REPORT
GEOTECHNICAL INVESTIGATION
GARDEN OAKS AND SHEPHERD PARK (CENTRAL)
DRAINAGE AND PAVING
WBS NO. M-000285-0001-4
HOUSTON, TEXAS

PREPARED BY

ASSOCIATED TESTING LABORATORIES, INC.
HOUSTON, TEXAS

ATL REPORT NO. G13-211
February 18, 2015

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February 18, 2015

ATL Job No: G13-211

PGAL, Inc..
3131 Briarpark Drive, Suite 200
Houston, Texas 77042

Attention: Mr. Costas Georghiou, P.E.

Reference: Final Geotechnical Investigation Report
Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No. M-000285-0001-4
Houston, Texas

Dear Mr. Georghiou:

We have completed the report for the geotechnical investigation for the above-referenced project. Our findings, geotechnical engineering analyses and recommendations are presented in this report.

It has been a pleasure working with you on this project. Should you have any questions concerning this project work, please call us at (713) 748-3717.

Sincerely,

ASSOCIATED TESTING LABORATORIES, INC.

STATE OF TEXAS
PENG SIA TANG
81150
REGISTERED PROFESSIONAL ENGINEER

Peng Sia Tang, P. E.
Manager, Geotechnical Servi

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President

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GEOTECHNICAL INVESTIGATION

GARDEN OAKS AND SHEPHERD PARK (CENTRAL)

DRAINAGE AND PAVING

HOUSTON, TEXAS

CONTENTS **PAGE**

EXECUTIVE SUMMARY.....v

1.0 INTRODUCTION.....1

1.1 General.....1

1.2 Location and Description of the Project.....1

1.3 Scope of Work.....2

2.0 SUBSURFACE INVESTIGATION PROGRAM.....3

3.0 LABORATORY TESTING PROGRAM.....5

4.0 SUBSURFACE AND SITE CONDITIONS.....6

4.1 Geology of Coastal Plain.....6

4.2 Geologic Faults.....7

4.3 Potentially Hazardous Material.....8

4.4 Site Stratigraphy and Geotechnical Characterization.....8

4.4.1 Dispersive Potential of Onsite Soils.....14

4.4.2 Suitability of Onsite Soils As Fill Material.....15

4.5 Groundwater.....15

5.0 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS.....16

5.1 Proposed Storm/Sanitary Sewer Installation.....17

5.1.1 OSHA Soil Types.....17

5.1.2 Open Cut/Trench Excavation.....18

5.1.3 Groundwater control.....23

5.1.4 Bedding Criteria 24
5.1.5 Trench Backfill 24
5.1.6 Loads on Buried Conduits 25
5.1.7 Trenchless Construction 26
5.1.8 Effects of Trenchless Construction on Surrounding Structures 28
5.1.9 Thrust Restraint 29
5.1.10 Flexible Pipe Deflection 30
5.1.11 Buoyant Uplift 31
5.1.12 Street Cut Repair 32
5.2 Slope Stability Analyses for Proposed Ditch Improvements 32
5.2.1 Existing Conditions and Proposed Improvements 32
5.2.2 Slope Stability Analyses 33
5.2.2.1 Results of Slope Stability Analyses 35
5.2.2.2 Conclusion 36
5.2.3 Ditch Improvement Construction 37
5.3 Pavement Design 38
5.3.1 Traffic Information 38
5.3.2 Pavement Subgrade Preparation 39
5.3.3 Pavement Subgrade Stabilization 40
5.3.4 New Concrete Pavement 41
5.3.5 Asphaltic Concrete Pavements 42
6.0 CONSTRUCTION CONSIDERATION 45
6.1 Quality Control 46
6.2 Monitoring 47
7.0 LIMITATIONS 48
8.0 REFERENCES 49

