Geotechnical Engineering Report

Townwest Commons

Hutto, Texas

August 24, 2018

Terracon Project No. 96185224

Prepared for:

NewQuest Properties

Houston, Texas

Prepared by:

Terracon Consultants, Inc.

Austin, Texas

August 24, 2018

NewQuest Properties
8827 W. Sam Houston Pkwy. N., Ste. 200
Houston, Texas 77040

Attn: Mr. Corey Pitts
P: (281) 477-4357
E: cpitts@newquest.com

Re: Geotechnical Engineering Report
Townwest Commons
State Highway 79 and CR 165
Hutto, Texas
Terracon Project No. 96185224

Dear Mr. Pitts:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P96185224 dated June 25, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, subgrade preparation, and the design and construction of foundations, pavements, and site improvements for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

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

STATE OF TEXAS
8/24/18
EDWARD ESCOBAR JAIMES
123388
LICENSED
PROFESSIONAL ENGINEER

Edward E. Jaimes, P.E.
Project Engineer

Bryan S. Moulin, P.E.
Principal, Geotechnical Department Manager

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Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon GeoReport logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS (Boring Logs and Laboratory Data)
SUPPORTING INFORMATION (General Notes and Unified Soil Classification System)

Geotechnical Engineering Report

Townwest Commons
State Highway 79 and CR 165
Hutto, Texas
Terracon Project No. 96185224
August 24, 2018

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Townwest Commons project to be located at State Highway 79 and CR 165 in Hutto, Texas. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Pavement design and construction
- Foundation design and construction
- Building subgrade preparation
- Seismic site classification per IBC
- Lateral earth pressures

The geotechnical engineering scope of services for this project included the advancement of eight (8) test borings, designated B-1 through B-8 to depths ranging from approximately 5 to 25 feet below existing site grades.

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

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 at the northeast quadrant of the intersection of State Highway 79 and CR 165 in Hutto, Texas. See **Site Location**.
Existing Improvements	None. The site is used as farmland.

Item	Description
Current Ground Cover	Soils. The corn crop at the site has been recently harvested.
Existing Topography	Unknown at this time. (Please provide a topographic survey, when available).
Geology	Based on our borings, the site consists of high plasticity clay soils over moderate to high plasticity clay soils.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed in the project planning stage. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Proposed Structures	The project includes the construction of the following; ■ 7,350 square foot retail building ■ 7,900 square foot retail building ■ Pavements for access drives and parking lot ■ Approximately 540 lineal feet rear access drive (not public road) connecting to CR 165
Building Construction	Unknown at this time. Assumed to be light-gage steel framing.
Finished Floor Elevation	Unknow at this time. Assumed to be within 2 feet of existing grades.
Maximum Loads	Unknow at this time. Assumed to be typically lightly-loaded structure.
Grading/Slopes	Unknown at this time. Assumed to be within 3 feet of existing grades.
Below Grade Structures	None anticipated.
Free-Standing Retaining Walls	Some low-height walls up to 4 feet tall are anticipated.

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

We have developed a general characterization of the subsurface soil and groundwater conditions based upon our review of the data and our understanding of the geologic setting and planned construction. The following table provides our geotechnical characterization.

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency/Density
1	8 – 10	Dark brown fat clay (CH)	Hard
2	25+	Light brown lean clays (CL)	Very stiff to hard

The geotechnical characterization forms the basis of our geotechnical calculations and evaluation of site preparation, foundation options and pavement options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

Conditions encountered at each boring location are indicated on the individual boring logs shown in the **Exploration Results** section and are attached to this report. 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 boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**, and are summarized below.

Boring Number	Date of Drilling	Approximate Depth to Groundwater (feet) [1]
B-1	8/3/2018	18
B-2	8/3/2018	21
B-3	8/3/2018	17

1. Below ground surface

Groundwater seepage is possible at this site, particularly in the form of seepage traveling along pervious seams/fissures in the soil and/or along soil stratum interfaces. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Please contact us if this is desired. Groundwater conditions should be evaluated immediately prior to construction.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. 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 possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

The near surface, stiff to hard high plasticity fat clay could become problematic with typical earthwork and construction traffic, especially after precipitation events. Effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. Additional site preparation recommendations including subgrade improvement and fill placement are provided in the **Earthwork** section.

The subgrade soils for the floor slabs consist of high plasticity fat clay, therefore extensive subgrade preparation is necessary in order to reduce post-construction movements to about 1-inch. The **Building Subgrade Preparation** section addresses the subgrade preparation.

Expansive soils are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We can discuss these additional measures if desired.

The **Shallow Foundations** section addresses the support of the structure on a monolithic slab-on-grade foundation / spread/strip footing foundation bearing into select fill. The **Building Subgrade Preparation** section addresses slab support of the structures.

Lateral earth pressures are provided for on-site retaining walls. The **Lateral Earth Pressures** section address the design of retaining walls.

Asphaltic concrete and portland cement concrete pavement systems are recommended for this site. The **Pavements** section addresses the design of pavement systems.

Slope inclinations and construction recommendations are provided for cut and fill slopes (embankments). The **Slope Stability** section addresses cut and fill slopes.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork will include clearing and grubbing, excavations and 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, floor slabs, and pavements.

Site Preparation

After demolition of the existing structure, construction areas should be stripped of all vegetation, loose soils, top soils, and other unsuitable material currently present at the site. Roots of trees to be removed within construction areas, if any, should be grubbed to full depths, including the dry soil around the roots. If any unusual items are unearthed during or after demolition, please contact us for further evaluation. Utilities to be abandoned should be completely removed from all proposed construction areas. If this is not feasible, then the abandoned utility piping should be filled with flowable fill (COA Item No. 402S or TxDOT Item No. 401) and plugged such that it does not become a conduit for water flow. We recommend that Terracon be retained to assist in evaluating exposed subgrades during earthwork so that unsuitable materials, if any, are removed at the time of construction.

Proof-Rolling

Once initial subgrade elevations have been achieved (i.e., after cuts but prior to fills), the exposed subgrade in all construction areas (except landscaping) should be carefully and thoroughly proof-rolled with a 20-ton pneumatic roller, fully-loaded dump truck, or similar equipment to detect weak zones in the subgrade. Weak areas detected during proof-rolling, zones containing debris or organics, and voids resulting from removal of tree roots, existing foundation elements, utilities, fill, boulders, etc. should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in-situ soils (or flowable fill). Proper site drainage should be maintained during construction so that ponding of surface runoff does not occur and cause construction delays and/or exhibit site access.

Moisture Conditioned Subgrade

After proof-rolling, and just prior to placement of fill, the exposed soil subgrade in all construction areas (except landscaping) should be evaluated for moisture and density through field density testing. If the moisture and/or density requirements do not meet the moisture and density requirements below, the subgrade should be scarified to a minimum depth of 6 inches, moisture conditioned and compacted as per the fill compaction requirements.

Temporary Groundwater Control

As encountered during our drilling operations, groundwater seepage might possibly be encountered during construction, especially after periods of wet weather. Temporary groundwater control during construction would typically consist of perimeter gravel-packed drains sloping toward common sump areas for groundwater collection and removal. Placement of drain laterals within the excavation could be required to remediate isolated water pockets.

Fill Material Types

Fill required to achieve design grade should be classified as select/structural fill and general fill. Select/structural fill is material used below, or within 5 feet of structures. General fill is material used to achieve grade in paving, non-reinforced earthen slopes, landscape, or other general areas (non-structural areas). Earthen materials used for select fill and general fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Specifications
Imported Select/Structural Fill [2,3]	CL, SC, and/or GC	■ TxDOT Item 247, Type A, Grade 3 ■ Percent Retained on No. 4 Sieve ≤ 40 percent with 5≤PI≤20 and rocks ≤ 4 inches in maximum dimensions ■ Crushed concrete (TxDOT Item 247, Type D, Grade 3 or better)
Paving Fill and General Fill [4]	CH, CL, SC and/or GC	PI ≤ 60; Rocks ≤ 4 inches in maximum dimension

1. Structural and general fill should consist of approved materials free of organic matter and debris. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. As an alternative to the Acceptable Specifications above, a low-plasticity granular material which does not meet these specifications may be used only if approved by Terracon.
3. Based on the laboratory testing performed during this exploration, the excavated on-site soils are not suitable for re-use as select fill. We do not recommend these soils be considered for re-use as select fill when planning budgets.
4. Excavated on-site soils, if free of organics, debris, and rocks larger than 4 inches may be considered for re-use as fill in pavement, landscape, or other general areas. Please note that the on-site soils exhibit high to very high shrink/swell potential. For economic reasons, expansive soils are often used in pavement and/or flatwork areas. The owner should be aware that the risk exists for future movements of the subgrade soils which may result in movement and/or cracking of pavement and/or flatwork. If paving fill is imported, the PI should not exceed 60.

Fill Compaction Requirements

Recommended compaction and moisture content criteria for engineered fill materials are as follows.

