Proposed Sherwin Williams – Fair Oaks

Geotechnical Engineering Report

January 18, 2023 | Terracon Project No. 90225351

Prepared for:

Belterra Partners LLC
728 Shades Creek Pkwy
Birmingham, Alabama, 35209

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January 18, 2023

Belterra Partners LLC
728 Shades Creek Pkwy
Birmingham, Alabama, 35209

Attn: Mr. Scott Smith

Re: Geotechnical Engineering Report
Proposed Sherwin Williams – Fair Oaks
IH-10 Access Road
Fair Oaks Ranch, Texas
Terracon Project No. 90225351

Dear Mr. Smith:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. P90225351 dated November 30, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning the design and construction of a restaurant and associated pavements 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 services during construction. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon
(Firm Registration No. F3272)

Andrew Anderson.
Project Manager

Arin Barkataki, P.E.
Principal Engineering Manager

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Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed Sherwin Williams facility and associated pavements to be located on the IH-10 Access Road in Fair Oaks Ranch, Texas. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Pavement design and construction

The Geotechnical Engineering Scope of Services for this project included drilling, laboratory testing, engineering analysis, and preparation of this report. The field program for this project included the advancement of five (5) test borings with depths ranging from between about 5 to 20 feet below grade surface (bgs).

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and separate graphs in the **Exploration Results** section.

Project Description

Our final understanding of the project conditions is as follows:

Item	Description
Project Description	The project includes a 4,500 sq. ft. building with associated parking and driveways.
Building Construction	The building is anticipated to be constructed of wood or metal frame and supported on shallow foundations.
Foundation Loads (Assumed)	Columns: up to 75 kips Walls: up to 3 kips per lineal feet
Existing Topography	Based on a preliminary site grading plan provide by Mr. Eric Warford with KFW, the site elevation ranges from about EL. 1422 feet in the north/northwest to about EL. 1425 feet in the south.

Item	Description
Finished Floor Elevation	Based on a preliminary grading plan provide by Mr. Eric Warford with KFW, the Finished Floor Elevation in 1427.10 for the proposed building.

Terracon should be notified if any of the above information is inconsistent with the planned construction, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located on the IH 10 access road in Fair Oaks RanchTX. See **Site Location**
Existing Improvements	The site appears to have been graded during the development of adjacent lots.
Current Ground Cover	Bare soil, grass, and some trees.

Geotechnical Characterization

Site Geology

The San Antonio Sheet (1983) of the Geologic Atlas of Texas published by the Bureau of Economic Geology of the University of Texas at Austin has mapped the **Glen Rose Limestone Formation**. The Glen Rose Limestone Formation subsurface materials encountered on-site are residual soil and weathered limestone of the Glen Rose Formation. The Glen Rose is a Cretaceous aged limestone comprised typically of alternating hard and soft layers of limestone, dolomite, marl, and completely weathered limestone. Surface expression of the formation is readily identifiable by its stair-stepped topography which is caused by differential weathering of the interbedded layers of soft and hard rock. Lithologically, the upper part of the Glen Rose is described as relatively thin interbeds of tan and gray limestone, yellowish brown dolomitic limestone, and dolomite. The alternating hard and soft beds form stairstep topography. Foundations bearing on Glen Rose limestone are generally stable.

Subsurface voids in the form of vugs, cavities, and caves do occur in the Glen Rose Formation, but not as commonly as in Edwards Limestone, known for its cavernous features. The voids are created through a geomorphic process requiring large quantities of flowing water through cracks and fissures in the rock over geologic time. The voids are solution features resulting from the slow dissolving of the limestone by acidic water. Rainfall and runoff in areas where live oak trees are present are typically slightly acidic. When the subsurface voids are present near the ground surface, the features may become unstable and collapse. Ancient features which have collapsed will generally fill in with surficial soils and are referred to as 'closed depressions'.

Subsurface Conditions

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. In general, the conditions consist of a thin veneer of clayey gravel over Limestone. The clayey gravel is on the order of 2 ft thick. As part of our analyses, we identified the following soil types within the subsurface profile.

No	Soil Type	General Description
1	Clayey Gravel[1]	Brown, Light Brown: Medium Dense to Dense
2	Limestone[2]	Light Tan to Light Gray; Hard
1/ The CLAYEY GRAVEL soils are primarily granular in nature and are expected to possess a negligible potential for volumetric changes as a result of moisture fluctuations.		
2/ The LIMESTONE is volumetrically stable when considered for expansive soil-related movements. However, the Edwards is considered a karstic formation and it is possible that voids may be encountered during construction.		

