



Tolunay-Wong  **Engineers, Inc.**

**REPORT of GEOTECHNICAL CONSULTING SERVICES
Hughes Park Project
6446 Sewanee Avenue
West University Place, Harris County, Texas**

Prepared for:

**City of West University Place
6104 Auden Street
West University Place, Texas 77005**

Prepared by:

**Tolunay-Wong Engineers, Inc.
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March 23, 2018

TWE Project No. 18.13.002



Tolunay-Wong Engineers, Inc.

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March 23, 2018

City of West University Place
6104 Auden Street
West University Place, Texas 77005

Attn: Susan White, Director of Parks and Recreation

Ref: **Report of Geotechnical Consulting Services**
Hughes Park Project
6446 Sewanee Avenue
West University Place, Harris County, Texas
TWE Project No. 18.13.002


Dear Ms. White,

Tolunay-Wong Engineers, Inc. (TWE) is pleased to submit this geotechnical report for the referenced project. This report summarizes the field and laboratory testing programs and presents foundation design and construction recommendations for the project.

We appreciate the opportunity to assist you on this phase of the project and we look forward to the opportunity of providing additional services as the project progresses. If you have any questions regarding this report or if we can be of further assistance, please contact us.

Sincerely,

TOLUNAY-WONG ENGINEERS, INC.
TBPE Firm Registration No. F-000124


Mariam Abdelwahab, E.I.T.
Staff Geotechnical Engineer




3-23-2018

David Barreiro, P.E.
Senior Manager

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1. INTRODUCTION and PROJECT DESCRIPTION

The City of West University Place contracted Tolunay-Wong Engineers (TWE) to perform a geotechnical study for the Hughes Park Project located at 6446 Sewanee Avenue on the northwest corner of the intersection of Sewanee Avenue and Pittsburgh Street in West University Place, Harris County, Texas (Key Map: 532 F).

The geotechnical study was conducted in accordance with TWE Proposal No. P17-G239 dated October 27, 2017 and was authorized via the City of West University Place Purchase Order No. 18-000018 issued on January 11, 2018. Project information was provided to TWE via email transmittals and telephone conversations.

Project Description

We understand the project plan is to develop the parcel (approximately 165 feet by 100 feet) into an open park with a 20 ft by 20 ft pavilion structure, paved pedestrian walking paths, and an 8-foot tall masonry wall along the north and west sides of the property. The pavilion foundation will consist of a reinforced-concrete, monolithic slab with thickened edges (perimeter grade beams) to which four columns will be anchored at the slab corners. Other proposed site features will include open grass lawn areas and new trees.

The parcel is a previously developed residential lot with maintained a single-family residence, grassy areas, shrubs, trees and concrete flatwork. Site demolition had been completed at the time of the geotechnical field exploration.

2. PURPOSE AND SCOPE OF SERVICES

The purpose of the geotechnical study was to explore the soil and groundwater conditions at the project site and to provide geotechnical design and construction recommendations.

The scope of services included the following:

1. Field exploration program utilizing two soil test borings advanced to depths of 20 feet below the present site grade to evaluate the subsurface soil and groundwater conditions.
2. Laboratory tests on recovered soil samples to evaluate the index and strength properties.
3. Geotechnical report deliverable summarizing the findings and providing technically-sound and cost-effective foundation design and construction recommendations.

The authorized scope of services did not include either an environmental site assessment or a geological fault study.

3. FIELD EXPLORATION

3.1 Subsurface Exploration

The field program was performed on February 5, 2018. The approximate boring locations are shown on the appended Soil Boring Location Plan.

3.2 Drilling Methods

The field exploration was conducted using a geotechnical drilling rig equipped with a rotary head. The boreholes were advanced in accordance with ASTM Standards using dry-auger drilling methods to the boring termination depths. Upon completion of the soil sampling activities and following groundwater level measurements, the boreholes were backfilled with soil cuttings to ground surface.

3.3 Soil Sampling

Continuous soil sampling was conducted in the upper 12 feet of the borehole and then at 5-foot intervals to the borehole termination depths. Soil sampling was performed in accordance with the applicable ASTM Standards. Undisturbed samples of clayey soil were recovered using thin-walled Shelby tube samplers.