Material Type		Minimum Compaction Requirement (%) [1]	Moisture Content Range (%)	Maximum Loose Lift Thickness (in) [2]
Select/Structural Fill		95 [3]	-3 to +3	8 inches
Moisture Conditioned Building Subgrade and Fill	**PI ≤ 25**	95	-3 to +3	8 inches
	PI > 25	92	+2 to +6	
Paving Fill, Paving Subgrade and General Fill	**PI ≤ 25**	95	-3 to +3	8 inches
	PI > 25	95	Optimum to +4	8 inches
Crushed Limestone Base (beneath pavements)		100 [4]	-3 to +3	8 inches

1. Per the Standard Proctor Test (ASTM D 698).
2. Fill lift thickness must be reduced (typically 4 to 6 inches) if light compaction equipment is used, as is customary within a few feet of retaining walls and utility trenches.
3. **For fills greater than 5 feet in depth, if any, the compaction should be increased to at least 100 percent of the ASTM D 698 maximum dry unit weight.**
4. Per TEX-113-E (or 95% of Modified Proctor, ASTM D1557).

Utility Trench Backfill

Leaking pipes underneath and/or near the foundations will increase the moisture content of the surrounding subgrade soils and will likely result in a PVR greater than discussed for these soils. For low permeability subgrades, utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. We recommend constructing an effective clay or flowable fill "trench plug" that extends at least 2 feet out from the face of the building exterior. The clay fill/flowable fill should be placed to completely surround the utility line and it should fill the utility trench completely in width and height, with the exception of topsoil at the surface. If clay plug is used, it should be fat clay with a minimum PI of 30 and should be compacted to comply with the water content and compaction recommendations for moisture conditioned building subgrade fill as specified in **Fill Compaction Requirements**. If flowable fill is used, it should be in accordance with TxDOT Item 401.

Grading and Drainage

The performance of the proposed structures will not only be dependent upon the quality of construction, but also upon the stability of the moisture content of the near surface soils.

Therefore, we highly recommend that site drainage be developed so that ponding of surface runoff near the structures does not occur. Accumulation of water near the structures may cause significant moisture variations in soils adjacent to the structures, thus increasing the potential for structural distress.

Effective drainage away from the structures must be provided during construction and maintained through the life of the proposed project. Infiltration of water into excavations should be prevented during construction. It is important that foundation soils are not allowed to become wetted. All grades must provide effective drainage away from the structures during and after construction. The most effective way to achieve this would be to provide concrete aprons (i.e., concrete sidewalks/pavements directly abutting the building) around the exterior perimeter of the structures for at least 6 feet (1 foot wider than the select fill overbuild). The concrete should be sloped to provide drainage away from the structures and all joints should be sealed, particularly those directly abutting the structures. In lieu of providing concrete aprons and if sloping unpaved ground is planned around the structures, then the select fill overbuild (recommended 5 feet beyond the building limits) should be excavated to a depth of at least 2 feet below final grades, removed and replaced with a minimum of 2 feet of moisture conditioned and compacted on-site fat clay soils. The fat clay soils should be compacted and moisture conditioned as per the **Fill Compaction Requirements** section of this report. This procedure is recommended to reduce the possibility of surface runoff infiltrating into the more pervious select fill soils and ponding below the proposed building. We would be glad to discuss other measures (e.g. horizontal or vertical barriers) to reduce moisture infiltration in unpaved areas, if desired. Exposed (unpaved) ground should be sloped at a minimum of 5 percent away from the structures for at least 10 feet beyond the perimeter of the structures. Locally, flatter grades may be necessary to transition ADA access requirement for flatwork.

Roof runoff and surface drainage should be collected and discharged away from the structures to prevent wetting of the foundation soils. Roof gutters should be installed and connected to downspouts and pipes directing roof runoff at least 10 feet away from the structures, or discharged on to positively sloped pavements.

Sprinkler mains and spray heads should preferably be located at least 5 feet away from the structures such that they cannot become a potential source of water directly adjacent to the structures. In addition, the owner and/or builder should be made aware that placing large bushes and trees adjacent to the structures may cause significant moisture variations in the soils underlying the structures. In general, tree roots can adversely influence the subsurface soil moisture content to a distance of 1 to 1½ times the mature height of the tree and beyond the tree canopy. Watering of vegetation should be performed in a timely and controlled manner and prolonged watering should be avoided. Landscaped irrigation adjacent to the foundation units should be minimized or eliminated. Special care should be taken such that underground utilities do not develop leaks with time.

After building construction and landscaping, final grades should be verified to document effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary as part of the structure's maintenance program. Where paving or flatwork abuts the structures, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration. Water permitted to pond next to the structures can result in greater soil movements than those discussed in this report. Estimated movements described in this report are based on effective drainage for the life of the structures and cannot be relied upon if effective drainage is not maintained.

Earthwork Construction Considerations

Based on our test borings, highly to very highly expansive soils that exhibit a potential for volumetric chance during moisture variations are present at this site. These subgrade soils at the surface may experience expansion and contraction due to changes in moisture content. Based on existing grades, the soils at this site could exhibit a Potential Vertical Rise (PVR) of up to about 5 inches, as estimated by the TxDOT Method TEX-124-E, if present in a dry condition.

Excavations, for the proposed structure and utilities, are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided as much as possible. 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 desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to floor slab construction.

Groundwater could affect over-excavation efforts, especially for replacement of lower strength soils. A temporary dewatering system consisting of sumps with pumps could be necessary to achieve the recommended depth of over-excavation. Sump pits should preferably be excavated just outside the building pad limits.

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.

Construction Observation and Testing

The earthwork efforts should be documented under the direction of the Geotechnical Engineer. This should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation and density/moisture testing of subgrade and fills. In the event that unanticipated conditions are encountered, the Geotechnical Engineer should be contacted to evaluate the conditions.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Fill should be tested for density and water content at a frequency of at least one test for every 5,000 square feet per lift of compacted fill in the building areas (with a minimum of 3 tests per lift) and 10,000 square feet per lift in pavement areas. A minimum of one density and water content test should be conducted for every 100 linear feet of compacted utility trench backfill in paving areas.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork** and **Building Subgrade Preparation**, the following design parameters are applicable for shallow foundations.

Design Parameters – Monolithic Slab-On-Grade

A monolithic slab-on-grade foundation system (either conventionally reinforced or post-tensioned) would be appropriate to support the proposed structures provided subgrade preparation as described in **Building Subgrade Preparation** is followed. The slab foundation design parameters presented in the tables below are based on the criteria published by the Building Research Advisory Board (BRAB), the Prestressed Concrete Institute (PCI), the Wire Reinforcement Institute (WRI), and the Post-Tensioning Institute (PTI) 3rd Edition. These are essentially empirical design methods and the recommended design parameters are based on our understanding of the proposed project, our interpretation of the information and data collected as a part of this study, our area experience, and the criteria published in the BRAB, PCI, WRI, and PTI design manuals.

Conventional Slab and Beam System Parameters	
Description	**Design Parameter**
Minimum Embedment of Grade Beams below Final Grade [1]	24 inches
Bearing Stratum	Select Fill
Bearing Pressures (allowable) [2]	Net Dead plus Sustained Live Load – 1,700 psf Net Total Load – 2,500 psf
Subgrade Modulus (k) [3]	100 pci
Approximate Potential Vertical Rise (PVR)	About 1-inch [4,5]

1. Embedment is to reduce surface water migration below the foundation elements and to develop proper end bearing and is not based on structural considerations. The grade beam width and depth should be properly evaluated by the structural engineer. Grade beams may be thickened and widened at interior column locations to serve as spread footings at these concentrated load areas.
2. Grade beams should bear on compacted select fill.
3. Several design methods use the modulus of subgrade reaction, k, to account for soil properties in design of flat, floor slabs. The modulus of subgrade reaction is a spring constant that depends on the kind of soil, the degree of compaction, and the moisture content. Based on our recommendations provided in **Floor Slabs/Building Subgrade Preparation**, the above indicated subgrade modulus can be used for design of a flat, grade-supported floor slab.
4. Differential movements may result from variances in subsurface conditions, loading conditions and construction procedures. We recommend that measures be taken whenever practical to increase the tolerance of the building to post-construction foundation movements. An example of such measures would be to provide frequent control joints for exterior masonry veneers and interior sheetrock walls (particularly near doors and windows) to control cracking across such walls and concentrate movement along the joints.
5. The building subgrade should be properly prepared as described in **Building Subgrade Preparation**.

BRAB/WRI/PCI Parameters			
Description	**Design Parameter**		
Design Plasticity Index (PI) [1]	BRAB/WRI/PCI	Prepared Subgrade [2]	27
Climatic Rating (C_w)			17
Unconfined Compressive Strength			1.0 tsf
Soil Support Index (C) for BRAB		Prepared Subgrade [2]	0.87

1. The BRAB effective PI is equal to the near surface PI if that PI is greater than all of the PI values in the upper 15 feet. If the near-surface PI is not highest (i.e., after the building pad is prepared), then the effective PI is the weighted average of the upper 15 feet. The WRI/PCI effective PI is always the weighted average of the PI values in the upper 15 feet.
2. The building subgrade should be properly prepared as described in **Building Subgrade Preparation**.