The individual logs can be found in the **Exploration Results** section of this report. It should be emphasized the stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

Groundwater Conditions

The borings were advanced to the required depths using dry drilling techniques to evaluate groundwater conditions at the time of our field program. The boreholes were observed for the presence of groundwater during and after completion of drilling. Groundwater was not observed in any of the locations.

Seasonal variations such as amount of rainfall and runoff, climatic conditions and other factors generally result in fluctuations of the groundwater level over time. The granular strata can easily transmit water. **After periods of heavy rain, water may be encountered in the seams and fractures contained within the weathered limestone. Also, in the Glen rose formation, seepage occurrence at the interface of Clay layers and Limestone is a common phenomenon.** Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The foundation contractor should check the groundwater conditions just before foundation excavation activities.

Seismic Site Class

Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with 1613.2.2 in the 2021 IBC and Table 20.3-1 in the 2016 ASCE-7. Based on the soil properties observed at the site and as described on the exploration logs and results, our professional opinion is for that a **Seismic Site Classification of C** be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 20 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area.

Geotechnical Overview

Based on our findings, the subsurface soils at this site generally exhibit low shrink/swell potential. Based on the information developed from our field and laboratory programs and on method TEX-124-E of the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, we estimate that the subgrade soils at this site exhibit a Potential Vertical Rise (PVR) of less than 1 inch in their present condition. It should be emphasized that the actual movements could be greater than the values presented in this report because of inadequate drainage, ponded water and moisture infiltration beneath the structures after construction.

Rock Excavation

Excavation operations at this site may penetrate through the upper Clayey gravel soils and into the underlying Limestone. While the soils should be relatively easy to excavate in comparison to the underlying Limestone, there is a probability of encountering cobbles, boulders, seams, and layers within these soils. Our past experience with the Limestone, along with the data obtained during our field work indicates that the Limestone may require sawcutting, jackhammering, hoe-ramming, milling, or similar techniques to excavate. The Contractor should be prepared to encounter and properly excavate near-surface Limestone anywhere on this site.

Our comments on excavation are based on our experience with the rock formation. Rock excavation depends on not only the rock hardness, weathering and fracture frequency, but also the contractor’s equipment, capabilities, and experience. Therefore, it should be the contractor’s responsibility to determine the most effective methods for excavation.

The above comments are intended for information purposes for the design team only and may be used to review the contractor's proposed excavation methods.

Earthwork

Earthwork is anticipated to include clearing and grubbing, excavations, and engineered fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, and pavements.

General Site Preparation

Prior to construction, the work area should be cleared off loose topsoil and any otherwise unsuitable materials should be removed from the construction area. 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. Soils that are observed to rut or deflect excessively (typically greater than 1-inch) under the moving load should be undercut and replaced with properly compacted on-site soils. The proof rolling and undercutting activities should be witnessed by a representative of the Geotechnical Engineer and should be performed during a period of dry weather. 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 Fill Compaction Requirements section of this report, one of the following measures may be required:

- Removal and replacement with Select Fill;
- Chemical treatment of the soil to dry and increase the stability of the subgrade; or
- Drying by natural means if the schedule allows.

Pad Preparation

Based on a grading plan provided to Terracon. we understand the grading at the building location ranges between about EL. 1425 and 1427 feet. We also understand the Finished Floor Elevation (FFE) of the building will be set at about EL. 1427.10 feet. Based on an assumed slab thickness of about 6 inches, the Finished Building Pad Elevation (FBPE) will be set at about EL. 1426.6 feet.

As previously mentioned, the Potential Vertical Rise (PVR) of the subgrade soils is less than 1 inch for the current conditions at the site. Recommendations for at-grade pad preparation to provide uniform support to the grade supported slabs are provided below.

- After completing stripping operations as discussed in the **General Site Preparation** section, excavate onsite soil to an elevation to about EL. 1425 feet of onsite soils or exposing the limestone in the building pad area. The excavated soil may be stockpiled for later used. The pad area is defined as the area that extends at least 3 feet (horizontal) beyond the perimeter of the proposed slab areas or to the outside edge of any movement sensitive flatwork. The limits of the pad should be indicated on the drawings. **Since the thickness of the Clayey Gravel soils and the depth to Limestone varies across the project site, some variability in the excavation depth should be anticipated.**

- After excavating as specified above, the exposed subgrade should be proof rolled with a fully loaded dump truck or comparable pneumatic tired vehicle to evidence any weak yielding zones. A Terracon Geotechnical Engineer or their representative should be present to observe proof rolling operations.