Disturbed samples of sandy soils were recovered using standard penetration test (SPT) split-spoon samplers. The SPT is performed by driving the sampler 18 inches in 6-inch intervals or to refusal with a 140-pound hammer, free-falling 30 inches. The SPT N-value, in blows per foot, is the total number of blows required to drive the sampler the second and third 6-inch intervals. The N-value provides an indication of in-place soil strength, relative density and consistency.

The TWE geotechnician visually classified the recovered soils in the field, and obtained strength measurements of recovered undisturbed samples using pocket penetrometer equipment. Soil specimens were preserved in the field and transported to the TWE geotechnical laboratory in accordance with ASTM Standards. Recovered samples were not examined, either visually or analytically, for chemical composition or environmental hazards.

3.4 Boring Logs

The engineering interpretations of the subsurface findings at the test locations are presented in the appended boring logs. The soil classifications were developed in accordance with ASTM Standards and published correlations. The transitions between various soil strata could actually occur gradually. Actual subsurface soil conditions could vary away from the test boring locations. When reviewing the boring logs reference should be made to the appended Key to Symbols and Terms.

3.5 Groundwater Level Measurements

The borings were initially dry-augered to evaluate the presence of perched groundwater or free water conditions in the boreholes. Free-water was encountered in both boreholes. Groundwater level observations in the open borehole may not accurately reflect the stabilized groundwater condition primarily due to time-dependent recharge associated with subsurface clay conditions. Where appropriate, standpipe piezometers can be used to evaluate long-term groundwater levels.

Due to the introduction of water into the borehole, groundwater levels measured after commencing rotary wash drilling may be unrepresentative of prevalent site conditions. Groundwater level measurements are reported on the appended boring logs and summarized in Table 3-1.

Table 3-1: Groundwater Level Measurements		
Test Boring	Free Water (feet)	Groundwater After Time Interval (feet)
B-1	13	8.7 (30 minutes)
B-2	12	9 (15 minutes)

4. LABORATORY TESTING PROGRAM

Laboratory tests were conducted on selected soil samples to assist with the classification of the recovered soil specimens, and to evaluate the soil index and strength properties. Laboratory tests were performed in general accordance with ASTM Standards. Results of the laboratory testing are presented in the appended boring logs.

5. SUBSURFACE CONDITIONS

Our interpretations of soil and groundwater conditions at the project site are partly based on information obtained from the soil test borings and TWE local experience. Subsurface conditions could vary away from the exploration test sites. Significant subsurface variations that could be identified during the construction-phase of the project will warrant revisiting the engineering analyses and recommendations.

5.1 Regional Geology

The site is located in an area identified with the Beaumont Formation. The Beaumont Formation includes mainly stream channel, point-bar, natural levee, back swamp and to a lesser extent coastal marsh and mud-flat deposits consisting of mostly clay, silt and sand.

5.2 Subsurface Conditions

The appended boring logs should be reviewed for the field and laboratory test results. The upper 8 inches to 2 feet of the subsurface profile is interpreted as possible fill materials consisting of firm to stiff, fat and lean clays (CH, CL). It is noted that it is sometimes difficult to differentiate fill from similar natural soils.

The underlying natural soil profile consists of stiff fat clays (CH) to depths of approximately 12 feet, where the clays are underlain by medium dense sands 13 feet underlain by sands (SC-SM, SP-SM) to boring termination depths of 20 feet.

6. TECHNICAL DISCUSSION

Potential Vertical Rise - The serviceability of shallow foundation systems that are directly supported on expansive soils can be negatively impacted by shrink-swell behavior of those soils. Grade slabs can “heave” and cause distortion of building elements during periods of increasing soil moisture. On the other hand, periods of decreasing soil moisture can result in slab and building settlement.

In the Houston area a common approach to estimating the potential vertical rise (PVR) of natural subgrade soils is the Test Procedure TEX-124-E. Considering an active (moisture change) zone of 8 feet the PVR value for the “existing” subsurface conditions is estimated to be on the order of 1.5 inches.

The elevated PVR value is a result of the presence of medium to high plasticity clays in the shallow subsurface profile. The laboratory test results identified the shallow clays (upper 8 feet) at this project site with plasticity index (PI) values in the range of 22 to 36 with an average PI value of 29. To help interpret the significance of these PI values, as general guidelines, the ranges below can be found in the geotechnical literature:

Plasticity Index (%):	0-10	10-15	15-25	25-35	35-100
Expansion Potential:	Very Low	Low	Medium	High	Very High

Plasticity Index (%):	less than 25	25-35	more than 35
Degree of Expansion:	Low	Marginal	High

For reference purposes, a PVR of less than 1 inch is generally considered the limit for shallow foundation construction without subgrade improvements. Elevated PVR values generally require implementation of subgrade improvements, such as lime stabilization, excavation/replacement, or soil moisture conditioning, beneath building pads and pavement areas, or the use of foundations bearing deeper in the subsurface profile (drilled footings) and the use of structural grade slabs with ground void space.