Post Tensioning Institute (PTI) Parameters [1]

Description		Design Parameter
Depth of Seasonal Moisture Change [2]		Up to 15 feet
Plasticity Index [3]		Select Fill – 15 Stratum 1 Soils – 49 Stratum 2 Soils - 30
Percent Finer than 2 Microns [3]		Select Fill – 20 Stratum 1 Soils – 54 Stratum 2 Soils - 38
Soil Fabric Factor		1.0
Approximate Thornthwaite Moisture Index		-12
Estimated Constant Soil Suction		3.5 pF
Range of Soil Suction		3.0 to 4.5 pF
Edge Moisture Variation Distance, e_m [4,5]	**Center Lift**	8.5 feet [6]
	Edge Lift	4.4 feet [6]
Differential Soil Movement, y_m [5]	**Center Lift**	¾ inches [6]
	Edge Lift	1 inch [6]

1. Based on our analysis of the field and laboratory data, design parameters were computed using the Addendum to the 2004 Post-Tensioning Institute (PTI) method[1] for slab-on-grade design and the subsequent Errata to the Addendum approved by the PTI Slab-on-Grade Committee on February 7, 2008.
2. The moisture beneath a shallow foundation will change in response to wetting and drying conditions around the foundation perimeter. The moisture condition has a significant effect on slab behavior and is highly variable with time, changing seasonally, with annual climate conditions, drainage patterns, ground cover, and vegetation (trees and shrubs).
3. The plasticity index and the clay mineral percentage are values of the soil that can be estimated by laboratory tests, and, although variable from location to location, remain relatively constant with time.
4. The maximum moisture variation distance is termed the edge moisture variation distance, e_m, and is an important factor governing the design of post-tensioned floor slabs. The e_m is related to percent fine clay and climatic conditions as well as other parameters, such as soil fabric factor and unsaturated diffusion coefficient.
5. The differential movements, y_m, and edge moisture variation distances, e_m, were calculated by modeling soil profiles using the commercial software program VOLFLO as recommended by the PTI manual.
6. Values may be used provided subgrade preparation is implemented as described in **Building Subgrade Preparation**.

1. *Post-Tensioning Institute, "Addendum No. 1 to the 3rd Edition of the Design of Post-Tensioned Slabs-on-Ground", Post-Tensioning Institute, Phoenix, AZ, May 2007.*

Design Parameters – Footings

As an alternative to a monolithic slab-on-grade foundation system, spread/strip footings may be considered.

Description	Design Parameter
Bearing Stratum [1]	Select Fill
Minimum Embedment Below Final Grade [2]	24 inches
Minimum Footing Dimensions	Spread – 3 feet by 3 feet square Strip – 18 inches wide
Allowable Bearing Pressures [3,4]	Net dead plus sustained live load – 1,700 psf Net allowable total load – 2,500 psf
Approximate Total Movement [5]	1-inch
Estimated Differential Movement [6]	½ to ¾ inch
Nominal (unfactored) Passive Resistance [7]	330 psf per foot of depth
Coefficient of Sliding Resistance [8]	0.35
Nominal (unfactored) Uplift Resistance [9]	Foundation Weight (150 pcf) & Soil Weight (120 pcf)

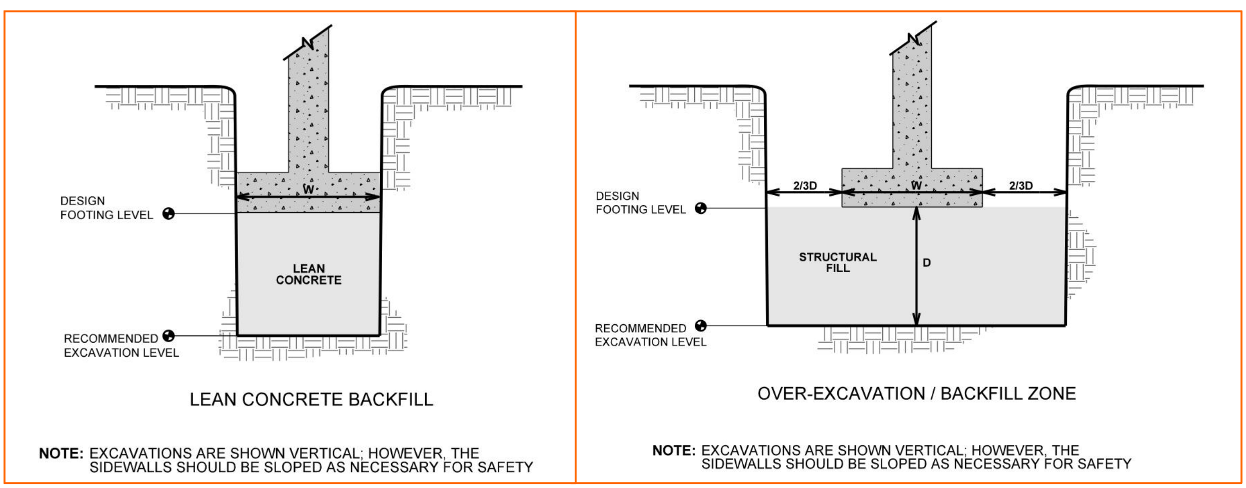
1. Unsuitable or soft soils must be over-excavated and replaced per the recommendations presented in **Earthwork** and the building area should be prepared as per **Building Subgrade Preparation**.
2. To bear within select fill soils.
3. Whichever condition yields a larger bearing area.
4. Values provided are for maximum loads noted in **Project Description**.
5. The estimated post-construction settlement of the shallow footings is assuming proper construction practices are followed.
6. Differential settlements may result from variances in subsurface conditions, loading conditions and construction procedures. The settlement response of the footings will be more dependent upon the quality of construction than upon the response of the subgrade to the foundation loads.
7. Passive resistance should be neglected in the first 12 inches below finished grades. Care should be taken to avoid disturbance of the footing bearing area since loose material could increase settlement and decrease resistance to lateral loading. If the footing is formed during construction, the open space between the footings and the in-situ soils should be backfilled with concrete.
8. Lateral loads transmitted to the footings will be resisted by a combination of soil-concrete friction on the base of the footings and passive pressure on the side of the footings. We recommend that the allowable frictional resistance be limited to 500 psf.
9. The nominal values should be reduced by an appropriate factor of safety to compute allowable values.

Foundation Construction Considerations

Footings/Grade beams should be neat excavated, if possible. If neat excavation is not possible, the foundation should be properly formed. If a toothed bucket is used, excavation with this bucket should be stopped approximately 6 inches above final grade of the footings and the footing excavation be completed with a smooth-mouthed bucket or by hand labor. Debris in the bottom of the excavation should be removed prior to steel reinforcement placement. The foundation excavation should be sloped sufficiently to create internal sumps for runoff collection and removal. If surface runoff water or groundwater seepage in excess of ½-inch accumulates at the bottom of the foundation excavation, it should be collected, removed, and not allowed to adversely affect the quality of the bearing surface.

If utilized, the post-tensioned slab-on-grade construction technique should be carefully monitored by qualified personnel. The sophistication of this construction procedure requires careful attention to details such as concrete integrity and anchorages, along with tendon spacing, support, covering, and stressing. Poor construction could result in a non-functional slab foundation system.

If unsuitable bearing soils are encountered at the base of the planned footing excavation (such as low strength or disturbed soils), the footing excavations should be deepened to expose suitable bearing materials. The footings could then bear directly on these soils at the lower level, on lean concrete backfill placed in the excavations, or on compacted structural fill backfilled in the excavations and compacted as in **Earthwork**. This is illustrated in the figure below.



Concrete should be placed as soon as possible after excavation to reduce bearing soil disturbance. Soils at bearing level that become disturbed or saturated should be removed prior to placing reinforcing steel and concrete. Adequate water control/dewatering system will aid in minimizing the need for over-excavation and backfill of any soils disturbed by prolonged exposure. It is important that the foundation subgrade not be disturbed by construction activities (e.g., setting forms and placing reinforcing steel). If disturbance occurs, we recommend that the disturbed soils be removed and that the foundation subgrade be protected with the placement of a lean concrete "mud mat".

Foundation Construction Monitoring

The performance of the foundation system for the proposed structure will be highly dependent upon the quality of construction. Thus, we recommend that the foundation construction be monitored by Terracon to identify the proper bearing strata and depths and to help evaluate foundation construction. We would be pleased to develop a plan for foundation monitoring to be incorporated in the overall quality assurance program.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. 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 Section 20.4 of ASCE 7-10.

Code Used	Seismic Design Category	Site Soil Classification
2015 International Building Code (IBC) [1]	A [2,3]	C [4]

1. Seismic site classification in general accordance with the *2015 International Building Code*, which refers to ASCE 7-10.
2. Per IBC 2015 Section 1613.3.1. Latitude: 30.5406°N Longitude 97.5663°W
   S_S=0.064; S_1=0.035; S_{MS}=0.077; S_{M1}=0.060, S_{DS}=0.051; S_{D1}=0.040
3. This seismic design category was obtained using online seismic design maps and tools provided by the USGS (http://earthquake.usgs.gov/hazards/designmaps/).
4. The 2015 International Building Code (IBC) uses a site profile extending to a depth of 100 feet for seismic site classification. Borings at this site were extended to a maximum depth of 25 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. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth. If you desire parameters for different versions of IBC, please contact us.

BUILDING SUBGRADE PREPARATION

The subgrade soils are comprised of high plasticity clays exhibiting the potential to shrink/swell with changes in water content. Construction of the floor slabs and revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content will cause the clays to swell and potentially damage the floor slabs.