- After proof rolling and replacement of weak yielding zones, the subgrade should be scarified, moisture conditioned between -2 and +3 percentage points of the optimum moisture content and compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. Moisture conditioning is not necessary if limestone is exposed.
- Place granular select fill to an elevation of 1426.6 feet in loose lifts of about 8 inches to achieve the Finished Building Pad Elevation (FBPE). Each lift should be moisture conditioned between -2 and +3 percentage points of the optimum moisture content, and then compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

- If grades are to be raised further, Granular Select Fill should be used to achieve FBPE.

Flatwork

As previously stated, we estimate that the subgrade soils at this site exhibit a PVR of less than 1 inch in their present condition. As indicated above, we recommend movement sensitive flatwork be included in the building pad. This is especially important for flatwork immediately adjacent to the building near entrances. The pad should extend only to the edge of the flatwork.

If cracking or any distress is not desired in other flatwork areas, then the pad beneath the flatwork should be prepared as described under Building Pad Preparation section. If the flatwork is not prepared as recommended under the Building Pad Preparation section, then movement and cracking should be expected that may result in uneven flatwork which in turn may cause trip hazard or reverse surface flow or doors which drag on the flatwork when opened. Consider including the door stoops into the slab to prevent interference with door operations.

Fill Material Types

Fill required to achieve design grade should be classified as Select Fill and General Fill. Material property requirements for General Fill and Select Fill are noted in the table below:

Fill Type	USCS Classification	Comments
Granular Select Fill	Varies	Notes 1 and 2
General Fill (Onsite Soils)	GC	Note 3
Granular Fill	Crushed Limestone (ASTM C33, Grade 57)	All locations and elevations

1/ Prior to any filling operations, samples of the proposed Select Fill 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 ensure that proper levels of compaction, including dry unit weight and moisture content are attained.

2/ Granular Select Fill should consist of material conforming to the gradation requirements of 2014 TxDOT Item 247, Type A, Grade 1-2 crushed limestone base material. If properly processed, excavated LIMESTONE from cut areas of the site may be considered for use as Granular Select Fill. The Limestone should be processed such that a relatively well-graded grain size distribution with a maximum rock size of 3 inches is achieved for building pad areas

3/ GC soils can be used as General Fill provided it meets the select fill criteria.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill
Fill Lift Thickness	All fill should be placed in thin, loose lifts of about 8 inches, with compacted thickness not exceeding 6 inches.
Compaction of Granular Select Fill	95 percent of the material's Standard Proctor maximum dry density (ASTM D 698)
Moisture Content of Granular Select Fill	Between -2 and +3 percentage points of the optimum moisture content.

Grading and Drainage

Effective drainage should be provided during construction and maintained throughout the life of the new improvements. After pad construction, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Proper site drainage should be maintained during the entire construction phase so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access, particularly in cut areas. During construction, it is possible that the surficial soils may become excessively wet as a result of inclement weather conditions. When the moisture content of these gravelly soils elevates above what is considered to be the optimum range of moisture for compaction operations, they can become difficult to handle and compact. If such conditions create a hindrance to compaction operations or site access, cement may be mixed with these soils to improve their workability. The additive can be mixed as per 2014 TxDOT Item 275 (cement). The purpose of the additive is to dry out the subgrade and improve site access. The strict requirements for curing and actual quantity of additive can be at the discretion of the contractor. The subgrade, however, should be compacted to at least 95 percent of the maximum dry density as per ASTM D 698 at moisture contents ranging from -2 to +3 percentage points of the optimum moisture content.

Flatwork and pavements will be subjected to post-construction movement. Maximum grades that are feasible should be used for paving and flatwork to prevent water from ponding. Allowances in final grades should also consider post-construction movement of flatwork, particularly if such movements are deemed critical. Where paving or flatwork abuts the structure, joints should be effectively sealed and maintained to prevent surface water infiltration. In areas where sidewalks or paving do not immediately adjoin the structure, we recommend that protective slopes be provided with a grade of at least five percent for at least 10 feet from perimeter walls (except in areas where ADA ramps are required; these should comply with state and local regulations). Backfill against grade beams, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of construction debris to reduce the possibility of moisture infiltration.

Planters and other surface features which could retain water in areas adjacent to the structures should be properly drained, designed, sealed or eliminated. Landscaped irrigation adjacent to the foundation systems should be properly designed and controlled to help maintain a relatively constant moisture content within 5 feet of the structure.