Settlement - Shallow foundation systems consisting of drilled piers on this project would be anticipated with total settlements of less than 1 inch. Actual settlements will vary depending on actual applied ground contact pressures and footing sizes. Significant fill placement (greater than 3 feet) above existing site grades could trigger post-construction settlements and such a scenario would need to be evaluated.

Bearing Capacity - The ability of a soil to sustain an applied load without shear failure is referred to as soil bearing capacity. Engineering evaluations consider the anticipated ground bearing pressure versus the allowable soil bearing capacity. The allowable bearing capacity is calculated by applying a factor of safety to the estimated ultimate bearing capacity of the subgrade soils. A factor of safety of 3 is considered appropriate for permanent shallow foundation systems.

7. RECOMMENDATIONS

The recommendations provided below are based on the project information described herein, the available subsurface data, our engineering evaluation and TWE past local experience. If project information or design concepts change, we should be advised of these changes in writing and should be provided with an opportunity to review our recommendations as presented in this report in light of the new design information.

7.1 Geotechnical Site Preparation

Site demolition should include removal of all below-grade elements associated with the previous site development, including foundations, slabs, underground utilities, etc. These should all be removed from beneath the new building/wall/sidewalk footprints and extending laterally a minimum of 3 feet, where possible.

The areas within the construction lines should be cleared and grubbed to remove topsoil, vegetation and debris. Tree stumps and major roots systems should be completely removed and the resulting ground depressions should be backfilled with compacted fill soils in accordance with Section 7.4 of this report.

Following site clearing/grubbing activities, the exposed subgrade soils should be proofrolled with a fully-loaded dump truck or similar equipment with a minimum weight of 10 tons under observation by the geotechnical engineer or his qualified representative. Any ground areas that yield excessively under the traffic of the proofroll equipment should be properly mitigated at the direction of the geotechnical engineer. A typical mitigation action would be to over excavate and replace with technically suitable material.

7.1.1 Site Preparation for Conventional Shallow Foundations

The existing high plastic, expansive clay subgrade soils should be removed to a depth of 4 feet below the current site grade from beneath the entire pavilion footprint and extending laterally a minimum of 3 feet where possible in order to reduce the PVR value to 1 inch.

The undercut areas should then be backfilled to rough site grade, using low-plasticity fill material that satisfies the type, placement and compaction requirements provided in Section 7.4 in this report, prior to conventional shallow foundation construction.

7.2 Groundwater Control

We recommend that the contract documents provide for determination of the depth to groundwater just prior to the start of construction and if any remedial dewatering which may be required. Further, we recommend that the groundwater level be maintained at least 24 inches below all earthwork and compaction surfaces during construction. The contractor is responsible for assessing the need for groundwater control at the site and for developing appropriate dewatering procedures.

7.3 Stormwater Runoff and Surface Water Control

We recommend positive drainage measures be established and maintained on the project site during construction and throughout the life of the project. Exterior site grades should be constructed to result in stormwater runoff flow away from the structure exteriors, both during and after construction. Roof runoff should be directed to collection systems designed to discharge at least 10 feet away from the foundation areas or onto areas graded away from the building footprint.

7.4 Fill Soils

Fill soils for general site grading, shallow foundation bearing, backfill and undercut replacements, utility backfill and pavement subgrades should consist of clayey sand (SC) or sandy clay (CL) material.

1. Fill soils should be free of organics, debris and otherwise deleterious materials. In general, suitable fill soils should have a liquid limit (LL) of less than 40, a plasticity index (PI) between 10 and 20, and at least 35% of the soil particles passing the No. 200 sieve.
2. The full depth of each lift of fill soil should be compacted to 95% of the Standard Proctor maximum dry density (ASTM D-698).
3. Fill soils should be placed with horizontal loose lift thicknesses of not more than 6 inches. To facilitate obtaining in-place compaction, the moisture content of the fill soils should be maintained within 3% of the optimum moisture content based on ASTM D-698.
4. Fill compaction efforts should be implemented with surface roller equipment of appropriate size.
5. Representative samples of the fill soils should be collected for classification and compaction testing. The maximum dry density, optimum moisture content, gradation and plasticity should be determined. These tests are needed for quality control of the compacted fill.