Due to the potential for significant moisture fluctuations of subgrade material beneath the select fill pad, the exposed final subgrade should be prepared as discussed in the first three sub-sections of **Earthwork**.

The most positive way to minimize the potential for foundation distress resulting from volumetric changes would be to suspend the building above the subgrade on drilled pier foundations with a crawl space or void boxes under the slab and beams. We don't anticipate this will be considered due to economic feasibility. An alternative to this foundation type would be to prepare the subgrade to reduce the shrink/swell potential of the near-surface soils and use grade-supported floor slabs as mentioned below. Although subgrade preparation does help to reduce the shrink/swell potential of the subgrade, a degree of risk of subgrade movements (and corresponding foundation distress) remains if grade-supported floor slabs are to be utilized.

The post-construction performance of the foundation will likely be influenced more by post-construction volumetric changes of the subgrade due to in-situ moisture variations than upon settlement due to foundation loads. Settlement response of select fill supported slabs will be influenced as much by the quality of construction and fill placements as by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the building pad and foundation.

Grade-Supported Floor Slab System

While the grade-supported floor slab option is not as effective as a structurally suspended floor slab in reducing slab movements, it does represent a compromise between economics and risk of slab distress. If a grade-supported floor slab is utilized, we recommend that the soils immediately below the lowest-level slab be prepared as stated below to reduce the potential for foundation movements associated with volumetric changes of the underlying clay soils due to moisture variation.

A select fill pad combined with a moisture conditioned clay subgrade may be implemented in order to reduce post-construction shrink/swell movements to approximately 1-inch. The table below provides options for various preparation options depending on the amount of select fill desired below the bottom of the floor slab.

Preparation Option	Select Fill Thickness, feet	Moisture Conditioned Clay Thickness (below select fill), feet	Total Building Pad Thickness, feet
1	7	0.5	7.5
2	6	2	8
3	5	4	9

1. As an example, if option 3 is selected, we recommend that the on-site clay soils be removed to a depth of 5 feet below the bottom of the floor slab. At least 4 feet of the excavated soils should be moisture conditioned as outlined in **Earthwork**. The moisture conditioned clay soils should not be allowed to dry out prior to subsequent lift placements. For option 3, select fill should be placed as outlined in **Earthwork** in order to provide a select fill pad of 9 feet below the floor slab.

The exposed building subgrade should be proof-rolled as discussed in **Earthwork**, prior to placement of the moisture conditioned subgrade. The above subgrade preparation recommendations should be applied to an area extending a minimum of 5 feet outside of building areas including attached walkways and any other architectural members. We suggest the use of crushed limestone base in the upper 6 inches of the select fill pad from a standpoint of construction access during wet weather, as well as from a standpoint of floor slab support.

For any flatwork (sidewalk, ramps, etc.) outside of the building area which will be sensitive to movement, subgrade preparation as discussed above should be considered to reduce differential movements between the flatwork and the adjacent building. If subgrade preparation as given above for building areas is not implemented in the exterior flatwork areas, those areas may be susceptible to post-construction movements in excess of that given above.

The potential movement values indicated are based upon moisture variations in the subgrade due to circumstances such as moisture increases due to rainfall and loss of evapotranspiration. In circumstances where significant water infiltration beneath the floor slab occurs (such as a leaking utility line or water seepage from outside the buildings resulting from poor drainage), movements in isolated floor slab areas could potentially be in excess of those indicated in this report.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means. Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual.

Although the indicated preparation options are anticipated to reduce cracking in the floor slab, differential movements at entryways may cause difficulty in opening and closing doors. If the floor slab is doweled into the perimeter grade beams to control movement, the resulting soil pressures may cause cracks to develop inside of the dowel bars, adjacent to the exterior walls. However, if the floor is not doweled at these locations, a “trip hazard” could result due to the resulting differential movements at entry ways, and difficulty in opening and closing doors could develop.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Floor Slab Construction Considerations

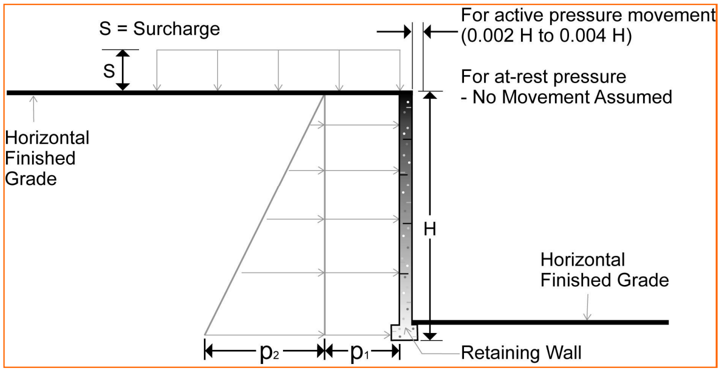
Design recommendations for floor slabs assume the requirements in **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the subgrade and select fill pad beneath the floor slab.

Finished subgrade within and for at least 10 feet beyond the floor slab should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

LATERAL EARTH PRESSURES

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated). The recommendations in this section apply to those walls which are installed in open cut or embankment fill areas such that the backfill extends out from the base at an angle of at least 45 degrees from vertical for the entire height and length of the wall.



Lateral Earth Pressure Design Parameters				
Backfill Type	**Estimated Total Unit Weight, pcf**[1]	**Lateral Earth Pressure Coefficients**[2]		
		At Rest, K_o	**Active, K_A**	**Passive, K_P**
Crushed Limestone	135	0.45	0.3	3.5
Clean Sand	120	0.5	0.35	3.0
Clean Gravel	120	0.45	0.3	3.5

1. Compaction should be maintained between 95 and 100 percent of Standard Proctor (ASTM D 698) maximum dry density. Overcompaction can produce lateral earth pressure coefficients in excess of those provided.
2. Coefficients represent nominal (unfactored) values. Appropriate safety factors should be applied.

The above values do not include a hydrostatic or ground-level surcharge component. To prevent hydrostatic pressure build-up, retaining walls should incorporate functional drainage (via free-draining aggregate or manufactured drainage mats) within the backfill zone. The effect of surcharge loads, where applicable, should be incorporated into wall pressure diagrams by adding a uniform horizontal pressure component equal to the applicable lateral earth pressure coefficient times the surcharge load, applied to the full height of the wall.

All retaining walls should be checked against failure due to overturning, sliding and overall slope stability. Such an analysis can only be performed once the dimensions of the wall and cut/fill scenarios are known. For retaining wall bearing capacity design, we recommend the following parameters.

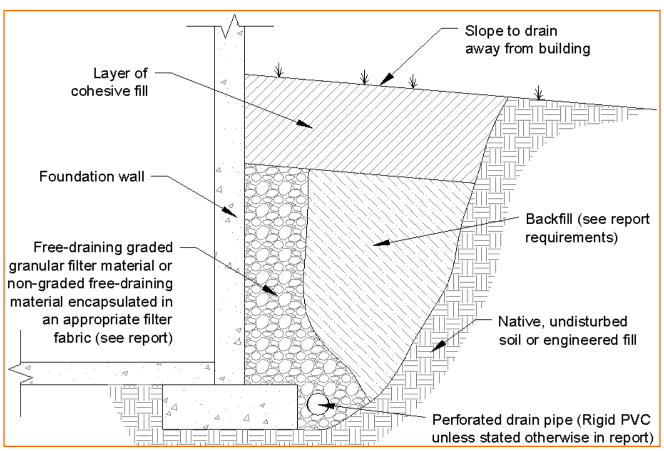
Bearing Material	**Coefficient of Sliding Resistance**	**Maximum Allowable Sliding Resistance, psf**	**Maximum Footing Bearing Capacity, psf**
On-site Soils [1,2]	0.3	500	2,500
Select Fill [3]	0.35		

1. There exists a high movement potential for any retaining walls bearing on the native on-site soils **(up to 5 inches)**. If lower movement potential is desired, please contact us so that we may provide additional recommendations.
2. Frequent joints should be provided throughout the length of the retaining wall to reduce cracking due to differential movements caused by the shrink/swell movement of the fat clay subgrade.
3. If the subgrade is prepared as recommended in **Building Subgrade Preparation**, the values for Select Fill may be considered.

We recommend that a "buffer zone" of at least 5 feet wide be applied between pavement areas and retaining walls (with a minimum height of 4 feet or more). This buffer zone should be increased to 10 feet for building areas. These recommended buffer zones are to reduce the potential of distress from any long-term ("creep") movements of the wall and backfill. Pedestrian sidewalks may be exempted from the above criteria, however some distress could still be observed in the sidewalks due to movements of the retaining walls and backfill.

Subsurface Drainage for Retaining Walls

A perforated rigid plastic drain line installed behind the base of walls and extending below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around an exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 10 percent passing the No. 8 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

PAVEMENTS

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs, noted in this section, must be applied to the site, which has been prepared as recommended in the **Earthwork** section.

Pavement designs are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. Support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade, such as the Stratum 1 soils encountered on this project. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. It is therefore important to minimize moisture changes in the subgrade to reduce shrink/swell movements. Proper site perimeter drainage should be provided so that infiltration of surface water from unpaved areas surrounding the pavement is minimized.