Earthwork Construction Considerations

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving or high-powered rock excavation equipment depending on encountered subgrade. **The Limestone will require rock excavation techniques for site grading where cuts are required, for foundation excavations and for trenching.**

Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of foundation elements and pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Shallow Foundations

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable.

Design Parameters – Slab on Grade

Conventional Method Parameters	Value
Net Allowable Bearing Pressures [1]	4,000 psf (Granular Select Fill) 10,000 psf (On-Site natural Limestone Rock)
Subgrade Modulus (k)	150 pci
Potential Vertical Rise (PVR)	1 inch
WRI Method Parameters	
Design Plasticity Index (PI)	15
Climatic Rating (C_w)	17
Soil – Climate Support Index (1-C)	0.05

1. The net allowable bearing pressure includes a factor of safety of 3. The allowable bearing pressure may be increased by up to one-third for wind or seismic loads

We recommend that exterior grade beams be at least 30 inches below the finished exterior grade or at least 6 inches into rock, whichever occurs first. Interior grade beams (If any) should be designed by the Structural Engineer. These recommendations are for a proper development of bearing capacity for the continuous beam sections of the foundation system and to reduce the potential for water to migrate beneath the slab foundation. These recommendations are not based on structural considerations. Grade beam depths may need to be greater than recommended herein for structural considerations and should be properly evaluated and designed by the Structural Engineer. The grade beams or slab portions may be thickened and widened to serve as spread footings at concentrated load areas.

For a slab foundation system designed and constructed as recommended in this report, post construction settlements should be about 1 inch. Settlement response of a select fill supported slab is influenced more by the quality of construction than by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the pad and foundation.

The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slabs will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions about the use and placement of a vapor retarder.

Pavements

Both flexible and rigid pavement systems may be considered for the project. Based on our knowledge of the project, we anticipate that traffic loads will be produced primarily by automobile traffic, delivery trucks and trash removal trucks.

Subgrade Preparation

Prior to construction, any vegetation, loose topsoil, and any otherwise unsuitable materials should be removed from proposed pavement areas. After stripping, the subgrade (rock or soil) should be proof-rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a 15-ton roller or fully loaded dump truck. Wet, soft, low-density or dry material should either be removed or moisture conditioned and recompacted to the moisture contents and densities described in section Compaction Requirements prior to placing fill.

Pavement Section Design

For this project Light and Heavy pavement section alternatives have been provided. Light is for areas expected to receive only passenger vehicles. Heavy assumes areas with heavy traffic, such as trash pickup areas, delivery areas, bus loops and main access drive areas.

The flexible pavement section was designed in general accordance with the National Asphalt Pavement Association (NAPA) Information Series (IS-109) method. The rigid pavement section was designed using the American Concrete Institute (ACI 330R-01) method. If heavier traffic loading is expected, Terracon should be provided with the information and allowed to review these pavement sections.

Flexible Pavement Thicknesses				
Layer	**Soil Subgrade**		**Limestone Subgrade**	
	Light Duty (inch)	**Heavy Duty (inch)**	**Light Duty (inch)**	**Heavy Duty (inch)**
Hot Mix Asphaltic Concrete	2.0	2.0	2.0	2.0
Granular Base Material	8.0	14.0	6.0	10.0
Moisture Conditioned Subgrade	6.0	6.0	----	----

Rigid Pavement Thicknesses				
Layer	**Soil Subgrade**		**Limestone Subgrade**	
	Light Duty (inch)	**Heavy Duty (inch)**	**Light Duty (inch)**	**Heavy Duty (inch)**
Reinforced Concrete	5.5	6.5	5.0	6.0
Moisture Conditioned Subgrade	6.0	6.0	----	----

Pavement areas that will be subjected to heavy wheel and traffic volumes, such as waste bin or "dumpster" areas, entrance/exit ramps, and delivery areas, should be a rigid pavement section constructed of reinforced concrete.

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 full 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 C or 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.

- **Concrete** - Concrete should have a minimum 28-day design compressive strength of 4,000 psi.

- **Granular Base Material** - Base material may be composed of crushed limestone base 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 D 1557 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 then moisture conditioned between -2 and +3 percentage points of the optimum moisture content and then compacted to at least 95 percent of the maximum dry density determined as per ASTM D 698. If Limestone is exposed, moisture conditioning of Limestone will not be required. However, the limestone subgrade still needs to be proof-rolled.

Pavement Maintenance and Drainage

It is of paramount importance to maintain proper drainage, maintain subgrade moisture levels and provide routine maintenance on the pavement to help long-term pavement performance. The following recommendations should be implemented:

- 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 subgrade for a depth of at least 3 inches or top of limestone to help reduce moisture migration into the subgrade soils beneath the pavement section.
- 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.
- Strip (wick) drains installed behind the curbs will also help protect the pavements from water which ponds behind the curbs.