LIST OF FIGURES

FIGURE 1	SITE VICINITY MAP
FIGURES 2a to 2d	LOCATION OF BORINGS
FIGURE 3a	PRINCIPAL ACTIVE FAULTS IN HOUSTON AREA
FIGURE 3b	ACTIVE SURFACE FAULTS ON LIDAR IMAGERY
FIGURES 4a to 4k	BORING LOG PROFILE
FIGURES 5a to 5c	EARTH PRESSURE DIAGRAMS
FIGURE 6	HIGHWAY LOADING ON A PIPE UNDER VARIOUS SOIL COVER
FIGURE 7	BOUSSINESQ'S EQUATION FOR POINT LOAD SURCHARGE
FIGURE 8	THRUST FORCE AT A PIPE BEND
FIGURE 9	BUOYANT UPLIFT RESISTANCE OF A BURIED STRUCTURE
FIGURES 10a & 10b	PROPOSED CROSS-SECTION OF DITCH PROTECTED BY ACB

LIST OF TABLES

TABLE 1	SUMMARY OF EXISTING PAVEMENT MEASUREMENTS
TABLE 2	SUMMARY OF GROUNDWATER MEASUREMENTS
TABLE 3	SUMMARY OF TEST RESULTS
TABLE 4	MARSTON SOIL COEFFICIENT (C_d) FOR TRENCH CONDUITS

LIST OF APPENDICES

APPENDIX 1	PHOTOGRAPHS OF THE PROJECT SITE
APPENDIX 2	PIEZOMETER INSTALLATION AND PLUGGING REPORTS
APPENDIX 3	BORING LOGS AND KEY TO LOG TERMS AND SYMBOLS
APPENDIX 4	BORING LOGS FROM PREVIOUS INVESTIGATIONS BY ATL AND OTHERS
APPENDIX 5	RESULTS OF CRUMB, PINHOLE AND TRIAXIAL CONSOLIDATED-UNDRAINED TESTS
APPENDIX 6	RESULTS OF SLOPE STABILITY ANALYSES

GEOTECHNICAL INVESTIGATION
GARDEN OAKS AND SHEPHERD PARK (CENTRAL)
DRAINAGE AND PAVING
HOUSTON, TEXAS

EXECUTIVE SUMMARY

Associated Testing Laboratories, Inc. (ATL) has completed the geotechnical study at the site of the proposed Garden Oaks and Shepherd Park (Central) Drainage and Paving improvements, as shown in Figure 1. The project entails improvement of approximately 16,000 linear feet of storm sewers, sanitary sewers and pavements, and approximately 1,700 linear feet of ditch improvements as part of the Phase I work in the Garden Oaks and Shepherd Park (Central) Area in Houston, Texas (see Figure 2a through 2d).

The approximate flow line depth of the proposed storm sewers is about 20 feet near Judiway St., and about 17 feet at the Alba Road/Chamboard Lane intersection, and approximately 10 feet near Lehman St., and at about 8 feet near the Brinkman Street/Pinemont Street intersection. The existing open ditch is approximately 6 feet deep. The improved ditch will have the same depth, with bottom width ranging from about 6 to 18 feet, and the side slopes will be trimmed to 2H:1V and protected by ACB.

Both open cut/trenching and tunneling/trenchless installation techniques will be employed. The subsurface conditions investigated by 24 soil borings (to depth of 15 to 30 feet below existing grade) along the project alignments, consists generally of an upper clay stratum that exists to a depth of about 8 to 14 feet below existing grade. This clay stratum is underlain by a sand stratum (SM,SC, SC-SM) that exists to a depth of about 12 to 30 (the maximum boring depth) feet. Below the sand stratum, a lower clay stratum exists in many borings to the bottom of borings at 15 to 30 (maximum boring depth) feet; this lower clay stratum was not found in Borings B-4, B-5, B-7, B-8, B-10, B-12,