6. Field density tests should be performed on the compacted fill at a frequency of one test for each 400 square feet of building pad and concrete flatwork areas, and one test every 40 linear feet at retaining wall footings per lift of fill.
7. Involvement of TWE geotechnical engineering personnel during all site work activities will help to verify that procedures and results are as specified and as anticipated. Any issues identified during this process should be addressed by the geotechnical engineer in the field.

7.5 Conventional Reinforced Shallow Foundations

Strip footings bearing on prepared compacted fill soils are technically suitable for support of the proposed 8-ft tall masonry wall. Monolithic slab construction is technically suitable for support of pavilion structure following completion of the recommended undercutting/replacement. Foundation loads should be transferred directly and continuously to the prepared bearing soils.

1. Shallow foundation systems could consist of either one or a combination of individual column spread footings, strip footings and monolithic grade slab.
2. Shallow foundation systems (strip footings and grade beams) should be designed for a maximum allowable ground contact pressure of 2,000 psf, and a minimum depth of embedment (bottom of foundation below adjacent exterior finished grade) of 18 inches.
3. A minimum thickness of 6 inches of compacted fill soils (in accordance with the previous recommendations) should be provided below the shallow foundation bases (footings and grade beams) and extending a minimum of 12 inches laterally beyond the foundation perimeters.
4. Individual column and wall footings should be sized with minimum widths of 24 inches and 18 inches, respectively.
5. The footings should be designed to resist lateral loads via soil-concrete friction along the base of the foundation. We recommend the available passive resistance on the faces of the footing be conservatively neglected in design. Resistance to sliding at the foundation bases should be calculated using a coefficient of friction of 0.35.
6. Shallow foundations should be designed resist uplift (hydrostatic) loads via combination of foundation concrete dead weight, superstructure dead weight and the buoyant weight of fill soils placed directly above the foundations.
7. If unusual or questionable soil bearing conditions are encountered while performing foundation excavations, the geotechnical engineer should be contacted for appropriate recommendations.

8. Foundation excavation bottoms should be level or suitably benched and free of any loose soils that have been disturbed by seepage or the construction process. Loosened bearing soils should be recompact prior to placement of reinforcing steel. The foundation excavation bottoms should be stable under the weight of construction equipment and personnel. Remedial actions that could be needed, as directed by the geotechnical engineer, should be implemented prior to proceeding with the foundation construction work.
9. Foundation excavations should be cut to final grade and footings constructed as soon as possible to minimize potential damage to bearing soils as result of exposure to the environment.
10. Shallow foundations could be cast directly against the exposed, vertical and horizontal, excavation faces. If formwork is used for construction, we recommend consideration of the use of flowable fill for backfill around the foundation perimeters.
11. Standing surface water in the open excavations should be removed prior to foundation concrete placement.
12. Excavations within in-situ soils could be expected to remain vertical and stable while open only for short periods of time. Excavation collapse due to rainfall or other on-site activities should be repaired to design bearing level prior to reinforcing steel placement.
13. The geotechnical engineer or his qualified representative should observe all shallow foundation excavation work, document the condition of the exposed subgrade soils within the open excavations and be involved with the field geotechnical observations during construction.

7.6 Grade Slabs

Concrete ground floor slabs and concrete flatwork on this project site should use slab-on-grade construction methods, following completion of the recommended undercutting/replacement actions (see Section 7.1.1 of this report) if a potential PVR value of 1.5 inches is not tolerable as the structural engineer's recommendations.

1. We recommend that a minimum of 6 inches of fill soils be placed and compacted (in accordance with the previous recommendations) below scheduled slab-on-grade areas and concrete sidewalk areas to provide uniform slab support. The prepared fill pads should extend a minimum of 12 inches beyond the foundation edges.
2. Grade slabs should be designed with a long-term modulus of subgrade reaction of 50 pci considering the recommended geotechnical site preparation activities.
3. Slab-on-grade loads should be transferred directly and continuously to the prepared fill pad.