Note that even with the subgrade preparation and pavement maintenance measures, minor pavement distress should be anticipated.

Pavement on Sloping Site

We understand that significant grade change across the site. Pavements constructed on sloping sites can present unusual situations which could tend to decrease the life of the pavement. These situations are mostly due to the detail at the horizontal contact between the natural surficial materials and the paved area on the up-slope portion of the pavement section. While vertical flow of water is generally stopped by a properly designed and installed asphaltic concrete wearing surface, horizontal influx of water from unpaved areas up slope of the pavement can be uninhibited. This condition generally results in surface runoff from the unpaved areas becoming trapped within the base material. The trapped water then flows with gravity towards the lower elevations. If a high hydraulic head is allowed to build up within the flexible base in a short time period, then the hydraulic pressure may actually raise the asphaltic concrete above the flexible base due to water pressures or may tend to wash the fines from the base material thereby reducing support of the pavement.

Generally such extreme cases do not occur, however, we have on other projects observed "healthy" asphaltic concrete which appears to "weep" water from cracks after periods of rainfall. In some instances, weeping has been noted even in areas where no distress is evident. The cracks are caused by the described hydraulic conditions. Traffic across the hydraulically induced cracks causes "pumping" of the fines from the supporting base material. Eventually, this condition can lead to premature failure of the flexible pavement.

In most cases this condition can be avoided, or at least reduced, by proper treatment of the horizontal detail of the unpaved/paved contact. We recommend that this contact include a curb which extends unbroken beyond the depth of the entire pavement section and at least 4 inches into the undisturbed, existing subgrade soils or top of limestone. This curb is intended to serve as a barrier against horizontal migration of water from the up slope unpaved areas to the flexible pavement. For Portland Cement Concrete (PCC) pavements, the edge of the pavement section could also be "turned down" to provide the necessary barrier against horizontal water migration. Landscape islands also qualify as an unpaved/paved contact and should be treated as described above. Wick drains installed behind the curbs will also help protect the pavements from water which ponds behind the curbs as previously noted.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations 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. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services 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.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth	Location
3	20	Proposed Building Area
2	6	Proposed pavement Area

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features.

Subsurface Exploration Procedures:

Soil borings were advanced with a truck-mounted drill rig using continuous flight augers (solid stem). Soils were sampled by means of split barrel sampling procedure. In the split barrel sampling procedure, a standard 2-inch outer diameter split barrel sampling spoon was 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 was recorded as the Standard Penetration Test (SPT) resistance value. The split barrel samples were removed from the samplers in the field, visually classified, and appropriately sealed in sample containers to preserve in-situ moisture contents. We observed and recorded groundwater levels during drilling, coring and sampling. For safety purposes, all borings were backfilled with cuttings after their completion.

Our exploration team prepared field boring logs as part of the drilling operations. The sampling depths, visual classification of the materials encountered, SPT values, pocket penetrometer readings, other pertinent sampling information were recorded on the field boring logs.