Lime treatment of the Stratum 1 fat clay subgrade is suggested to enhance the workability and support characteristics of the subgrade as well as to provide a barrier to reduce moisture infiltration in the underlying clay subgrade. The lime treatment also helps to reduce the shrink/swell potential of the lime-treated layer. We should note that if lime treatment is planned, we recommend that the subgrade soils be investigated for the presence of sulfates during construction. Excessive concentrations of sulfates in the soils can result in poor performance of lime-treated subgrade. Based on numerous research studies performed by education institutions, regulatory agencies, and both public and private entities, soils that contain significant amounts of soluble sulfates are not optimal candidates for lime treatment and may result in excessive heave and subsequent distress to the pavements. Soluble sulfate levels of up to 3,000 ppm or less are generally considered to be acceptable for lime treatment. Soluble sulfate levels between 3,000 ppm and 10,000 ppm in clay soils are generally considered to be moderate to high and pose a greater risk to successful traditional lime treatment.

Although lime treatment of the subgrade will likely reduce differential movement and heave in the new pavement system, some differential movement will likely occur. Cracking of the concrete pavement due to differential movements should be expected.

Pavement Design Parameters

Design of Asphaltic Concrete (HMAC) pavements are based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993). Design of Portland Cement Concrete (PCC) pavements are based upon American Concrete Institute (ACI) 330R-01; Guide for Design and Construction of Concrete Parking Lots.

Detailed traffic loads and frequencies were not available, however we anticipate that traffic will consist primarily of passenger vehicles in the parking areas and passenger vehicles combined with emergency vehicles, occasional garbage trucks, service trucks, and delivery trucks in driveways. If heavier traffic loading is expected or other traffic information is available, Terracon should be provided with the information and allowed to review the pavement sections provided herein. Tabulated below are the assumed traffic frequencies and loads used to design pavement sections for this project.

Pavement Area	Traffic Design Index	Description
Parking Areas (Passenger Vehicles Only)	DI-1	Light traffic – (ESALs [1]<5) Passenger cars and pickup trucks, no regular use by heavily loaded two axle trucks or lightly loaded larger vehicles.
Secondary Driveways (non-Delivery or Loading Areas)	DI-2 [2]	Light to medium traffic – (5≤ESALs≤20) Passenger cars and pickup trucks with no more than 50 heavily loaded two-axle trucks or lightly loaded three axle trucks per day. No regular use by heavily loaded trucks with three or more axles.
Primary Driveways, Loading/Unloading Areas and Dumpster Enclosures	DI-3	Medium traffic – (20<ESALs≤75) No more than 300 heavily loaded two axle trucks or lightly loaded three axle trucks and no more than 30 heavily loaded three axle trucks per day.

1. 18-kip equivalent single axle load applications.
2. For Fire Lanes to withstand the occasional HS-20 loading of 32,000 pounds per axle and 80,000-pound gross truck weight, use DI-2 pavements or thicker.

An estimated subgrade CBR of 3 was used for HMAC pavement designs, and an estimated modulus of subgrade reaction of 100 pci was used for the PCC pavement designs. The values were empirically derived based upon our experience with the described subgrade soils and our understanding of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**.

Local drainage characteristics of proposed pavements areas are poor. These characteristics, coupled with the approximate duration of saturated subgrade conditions, results in a design drainage coefficient of 1.0 when applying the AASHTO criteria for design.

Pavement Section Thicknesses

The following tables provides options for HMAC and PCC pavement sections.

Asphaltic Concrete Design				
Layer	Thickness (inches)			
	DI-1		DI-2	
	Option 1A	Option 1B	Option 2A	Option 2B
Asphaltic Concrete (HMAC)	2.0	2.0	2.5	2.5
Crushed Limestone Base	9.0	12.0	11.0	13.0
Lime Treated Subgrade	8.0	-	8.0	-
Moisture Conditioned Subgrade [1]	-	6.0	-	6.0

Portland Cement Concrete Design			
Layer	Thickness (inches)		
	DI-1	DI-2 [1]	DI-3 [1]
Reinforced Concrete (PCC)	5	6	7
Moisture Conditioned Subgrade	6	6	6

1. For the DI-2 and DI-3 traffic loading conditions, the reinforced concrete thickness may be reduced by ½ inch if the clay subgrade is lime treated to a depth of at least 8 inches instead of moisture conditioned.

Rigid PCC pavements will perform better than HMAC pavements in areas where short-radii turning and braking are expected (i.e. entrance/exit aprons) due to better resistance to rutting and shoving. In addition, PCC pavements will perform better in areas subject to large or sustained loads, such as loading docks, dumpster enclosures, and loading/unloading areas.

Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e. concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles. As an option, thicker sections could be constructed to decrease future maintenance.

Pavement Materials

Presented below are our recommended material requirements for the various pavement sections.

Item	Value
Hot Mix Asphaltic Concrete (HMAC) [1]	Plant mixed, hot laid Type D (Fine-Grade Surface Course) meeting the specifications in TxDOT Item 340 or COA Item 340.

Item	Value
Reinforced Portland Cement Concrete (PCC)	28-day flexural strength (third-point loading) ≥ 500 psi, or 28-day compressive strength ≥ 3,500 psi
Crushed Limestone Base [2]	TxDOT Item 247, Type A, Grade 1-2 compacted as outlined in **Earthwork**.
Lime Treated Subgrade [3,4]	If soil subgrade consists of high PI (≥30) with ≤ 15% gravel, lime treatment as per TxDOT Item 260 is applicable either through dry placement or slurry placement.
Moisture Conditioned Subgrade [5]	As outlined in **Earthwork**.

1. For acceptance and payment evaluation purposes, we recommend the use of the provisions in COA Item 340.
2. Each lift of base should be thoroughly proof-rolled just prior to placement of subsequent lifts and/or asphalt. Particular attention should be paid to areas along curbs, above utility trenches, and adjacent to landscape islands, manholes, and storm drain inlets. Preparation of the base material should extend at least 24 inches behind curbs.
3. We anticipate that approximately 6 to 10 percent hydrated lime will be required to treat the subgrade soils. We suggest 8% lime be used for bidding purposes with add/deduct line items for 1 to 2% lime above or below the base bid items. Prior to the application of lime to the subgrade, the optimum percentage of lime to be added should be determined based on Plasticity Index (TEX-112-E) and/or pH (ASTM D 6276) laboratory tests conducted on mixtures of the subgrade soils with lime. Subgrade soil samples should be obtained from the pavement areas at the proposed final subgrade elevation. Please note that these tests require up to 5 business days to complete.
4. The lime should initially be blended with a mixing device such as a Pulvermixer, sufficient water added, and allowed to cure for at least 48 hours. After curing, mixing should continue until gradation requirements of TxDOT Item 260.4 are achieved. The mixture should then be moisture adjusted and compacted as outlined in Earthwork. Preparation of the lime-treated subgrade should extend at least 24 inches behind curbs, or edge of pavements, whichever is greater.
5. Subgrade should not dry out or become saturated prior to pavement construction. The pavement subgrade should be thoroughly proof-rolled as outlined in **Earthwork**. Particular attention should be paid to areas along curbs, above utility trenches, and adjacent to landscape islands, manholes, and storm drain inlets. Preparation of the moisture conditioned subgrade should extend at least 24 inches behind curbs.

Presented below are our recommendations for the construction of the reinforced concrete pavements.

Item	Value
Reinforcing Steel	#3 bars spaced at 18 inches on center in both directions
Control (i.e., Contraction) Joint Spacing	In accordance with ACI 330R-08, control joints should be spaced no greater than 15 feet for 6-inch thick or greater concrete. If sawcut, control joints should be cut within 6 to 12 hours of concrete placement. Sawcut joint should be at least ¼ of the slab thickness.

Item	Value
Expansion (i.e., Isolation) Joint Spacing	ACI 330R-08 indicates that regularly spaced expansion joints may be deleted from concrete pavements. Therefore, the installation of expansion joints is optional and should be evaluated by the design/construction team. Expansion joints, if not sealed and maintained can allow infiltration of surface water into the subgrade.
Dowels at Expansion Joints	¾-inch smooth bars, 18 inches in length, with one end treated to slip, spaced at 12 inches on centers at each joint.

Pavement Drainage

On most projects, rough site grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, dry weather may desiccate some areas, rainfall and surface water saturates some areas, heavy traffic from concrete and other delivery vehicles disturbs the subgrade, and many surface irregularities are filled in with loose soils to temporarily improve subgrade conditions. As a result, the pavement subgrade should be carefully evaluated as the time for pavement construction approaches. This is particularly important in and around utility trench cuts. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving. Thorough proof-rolling of pavement areas should be performed no more than 36 hours prior to surface paving. Proof-rolling should be repeated if the site received rainfall prior to paving. Any problematic areas should be reworked and compacted at that time.

Openings in pavements, such as landscaped islands, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are self-contained planters, edge drains connected to the storm water collection system, longitudinal subdrains, or other suitable outlet, and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

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 sufficiently to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install perimeter pavement drainage systems (i.e., French drains) surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Construct curb, gutter and/or sidewalk directly on clay subgrade soils rather than on granular base course materials.