4. Standing surface water should be removed prior to slab-on-grade concrete placement.
5. Construction joints should be provided throughout the slab so as to minimize the potential for slab cracking.
6. Involvement of the project geotechnical engineer or his qualified representative during slab-on-grade construction activities will help to verify that procedures and results are as specified and as anticipated.

7.7 Drilled and Underreamed Piers

In the Houston area, drilled and underreamed piers (drilled footings) are commonly utilized for support of structures in the presence of expansive bearing soils. A drilled footing is a cast-in-place concrete foundation with an enlarged bearing area extending downward to a soil stratum capable of supporting the building loads. The depth of the drilled pier should extend to a depth below the moisture active zone that is sufficient to anchor the pier against upward movements of swelling soils in the upper active zone.

The geotechnical site preparation previously recommended (see Section 7.1.1) is not necessary where building loads are designed to be transferred directly to the drilled footings and an elevated structural grade slab is utilized.

Geotechnical design and construction recommendations for underreamed drilled footings are provided below.

1. The drilled footings should be designed to bear on the stiff fat clay layer at a depth of 8 feet below the existing site grade.
2. Drilled footings should utilize a minimum shaft diameter of 18 inches to facilitate inspection of the excavation and reinforcement placement. The ratio of the underream to shaft diameter should be no greater than 3.
3. The drilled footings should be designed for an average base ground contact pressure of 3,000 psf.
4. The drilled footings should be provided appropriate mild steel reinforcement, top to bottom of shaft, as per the structural engineer's recommendations.
5. The angle of underreamed bells to the horizontal should not be less than 45 degrees to avoid potential collapse of the bells during construction.
6. Drilled footings may be designed to resist lateral loads via passive pressure against the vertical sides of the footing. An allowable passive resistance of 750 psf may be used in design while neglecting the upper 2 feet of the adjacent soil profile

7. Drilled footing uplift requirements should be addressed via buoyant concrete/steel dead weight. For underreamed footing design the weight of the soil wedge extending upwards from the base on a slope of 1:1 (H:V) to finished grade may be utilized for uplift resistance. To resist uplift forces the bell diameter should be at least one foot larger than the shaft diameter. The surrounding clay soils may be considered with a buoyant unit weight of 50 pcf and an appropriate factor of safety should be considered in design. An allowable shaft side friction of 300 psf may be used for design.
8. A minimum clearance of one bell diameter should be provided between the underreams to utilize the recommended base contact pressure and to control settlement. If a clearance of one diameter cannot be maintained, the design contact pressure should be reduced by 20 percent for a clearance between one-half and one bell diameters. Underreams closer than a clearance of one half of the bell diameter are not recommended.
9. Based on the available field exploration data, footings drilled to the recommended depth may not encounter the groundwater level, however if perched groundwater is encountered temporary steel casings or drilling mud will be required for footing construction.
10. Drilled footings should be inspected by the geotechnical engineer to document that (a) the excavation has been constructed to the specified dimensions, bearing depth and into the appropriate bearing soil stratum, and (b) loose soil cuttings and any soft-compressible materials have been removed from the bottom of the excavation.
11. Placement of concrete should be accomplished as soon as possible following completion of the excavation activities to mitigate the potential for damage to bearing soils as result of exposure to the environment and sloughing of the vertical excavation faces.

8. LIMITATIONS AND PLAN REVIEW

8.1 Limitations

This report has been prepared for the use of City of West University Place and other members of the project design and construction teams for specific application to the project discussed herein. This report was prepared in accordance with generally accepted geotechnical engineering practices common to the local area. No other warranty is expressed or implied.

We request the opportunity to revisit and supplement, as necessary, our recommendations as provided in this report, if in fact our assumptions or understandings are incorrect or inaccurate. In such a case, we should be provided with appropriate site plans, and system installation procedures for our review and use.

The engineering analyses and recommendations are based on the field and laboratory soil data summarized in the appended documents. The subsurface findings at the field exploration location may not necessarily reflect the actual soil strata vertical and horizontal variations throughout the project area. The analyses and recommendations are also based in part on the geotechnical engineer's engineering judgment and experience with similar project settings and conditions.

TWE recommendations presented in this report must be revisited if subsurface conditions exposed during construction vary significantly from those described in this report. If any changes in the nature, design or location of the project are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed, and the conclusions modified or verified in writing by TWE.