Site Location and Exploration Plans

Site Location

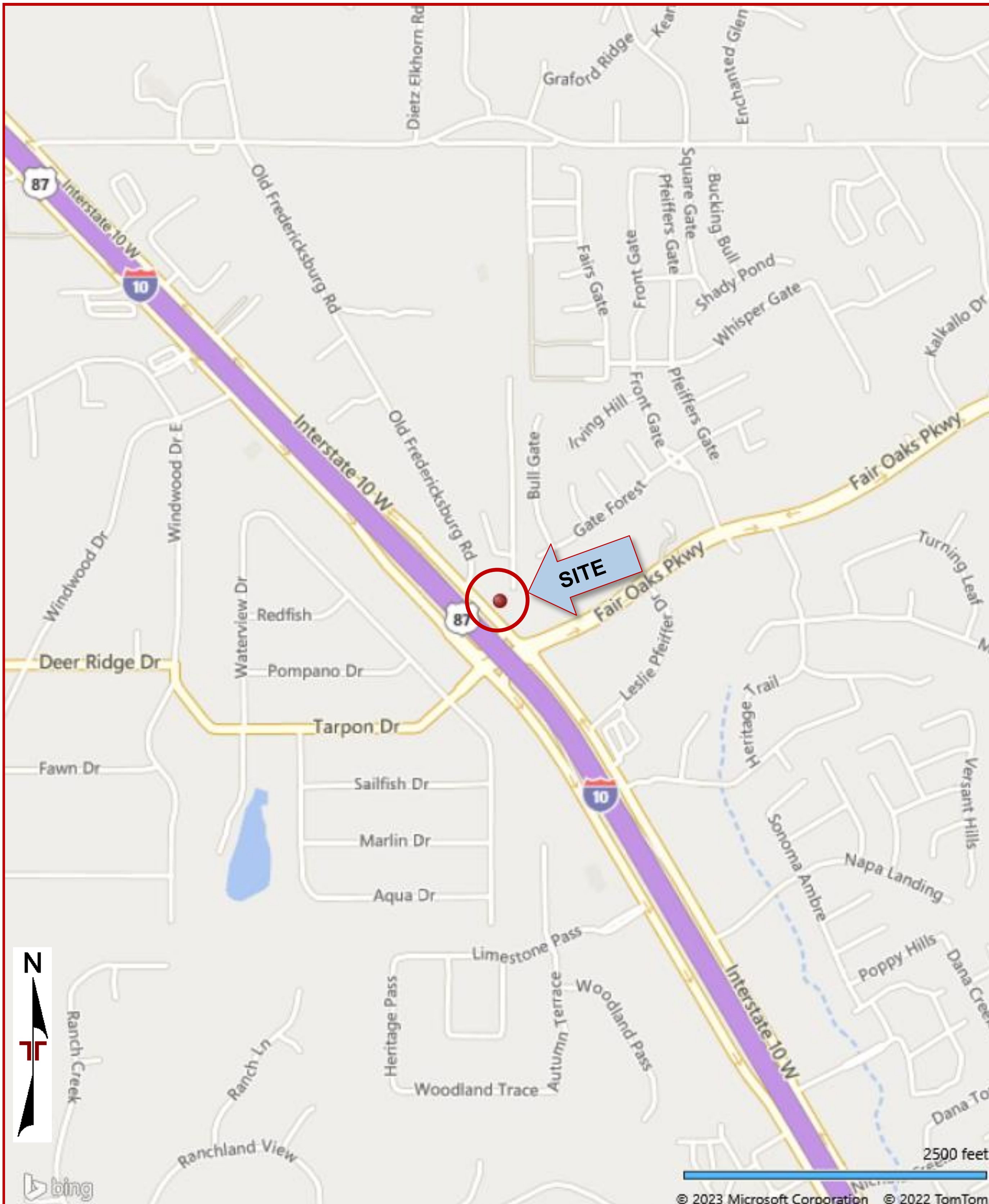


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

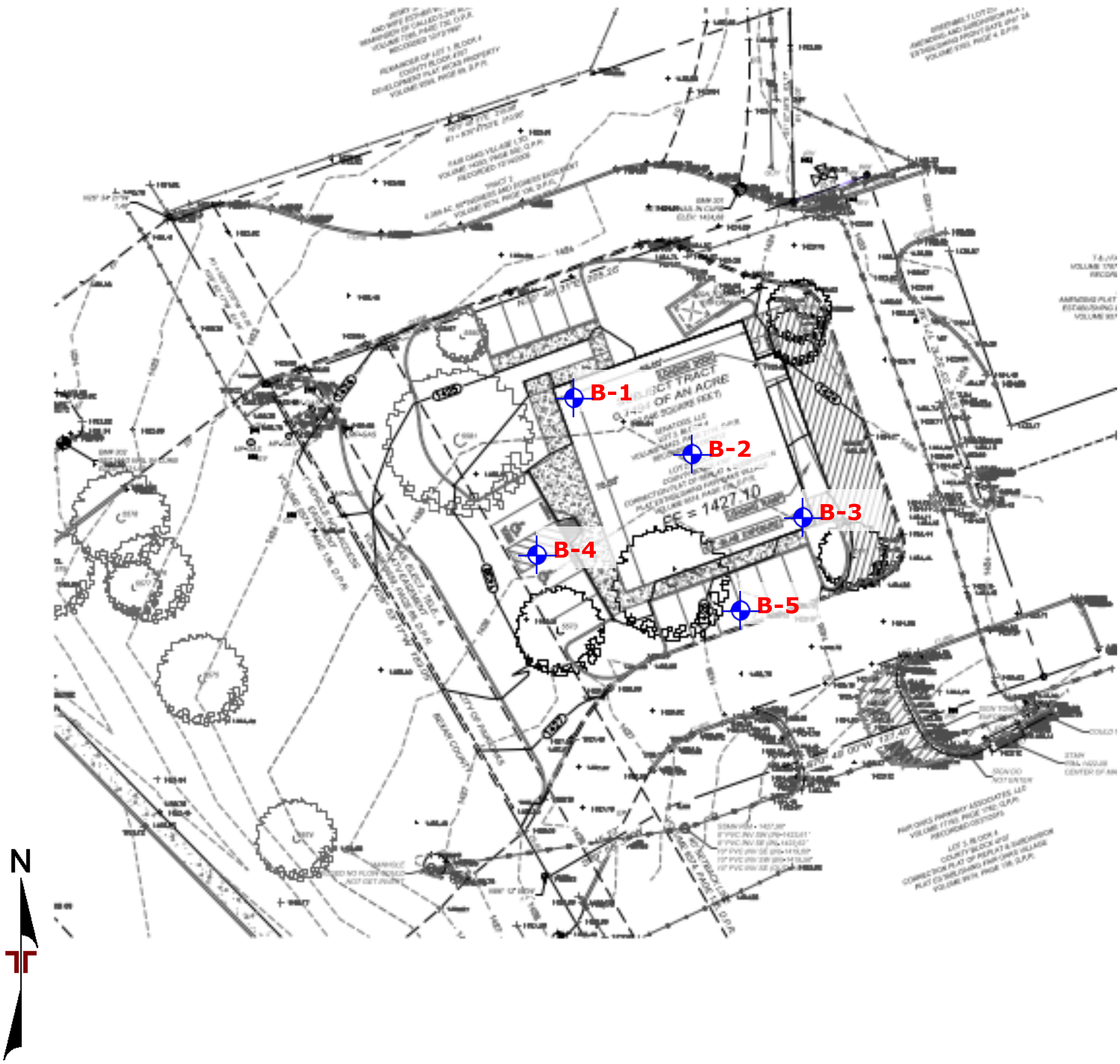


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Terracon
6911 Blanco Rd
San Antonio, TX

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 29.7210° Longitude: -98.6660°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		1.0	**CLAYEY GRAVEL (GC)**, with sand, brown to light brown, medium dense				8-6-50/1"	11.7	37-24-13	
2			**LIMESTONE**, light gray and light tan, hard				50/1"			
				5			50/0"			
							50/0"			
							50/0"			
				10						
							50/0"			
				15						
		20.0		20			50/0"			
			Boring Terminated at 20 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations
No free water observed

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
Moe R

Boring Started
12-13-2023

Boring Completed
12-13-2023

Terracon
6911 Blanco Rd
San Antonio, TX

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 29.7210° Longitude: -98.6659°

Model Layer	Graphic Log	Depth (Ft.)	Description	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		2.0	**CLAYEY GRAVEL (GC)**, with sand, brown to light brown, medium dense			7-10-14 N=24	10.7	32-21-11	
2		20.0	**LIMESTONE**, light gray and light tan, hard			50/1"	3.9		
						50/0"			
						50/0"			
						50/0"			
						50/0"			
						50/0"			
			Boring Terminated at 20 Feet						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations
No free water observed

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
Moe R

Boring Started
12-13-2023

Boring Completed
12-13-2023

Terracon
6911 Blanco Rd
San Antonio, TX

