encountered	FIELD TESTS	(HP) Hand Penetrometer	
	Auger	Split Spoon			Water Level After a Specified Period of Time		(T) Torvane	
					Water Level After a Specified Period of Time		(b/f) Standard Penetration Test (blows per foot)	
	Shelby Tube	Macro Core		Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.			(PID) Photo-Ionization Detector	
							(OVA) Organic Vapor Analyzer	
Ring Sampler	Rock Core							
								
Grab Sample	No Recovery							

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS	RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
	Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, tsf	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42
			Hard	> 4.00	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

<u>Major Component of Sample</u>	<u>Particle Size</u>
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

<u>Term</u>	<u>Plasticity Index</u>
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A				Soil Classification			
				Group Symbol	Group Name ^B		
Coarse Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines ^C	$Cu \geq 4$ and $1 \leq Cc \leq 3$ ^E	GW	Well-graded gravel ^F		
		Gravels with Fines: More than 12% fines ^C	Fines classify as ML or MH	GP	Poorly graded gravel ^F		
			Fines classify as CL or CH	GM	Silty gravel ^{F,G,H}		
		Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines ^D	$Cu \geq 6$ and $1 \leq Cc \leq 3$ ^E	GC	Clayey gravel ^{F,G,H}	
	Sands with Fines: More than 12% fines ^D		$Cu < 6$ and/or $1 > Cc > 3$ ^E	SW	Well-graded sand ^I		
			Fines classify as ML or MH	SP	Poorly graded sand ^I		
	Fines classify as CL or CH		SM	Silty sand ^{G,H,I}			
	Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	$PI > 7$ and plots on or above "A" line ^J	CL	Lean clay ^{K,L,M}	
$PI < 4$ or plots below "A" line ^J				ML	Silt ^{K,L,M}		
Organic:			Liquid limit - oven dried	< 0.75	OL	Organic clay ^{K,L,M,N}	
			Liquid limit - not dried		OH	Organic silt ^{K,L,M,O}	
Silts and Clays: Liquid limit 50 or more		Inorganic:	PI plots on or above "A" line	CH	Fat clay ^{K,L,M}		
			PI plots below "A" line	MH	Elastic Silt ^{K,L,M}		
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay ^{K,L,M,P}	
			Liquid limit - not dried		OH	Organic silt ^{K,L,M,Q}	
		Highly organic soils: Primarily organic matter, dark in color, and organic odor				PT	Peat

^A Based on the material passing the 3-inch (75-mm) sieve

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

^D Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

$${}^E Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^L If soil contains $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.