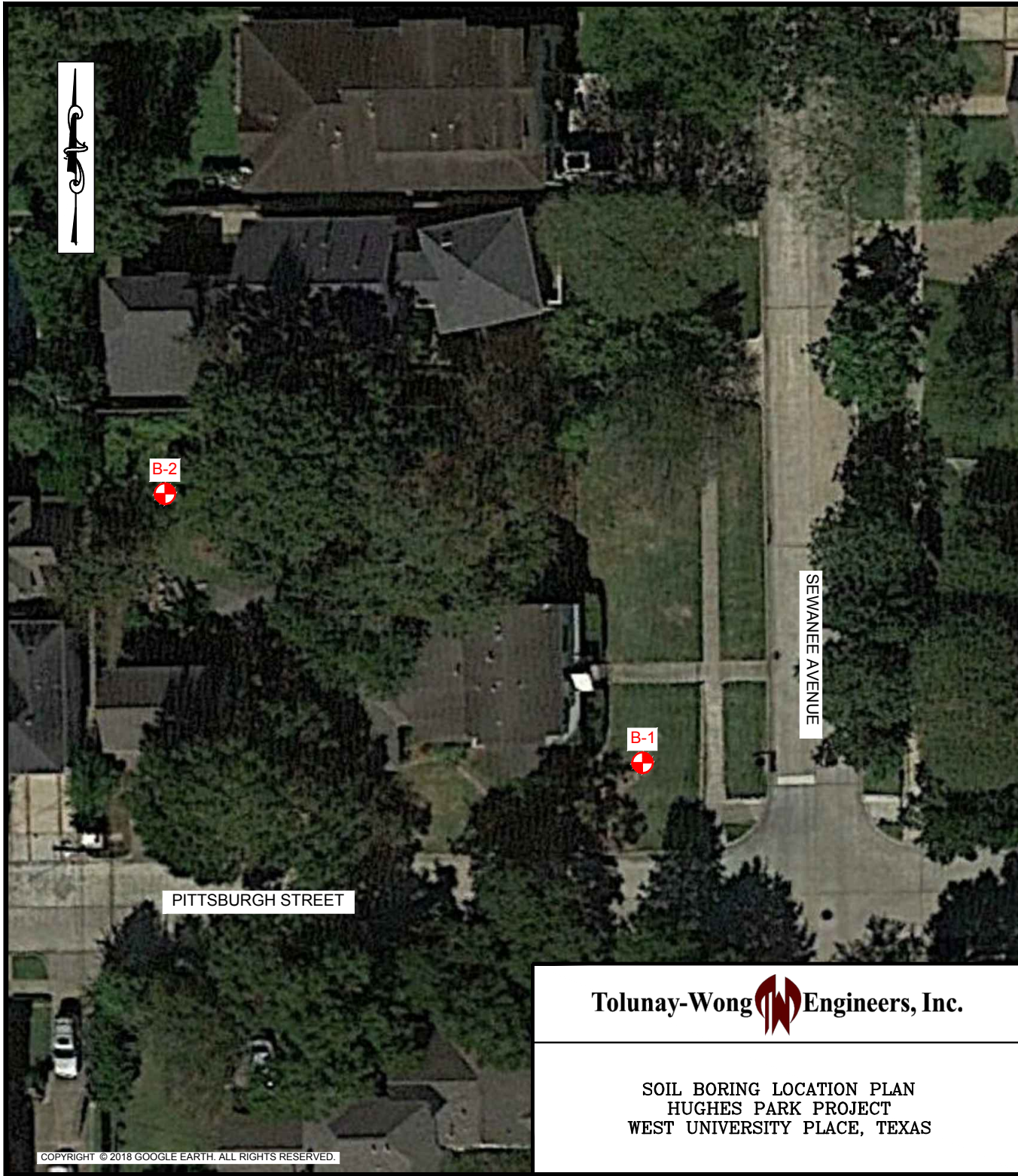
8.2 Plan Review and Construction Monitoring

TWE should be provided the opportunity to review the construction drawings to determine if those documents are in harmony with the intent of the geotechnical design and construction recommendations contained in this report.

TWE should be provided the opportunity to observe and document the field conditions of exposed subgrade soils, geotechnical site preparation activities, placement and compaction of backfill soils and general foundation construction activities.