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 29.7209° Longitude: -98.6657°

Model Layer	Graphic Log Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1	1.0	**CLAYEY GRAVEL (GC)**, with sand, light brown, medium dense				5-11-50/2"	9.2		37
2		**LIMESTONE**, light gray and light tan, hard				50/1"			
			5			50/0"			
						50/0"			
						50/0"			
			10						
						50/0"			
			15						
	20.0		20			50/0"			
		Boring Terminated at 20 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations
No free water observed

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
Moe R

Boring Started
12-13-2023

Boring Completed
12-13-2023

Terracon
6911 Blanco Rd
San Antonio, TX

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 29.7209° Longitude: -98.6661°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		2.0	**CLAYEY GRAVEL (GC)**, with sand, light brown, dense				28-24-22 N=46	5.5		41
							50/1"			
2		5.0	**LIMESTONE**, light gray and light tan, hard	5			50/0"			
			Boring Terminated at 5 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations
No free water observed

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
Moe R

Boring Started
12-13-2023

Boring Completed
12-13-2023

Terracon
6911 Blanco Rd
San Antonio, TX

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 29.7208° Longitude: -98.6658°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		2.0	**CLAYEY GRAVEL (GC)**, with sand, light brown, medium dense				8-11-15 N=26	9.9	29-15-14	
							50/1"			
2		5.0	**LIMESTONE**, light gray and light tan, hard	5			50/0"			
			Boring Terminated at 5 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations
No free water observed