B-13, B-16, B-17, B-18, B-20, B-21 through B-24 because these borings terminated in sand. In Boring B-1, alternating 2-foot thick stratum of Lean Clay (CL), Clayey Sand (SC) and Silty Sand (SM) stratum exist below the AC pavement to a depth of about 10 feet below existing grade. Below that, a stratum of very stiff Lean Clays (CL) exists to the bottom of the boring at 30 feet. In Boring B-2, soft to stiff Lean Clay (CL) fill exists to a depth of about 10 feet, followed by a stratum of medium dense Silty Sand (SM) to 12 feet, and then very stiff Lean Clay (CL) to the bottom of boring at 15 feet. Detailed subsurface soils and stratigraphy are shown in the individual boring logs in Appendix 3 and in the Boring Log Profiles in Figures 4a through 4k.

Free water was encountered during drilling operation in most borings except B-5 and B-9 at depths between 10 and 27 feet; free water was measured at depths ranging from 10 to 23 feet at completion of drilling. Borings B-1, B-11, B-19 and B-21 were converted into Piezometer PZ-1 through PZ-4 after completion of drilling and soil sampling. Water level in PZ-1 through PZ-4 was measured after 24-hour at a depth of about 17, 11, 11 and 13 feet, respectively. Water level in PZ-1 through PZ-4 was measured after 7 days at a depth of about 16, 11, 11.5 and 13 feet, respectively. Water level in PZ-1 through PZ-4 was measured after 30 days at a depth of about 15, 11, 11 and 12 feet, respectively.

Our main geotechnical findings and recommendations are summarized below:

1. No unusual staining or hydrocarbon-like odor was noted in the soil samples recovered from the soil borings drilled in ATL's geotechnical investigation.
2. A preliminary fault evaluation based on review of available fault maps and literature review indicated that the Eureka Heights Fault is located within about ¼ miles south and east of the project area. A Phase I fault investigation is not recommended at this time.
3. Based on the proposed invert elevation and the gathered groundwater information, the storm and sanitary sewer line construction excavations will be advanced in both clays and sands; Table D in Section 5.1.2 of this report identifies locations (but not limited to) where sands will likely or may be encounter during construction excavation. Excavations

approaching or exceeds about 10 feet will likely to encounter groundwater. It should also be noted that groundwater level will fluctuate with the amount of precipitation prior to and during the construction.

4. Geotechnical parameters/information and construction recommendations for the proposed open cut/trenching and trenchless installation of the proposed storm and sanitary sewer lines, slope stability analyses and design and construction of the proposed HCFCD Ditch E-100-10-01, the design and construction of the new portland cement concrete (PCC) pavements for Brinkman Street, as well as the asphaltic concrete (AC) pavements along Alba Street and the temporary road during construction, are presented in Section 5 and 6.

GEOTECHNICAL INVESTIGATION
GARDEN OAKS AND SHEPHERD PARK (CENTRAL)
DRAINAGE AND PAVING
HOUSTON, TEXAS

1.0 INTRODUCTION

1.1 General

The geotechnical investigation for the proposed Garden Oaks and Shepherd Park (Central) Paving and Drainage Improvements was authorized by Mr. Costas Georghiou, P.E. of **PGAL, Inc.** with the acceptance of the **Associated Testing Laboratories, Inc., (ATL)** Proposal No. CP12-0302I (dated August 8, 2013). Project details were provided to ATL by PGAL, Inc. This report includes results of the field investigation, laboratory testing, geotechnical engineering analysis and recommendations for the proposed improvements for this project.

1.2 Location and Description of the Project

The project sites of this project are located in a mostly residential with some commercial neighborhood, a Site Vicinity Map showing the project alignments is presented in Figure 1. Photographs of the project sites were taken at the time of our site visit, and some are presented in Appendix 1.