APPENDIX A

SOIL BORING LOCATION PLAN



B-2



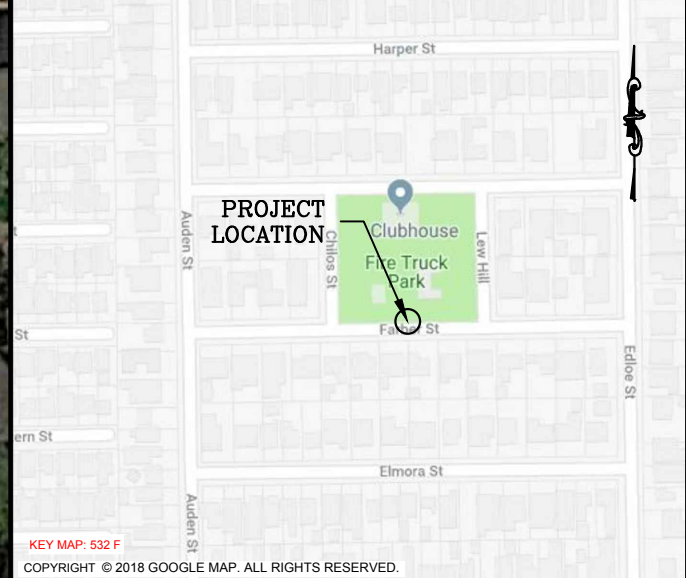
B-1



PITTSBURGH STREET

SEWANEE AVENUE

VICINITY MAP



KEY MAP: 532 F
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SOIL BORING COORDINATES

BORING	DEPTH	LATITUDE	LONGITUDE
B-1	20'	29° 42' 39.77" N	95° 25' 52.07" W
B-2	20'	29° 42' 40.44" N	95° 25' 53.44" W

LEGEND

SYMBOL	DESCRIPTION
	SOIL BORING LOCATION

Tolunay-Wong  Engineers, Inc.

SOIL BORING LOCATION PLAN
HUGHES PARK PROJECT
WEST UNIVERSITY PLACE, TEXAS

<i>Drawn</i>	M.A.	02-23-2018
<i>Checked</i>	M.A.	02-23-2018
<i>Approved</i>	D.B.	02-26-2018
<i>Scale</i>	N.T.S.	

TWE DRAWING NO. 18.13.002-1

APPENDIX B

BORING LOGS and KEY to SYMBOLS AND TERMS

LOG OF BORING B-1

PROJECT: Hughes Park Project
West University Place, Texas

CLIENT: City of West University Place
West University Place, Texas

ELEVATION (FT) ----- DEPTH (FT)	SAMPLE TYPE	SYMBOL	COORDINATES: N 29° 42' 39.77" W 95° 25' 52.07"	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N ₆₀	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
			SURFACE ELEVATION:													
0			Stiff, gray SANDY LEAN CLAY (CL) with fine roots (possible fill soils in upper 2')	(P)1.75			24		42	24					66	
4			Stiff, gray FAT CLAY with SAND (CH)	(P)1.5												
8			Stiff, gray-tan SANDY FAT CLAY (CH)	(P)2.0												
12			Medium dense, tan-gray SILTY CLAYEY SAND (SC- SM)	(P)2.75					21	108	52	33	1.57	7 *	69	
16					4/6" 8/6" 12/6"		20		24	7					38	
20			Bottom @ 20'		4/6" 8/6" 13/6"											
24																
28																

COMPLETION DEPTH: 20 ft
 DATE BORING STARTED: 2/5/2018
 DATE BORING COMPLETED: 2/5/2018
 LOGGER: M. Anderson
 PROJECT NO.: 18.13.002

NOTES: 1) Free water encountered at 13 ft and rose to 8.7 ft after 30 minutes.
 2) Borehole backfilled with soil cuttings to ground surface upon work completion.

LOG OF BORING B-2

PROJECT: Hughes Park Project
West University Place, Texas

CLIENT: City of West University Place
West University Place, Texas

ELEVATION (FT) ----- DEPTH (FT)	SAMPLE TYPE	SYMBOL	COORDINATES: N 29° 42' 40.44" W 95° 25' 53.44" SURFACE ELEVATION: DRILLING METHOD: Dry Augered: 0 to 15' Wash Bored: 15' to 20'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N ₆₀	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
			MATERIAL DESCRIPTION													
0			Firm, dark gray SANDY FAT CLAY (CH) (possible fill soils in upper 8") Stiff, gray SANDY FAT CLAY (CH)	(P)1.0												
4			-gray and tan from 4'	(P)2.0			21	106	50	30		1.97	15		66	
6			-with sand seams from 6'	(P)2.25												
8				(P)2.5			20		39	22					46	
12			Medium dense, tan POORLY GRADED SAND with SAND (SP-SM)													
16					2/6" 4/6" 6/6"											
20					9/6" 12/6" 16/6"		21		0	NP					7	
20			Bottom @ 20'													
24																
28																