Advancement Method
Air Rotary

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

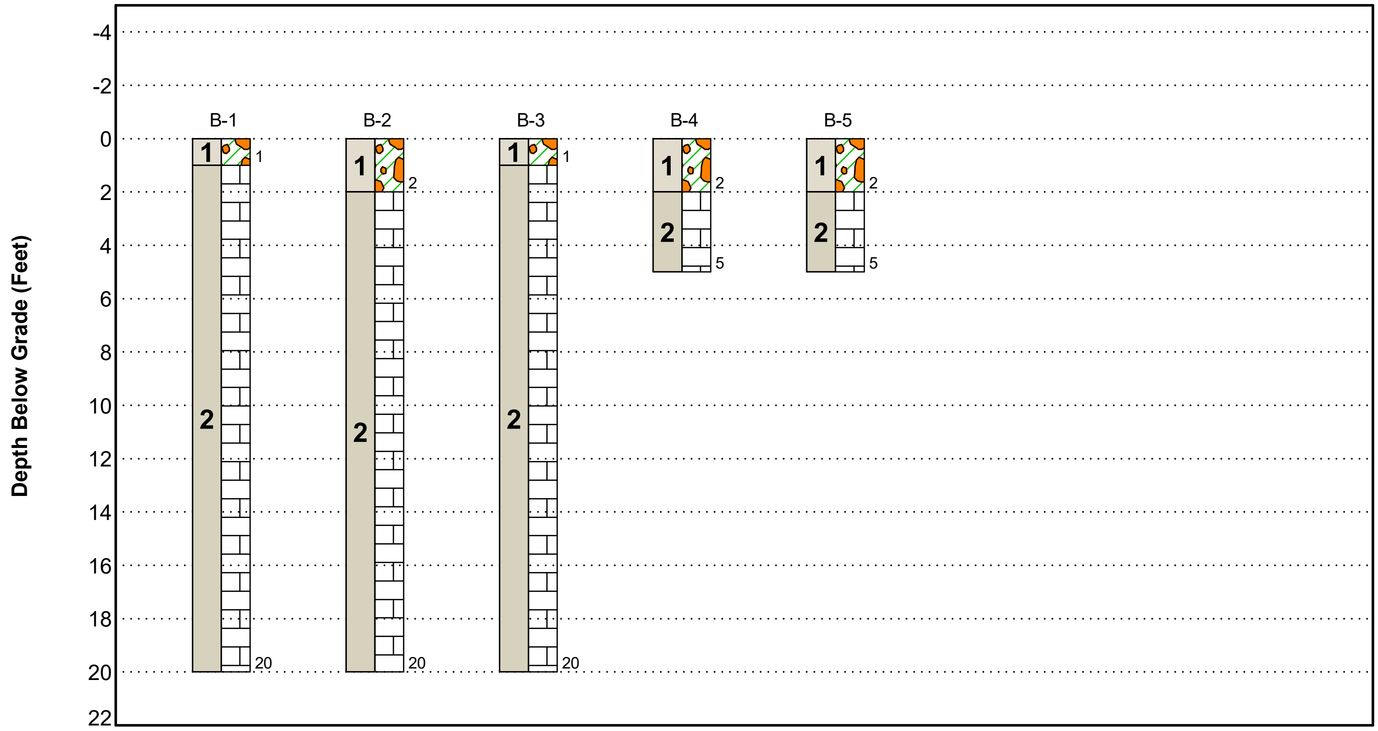
Logged by
Moe R

Boring Started
12-13-2023

Boring Completed
12-13-2023

Terracon
6911 Blanco Rd
San Antonio, TX

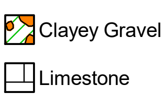
GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Clayey Gravel (GC)**	Brown, Light brown; Medium Dense to Dense
2	**Limestone**	Light Gray, Light Tan; Hard

LEGEND



NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Supporting Information

Terracon
6911 Blanco Rd
San Antonio, TX

General Notes

Sampling	Water Level	Field Tests
Split Spoon	Water Initially Encountered	N — Standard Penetration Test Resistance (Blows/Ft.)
	Water Level After a Specified Period of Time	(HP) — Hand Penetrometer
	Water Level After a Specified Period of Time	(T) — Torvane
	Cave In Encountered	(DCP) — Dynamic Cone Penetrometer
	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.	UC — Unconfined Compressive Strength
		(PID) — Photo-Ionization Detector
		(OVA) — Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. 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		**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		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

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≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey 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 above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					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:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					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] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 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 ≥ 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 ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 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.