SLOPE STABILITY

Cut Slopes

The table below provides the recommended slope inclinations for both permanent cut slopes and temporary cut slopes. In our opinion, cut slopes at the inclinations discussed below should be stable against a large-scale slide, however the potential for sloughing of loose soils zones exists.

Slope Type	Maximum Slope Inclinations
Temporary	1½(H):1(V) in on-site soils
Permanent	3(H):1(V) in on-site soils

Exposed cut slopes will also be susceptible to further erosion due to the nature of the on-site soils. Installation of erosion control measures in such areas would be beneficial in reducing the potential slope stability which could result from excessive erosion. In addition to initial erosion control measures, the cut slopes should be periodically checked for erosion (particularly after heavy rainfall events) and maintenance performed on areas exhibiting erosion.

In regards to worker safety, Occupation Safety and Health Administration (OSHA) Safety and Health Standards require the protection of workers adjacent to excavations. The OSHA guidelines and directives should be adhered by the Contractor during construction to provide a safe working environment.

Buffer Zones Adjacent to Cut Slopes

Excavation methods could result in decreased slope stability. To allow for some sloughing to occur, we recommend that a "buffer zone" at least 5 feet wide adjacent to pavement and other general areas be provided between the proposed construction areas and the permanent cut slopes (both at the toe and the crest). If buildings are planned near these areas, the buffer zones should be increased to at least 10 feet. This should help reduce the possibility of sloughing soils/rock from contacting the adjacent improvements on the downhill side and from undermining the improvements on the uphill side.

Embankment Fill Slopes

The table below provides the recommended slope inclinations for embankment fill slopes which are constructed in association with building, pavement, and/or general site improvements.

Slope Type	Maximum Slope Inclinations
Embankment Fill Slopes [1,2]	3(H):1(V)

1. For slopes to be used by mowers or other maintenance equipment, 4H:1V slopes are generally acceptable.
2. Fill placement for the embankments should proceed as outlined in **Earthwork**.

The embankment slopes should be properly protected from erosion. The use of rock rip-rap, erosion control fabrics, and/or vegetation is common). In addition to initial erosion control measures, the embankments should be periodically checked for erosion (particularly after heavy rainfall events) and maintenance performed on areas exhibiting erosion.

Embankments which are constructed on natural subgrade sloping steeper than 5(H):1(V) should be "keyed" into the subgrade at the toe of the embankment. The keyed-in toe should consist of a 12-foot wide section which is excavated into the subgrade such that a horizontal working surface is attained for compaction of the first embankment lift. Successive lifts should remain horizontal and should not tend to follow the slope of the natural subgrade.

The edges of fill embankments are often undercompacted in the field due to loose material being pushed off the edges as the embankment lifts are compacted. To reduce the possibility of this impacting the stability of the embankment fill, the embankments should be overbuilt and compacted as outlined in **Earthwork**. Then the embankment should be cut back to the slopes recommended above.

GENERAL COMMENTS

As the project progresses, we address assumptions by incorporating information provided by the design team, if any. Revised project information that reflects actual conditions important to our services is reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

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. Natural 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 the final 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 or collaboration through this system 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 impact 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. 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

Planned Location	Number of Borings	Planned Boring Depth (feet)
Building Area	3	25
Pavement Area	3	5
Rear Access Drive	2	5
TOTAL	8	100

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provide the boring layout. Coordinates are obtained with a handheld GPS unit (estimated horizontal accuracy of about ±5 feet) and approximate elevations are obtained by interpolation from Google Earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advance the borings with a truck-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem as necessary depending on soil conditions). Four to five samples are obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. 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. We observe and record groundwater levels during drilling and sampling. For safety purposes, all borings are backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information are recorded on the field boring logs. The samples are placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepares field boring logs as part of the drilling operations. These field logs include visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs are prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviews the field data and assigns various laboratory tests to better understand the engineering properties of the various soil strata as necessary for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods are applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D2166/D2166M Standard Test Method for Unconfined Compressive Strength of Cohesive Soil

The laboratory testing program often includes examination of soil samples by an engineer. Based on the material's texture and plasticity, we describe and classify the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION

Townwest Commons ■ Hutto, Texas

August 24, 2018 ■ Terracon Project No. 96185224

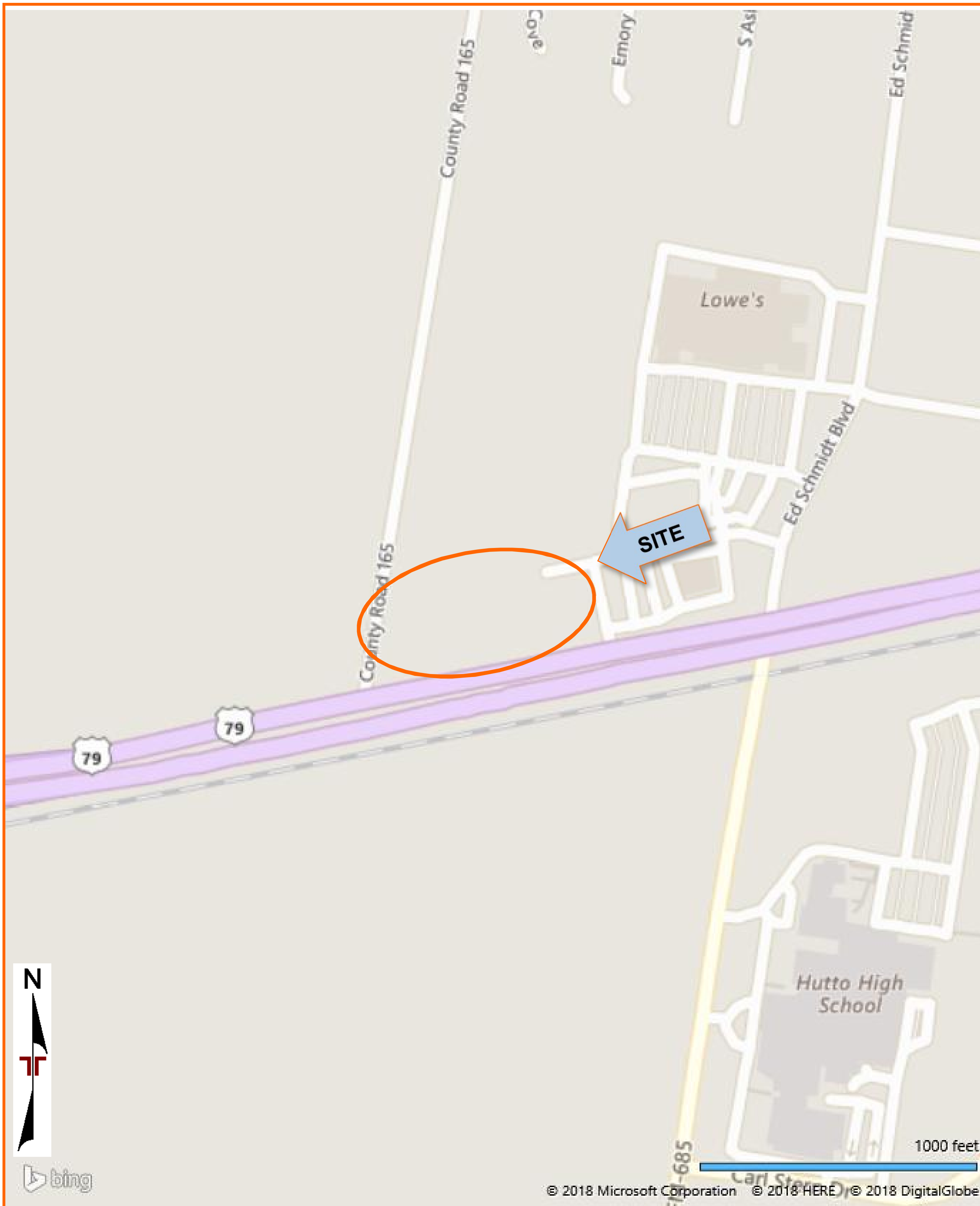


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Townwest Commons ■ Hutto, Texas
August 24, 2018 ■ Terracon Project No. 96185224