COMPLETION DEPTH: 20 ft
 DATE BORING STARTED: 2/5/2018
 DATE BORING COMPLETED: 2/5/2018
 LOGGER: M. Anderson
 PROJECT NO.: 18.13.002

NOTES: 1) Free water encountered at 12 ft and rose to 9 ft after 15 minutes.
 2) Borehole backfilled with soil cuttings to ground surface upon work completion.

KEY TO SYMBOLS AND TERMS USED ON BORING LOGS FOR SOIL

Most Common Unified Soil Classifications System Symbols

	Lean Clay (CL)		Well Graded Sand (SW)
	Lean Clay w/ Sand (CL)		Well Graded Sand w/ Gravel (SW-GM)
	Sandy Lean Clay (CL)		Poorly Graded Sand (SP)
	Fat Clay (CH)		Poorly Graded Sand w/ Silt (SP-SM)
	Fat Clay w/ Sand (CH)		Silt (ML)
	Sandy Fat Clay (CH)		Elastic Silt (MH)
	Silty Clay (CL-ML)		Elastic Silt w/ Sand (MH-SP)
	Sandy Silty Clay (CL-ML)		Silty Gravel (GM)
	Silty Clayey Sand (SC-SM)		Clayey Gravel (GC)
	Clayey Sand (SC)		Well Graded Gravel (GW)
	Sandy Silt (ML)		Well Graded Gravel w/ Sand (SP-GM)
	Silty Sand (SM)		Poorly Graded Gravel (GP)
	Silt w/ Sand (ML)		Peat

Miscellaneous Materials

	Fill		Concrete		Asphalt and/or Base
--	------	--	----------	--	---------------------

Sampler Symbols

Meaning

	Pavement core
	Thin-walled tube sample
	Standard Penetration Test (SPT)
	Auger sample
	Sampling attempt with no recovery
	TxDOT Cone Penetrometer Test

Field Test Data

2.50	Pocket penetrometer reading in tons per square foot
(T)1.13	Torvane Measurement in tons per square foot
8/6"	Blow count per 6 - in. interval of the Standard Penetration Test
	Observed free water during drilling
	Observed static water level

Laboratory Test Data

Wc (%)	Moisture content in percent
Dens. (pcf)	Dry unit weight in pounds per cubic foot
Qu (tsf)	Unconfined compressive strength in tons per square foot
UU (tsf)	Compressive strength under confining pressure in tons per square foot
Str. (%)	Strain at failure in percent
LL	Liquid Limit in percent
PI	Plasticity Index
#200 (%)	Percent passing the No. 200 mesh sieve
()	Confining pressure in pounds per square inch
*	Slickensided failure
**	Did not fail @ 15% strain

RELATIVE DENSITY OF COHESIONLESS & SEMI-COHESIONLESS SOILS

The following descriptive terms for relative density apply to cohesionless soils such as gravels, silty sands, and sands as well as semi-cohesive and semi-cohesionless soils such as sandy silts, and clayey sands.

Relative Density	Typical N_{60} Value Range*
Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	Over 50

* N_{60} is the number of blows from a 140-lb weight having a free fall of 30-in. required to penetrate the final 12-in. of an 18-in. sample interval, corrected for field procedure to an average energy ratio of 60% (Terzaghi, Peck, and Mesri, 1996).

CONSISTENCY OF COHESIVE SOILS

The following descriptive terms for consistency apply to cohesive soils such as clays, sandy clays, and silty clays.

Typical Compressive Strength (tsf)	Consistency	Typical SPT " N_{60} " Value Range**
$q_u < 0.25$	Very soft	≤ 2
$0.25 \leq q_u < 0.50$	Soft	3-4
$0.50 \leq q_u < 1.00$	Firm	5-8
$1.00 \leq q_u < 2.00$	Stiff	9-15
$2.00 \leq q_u < 4.00$	Very Stiff	16-30
$q_u \geq 4.00$	Hard	≥ 31

** An " N_{60} " value of 31 or greater corresponds to a hard consistency. The correlation of consistency with a typical SPT " N_{60} " value range is approximate.