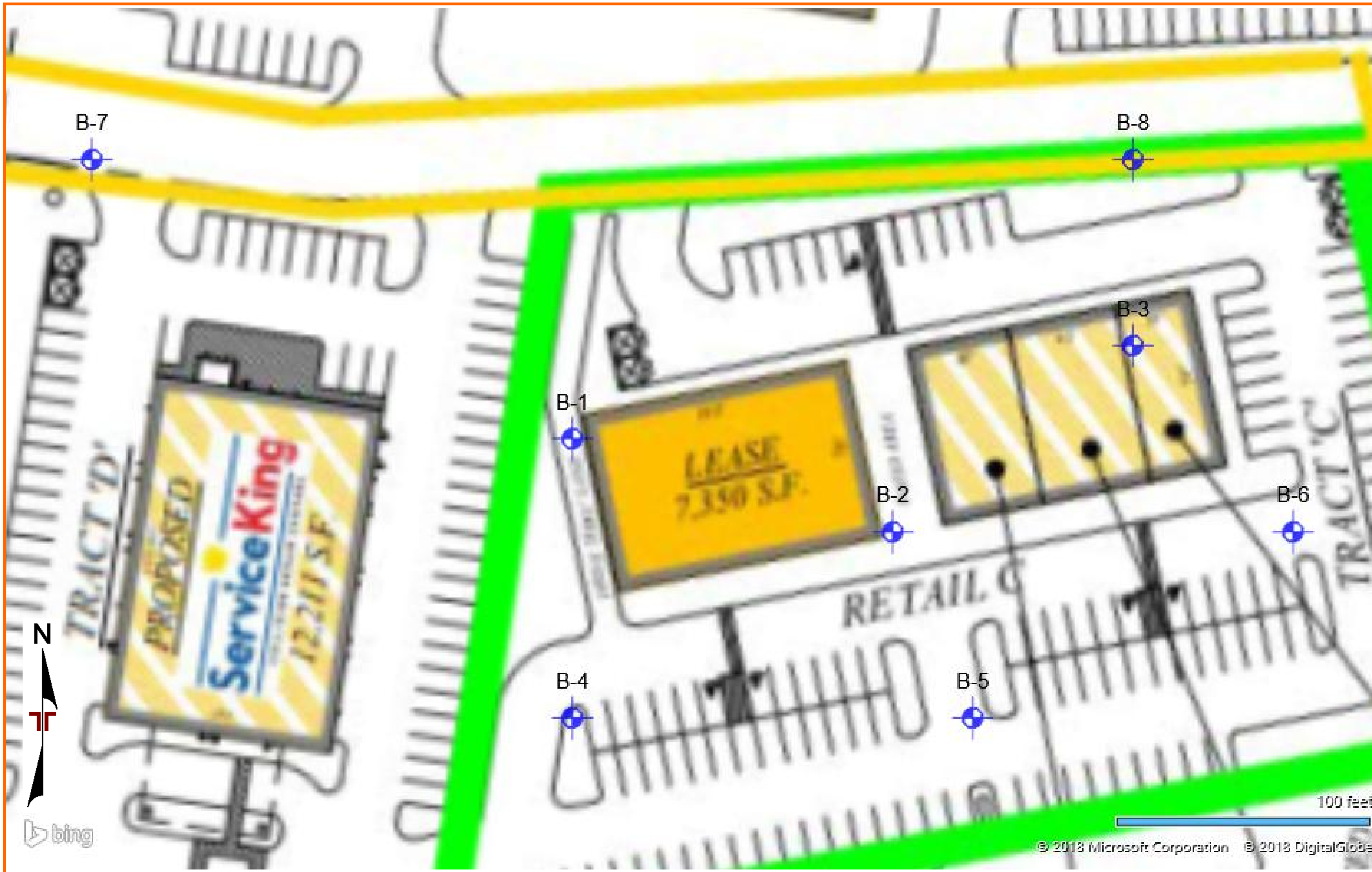


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Townwest Commons ■ Hutto, Texas
August 24, 2018 ■ Terracon Project No. 96185224

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

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

BORING LOG NO. B-1

PROJECT: Townwest Commons

CLIENT: NewQuest Properties
Houston, TX

SITE: US 79 and CR 165
Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5406° Longitude: -97.5663°

GRAPHIC LOG	MODEL LAYER	DEPTH / Description / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard				4.5 tsf (HP)				20		57-22-35	96
						4.5 tsf (HP)				22			
			5			4.5 tsf (HP)				24			
		8.0 +/-				4.5 tsf (HP)				24		71-21-50	
	2	**LEAN CLAY (CL)**, light brown, very stiff to hard, with calcareous deposits from 8 to 15 feet	10			4.5 tsf (HP)	UC	5.73	7.4	19	107	54-16-38	87
			15			4.5 tsf (HP)	UC	3.86	7.1	13	113		
		-increase in sand deposits from 18 to 20 feet	20	▽		4.5 tsf (HP)	UC	2.87	8.6	20	108		
		25.0 +/-	25			4.5 tsf (HP)							
		Boring Terminated at 25 Feet											

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 25 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

▽ *18' While drilling*

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

BORING LOG NO. B-2

PROJECT: Townwest Commons

CLIENT: NewQuest Properties
Houston, TX

SITE: US 79 and CR 165
Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5405° Longitude: -97.5659°

MODEL LAYER	DEPTH / DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	**FAT CLAY WITH SAND (CH)**, dark brown, hard			4.5 tsf (HP)				19			
				4.5 tsf (HP)				17	106		
		5		4.5 tsf (HP)				20		82-23-59	81
	8.0 +/-			4.5 tsf (HP)	UC	6.01	10.4	20	110		
2	**LEAN CLAY WITH SAND (CL)**, light brown, very stiff to hard	10		4.5 tsf (HP)				17		41-19-22	83
		15		4.5 tsf (HP)				16			
		20	▽	15-8-13 N=21							
	-with gravel at 23 feet			45-50/3"							
	25.0 +/-	25									
	Boring Terminated at 25 Feet										

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 25 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

▽ *21' While drilling*

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

BORING LOG NO. B-3

PROJECT: Townwest Commons

CLIENT: NewQuest Properties Houston, TX

SITE: US 79 and CR 165 Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5407° Longitude: -97.5656°

Model Layer	Depth / Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	**FAT CLAY (CH)**, dark brown, hard				4.5 tsf (HP)				16			
					4.5 tsf (HP)				22		77-24-53	94
		5			4.5 tsf (HP)	UC	4.07	5.3	25	95		
					4.5 tsf (HP)				24			
	10.0 +/-				4.5 tsf (HP)	UC	6.01	5.3	22	108	65-21-44	
2	**LEAN CLAY WITH SAND (CL)**, light brown, hard, with calcareous deposits to 15 feet	10										
					4.5 tsf (HP)				14			69
		15	▽ (17')									
					44-50/3"							
		20										
	25.0 +/-				50/5"							
	Boring Terminated at 25 Feet	25										

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 25 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

▽ *17' While drilling*

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

BORING LOG NO. B-4

PROJECT: Townwest Commons

CLIENT: NewQuest Properties
Houston, TX

SITE: US 79 and CR 165
Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5403° Longitude: -97.5663°

GRAPHIC LOG	MODEL LAYER	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard					4.5 tsf (HP)				19			
							4.5 tsf (HP)				23		83-23-60	
		5.0	+/-	5			4.5 tsf (HP)							
		Boring Terminated at 5 Feet												

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 5 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

BORING LOG NO. B-5

PROJECT: Townwest Commons

CLIENT: NewQuest Properties
Houston, TX

SITE: US 79 and CR 165
Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5403° Longitude: -97.5658°

GRAPHIC LOG	MODEL LAYER	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard				4.5 tsf (HP)				17			
						4.5 tsf (HP)				23			
		5.0 +/-	5			4.5 tsf (HP)							
		Boring Terminated at 5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 5 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018

Boring Completed: 08-03-2018

Drill Rig: CME 55

Driller: GeoTechnical Services

Project No.: 96185224

BORING LOG NO. B-6

PROJECT: **Townwest Commons**

CLIENT: **NewQuest Properties**
Houston, TX

SITE: **US 79 and CR 165**
Hutto, TX

GRAPHIC LOG	MODEL LAYER	LOCATION See Exploration Plan Latitude: 30.5405° Longitude: -97.5654° DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard				4.5 tsf (HP)				17			
						4.5 tsf (HP)				22			
		5.0 +/-	5			4.5 tsf (HP)							
		Boring Terminated at 5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 5 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

BORING LOG NO. B-7

PROJECT: Townwest Commons

CLIENT: NewQuest Properties
Houston, TX

SITE: US 79 and CR 165
Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5409° Longitude: -97.5669°

GRAPHIC LOG	MODEL LAYER	DEPTH / Description / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard				4.5 tsf (HP)				20		69-25-44	
						4.5 tsf (HP)				21			89
		5.0 +/-	5			4.5 tsf (HP)							
		Boring Terminated at 5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 5 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

BORING LOG NO. B-8

PROJECT: Townwest Commons

CLIENT: NewQuest Properties Houston, TX

SITE: US 79 and CR 165 Hutto, TX

LOCATION See Exploration Plan

Latitude: 30.5409° Longitude: -97.5656°

GRAPHIC LOG	MODEL LAYER	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	1	**FAT CLAY (CH)**, dark brown, hard				4.5 tsf (HP)				13			
						4.5 tsf (HP)							
		5.0 +/-	5			4.5 tsf (HP)				13			
		Boring Terminated at 5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Dry Augered 0 to 5 feet

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

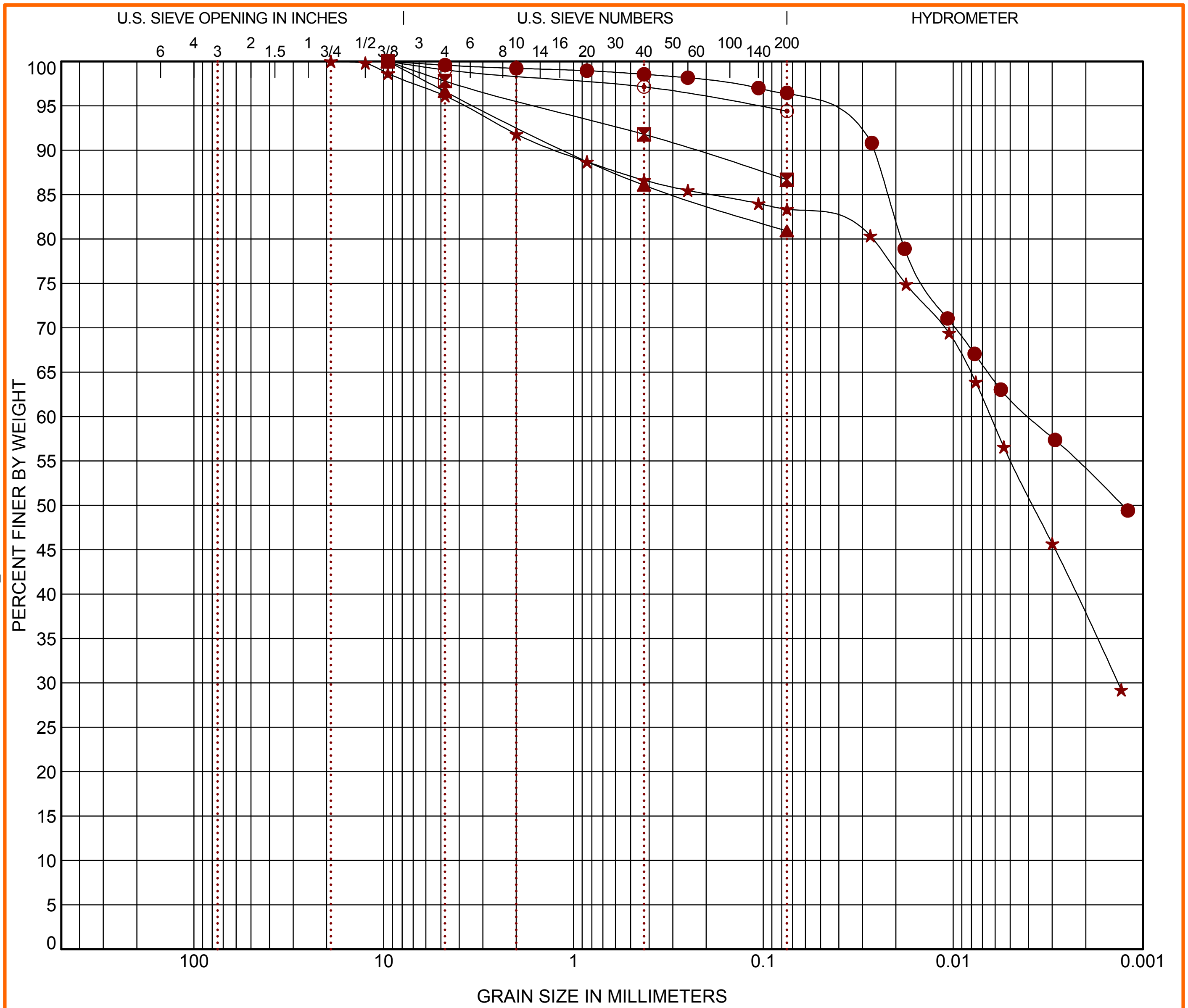
Terracon

5307 Industrial Oaks Blvd, Ste 160
Austin, TX

Boring Started: 08-03-2018	Boring Completed: 08-03-2018
Drill Rig: CME 55	Driller: GeoTechnical Services
Project No.: 96185224	

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	0 - 2	FAT CLAY (CH)	20	57	22	35		
⊠	B-1	8 - 10	FAT CLAY (CH)	19	54	16	38		
▲	B-2	4 - 6	FAT CLAY with SAND (CH)	20	82	23	59		
★	B-2	8 - 10	LEAN CLAY with SAND (CL)	17	41	19	22		
⊙	B-3	2 - 4	FAT CLAY (CH)	22	77	24	53		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	0 - 2	9.5	0.004			0.4	3.1	34.4		62.1
⊠	B-1	8 - 10	9.5				2.2	11.1		86.7	
▲	B-2	4 - 6	9.5				3.4	15.7		80.9	
★	B-2	8 - 10	19	0.006	0.001		3.9	12.8	28.2		55.1
⊙	B-3	2 - 4	9.5				1.0	4.6		94.4	

PROJECT: Townwest Commons

PROJECT NUMBER: 96185224

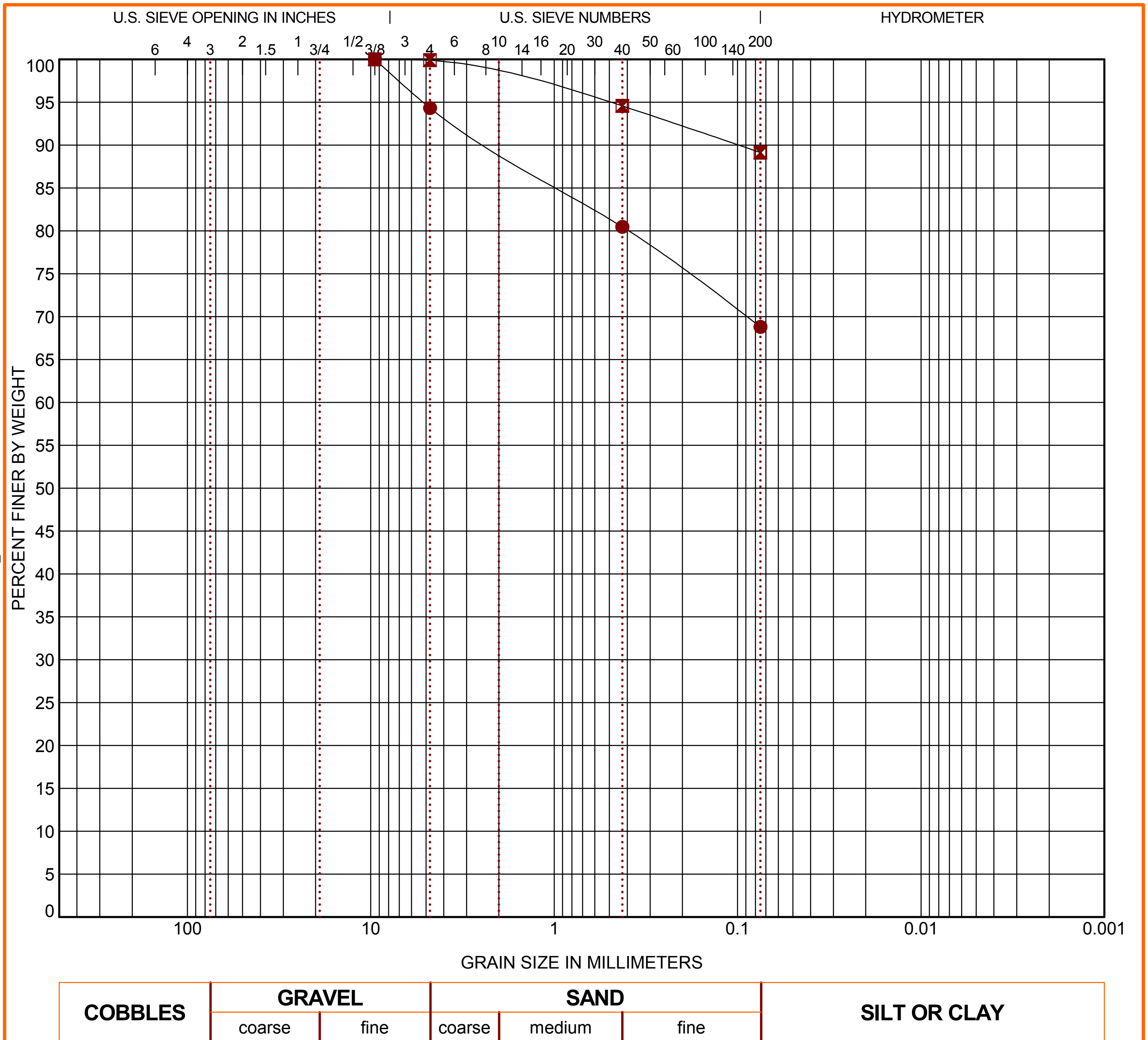
Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

SITE: US 79 and CR 165
Hutto, TX

CLIENT: NewQuest Properties
Houston, TX

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-3	13 - 15		14					
☒	B-7	2 - 4		21					

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-3	13 - 15	9.5				5.7	25.5		68.8	
☒	B-7	2 - 4	9.5				0.1	10.8		89.1	

PROJECT: Townwest Commons

SITE: US 79 and CR 165
Hutto, TX

Terracon
5307 Industrial Oaks Blvd, Ste 160
Austin, TX

PROJECT NUMBER: 96185224

CLIENT: NewQuest Properties
Houston, TX

SUPPORTING INFORMATION

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Townwest Commons ■ Hutto, TX

August 22, 2018 ■ Terracon Project No. 96185224

SAMPLING	WATER LEVEL	FIELD TESTS
Shelby Tube Split Spoon	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time 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.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

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		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.**	**Descriptive Term (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

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: 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 ³ 4 and 1 £ Cc £ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [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 ³ 6 and 1 £ Cc £ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [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 on or above "A"	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - 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:	Liquid limit - oven dried / Liquid limit - 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 ³ 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 ³ 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 ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ³ 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.