The project entails improvement of approximately 16,000 linear feet of storm sewers, sanitary sewers and pavements, and approximately 1,700 linear feet of ditch improvements as part of the Phase I work in the Garden Oaks and Shepherd Park (Central) Area in Houston, Texas. The project alignments are along streets in Key Map 452 blocks P, G, L and Q, and are shown in Figures 2a through 2d. Figure 2a shows the surveyed boring locations drilled in this study, Figures 2b through 2d shows the approximate locations of the borings drilled in this study as well as those drilled by

ATL and others prior to this study. The project alignments traverse Alba Road from Judiway to Chamboard, Chamboard Lane from Alba to Brinkman, Brinkman Street from Chamboard to Pinemont Street, with small sections of the side streets along Alba Road including Wakefield Dr., Fisher, West 41st Street, West 42nd Street, Lamonte, Azalea Street and Sue Barnett (see enclosed Boring Location Plan). The project alignments will be improved with approximately 16,000 LF of new storm sewers and new pavements. In addition, new sanitary sewers are planned along Alba Road from south of West 41st Street to south of Chamboard Lane, and, along Brinkman from Curtin to Janisch Streets. Also, the existing HCFCD Ditch E101-10-01 east of Brinkman between Janisch and Lehman Streets will be improved.

The storm sewers will consist of new 36- to 60-inch diameter RCP, and 5'x5', 6'x5', 8'x5', 10'x5', 10'x8', 12'x10' and 14'x10' RCB. The approximate flow line depth of the proposed storm sewers is about 20 feet near Judiway St., and about 17 feet at the Alba Road/Chamboard Lane intersection, and approximately 10 feet near Lehman St., and at about 8 feet near the Brinkman Street/Pinemont Street intersection. The existing HCFCD Ditch E-101-10-01 is approximately 6 feet deep and approximately 1,700 feet in length. The improved ditch will have the same depth but the side slopes will be improved and/or paved; the storm and sanitary sewers may be installed using a combination of open trench and augering techniques.

1.3 Scope of Work

A geotechnical investigation was conducted to determine subsurface soil conditions along the proposed project alignments and to develop geotechnical engineering recommendations for the design and construction of new concrete pavements, new storm and sanitary sewers, and the improvements of the drainage ditch. **Associated Testing Laboratories, Inc. (ATL)** has completed a subsurface exploration program for this project consisted of the following scope:

- Augering through existing asphaltic concrete (AC) pavements at seven (7) boring locations using the drill rig auger.

- Coring through existing portland cement concrete (PCC) pavements and PCC pavements with AC overlay at four (4) boring locations using a pavement coring machine.
- Drilling and sampling a total of twenty-four (24) borings (Borings B-1 through B-24), to depths ranging from 15 to 30 feet below existing grade, for a total of 490.5 lineal feet of drilling, and converting four (4) borings into piezometers (totaling 102 lineal feet) after completion of drilling and sampling.
- Conducting laboratory tests on selected soil samples recovered from the soil borings.
- Developing boring logs and boring log profiles to present the general subsurface soil and groundwater conditions.
- Incorporate relevant information from boring logs developed based on previously drilled borings by ATL and others.
- Conducting a preliminary fault review of the project area based on review of available fault maps and literature.

Based on results from the field investigation, laboratory testing and gathered geological information, ATL performed geotechnical analyses to develop geotechnical recommendations for the proposed improvements.

2.0 SUBSURFACE INVESTIGATION PROGRAM

The field investigation for this project consisted of drilling and sampling a total of twenty-four (24) soil borings and installing four (4) piezometers along the project alignments. The boring/piezometer locations and depths were approved during the proposal phase. The proposed borings and piezometers were selected based on criteria for borings and piezometers specified in City of Houston Department of Public Works and Engineering Design Manual, Chapter 11 "Geotechnical and Environmental Requirements".

Seven of the 24 borings are located within existing asphaltic concrete (AC) pavements, and four were located with existing portland cement concrete (PCC) pavements or PCC pavements with AC overlay. The existing AC pavement at this boring location was augered through using the drill rig auger; the existing PCC pavements were cored through using a pavement coring machine. The information from our boring/piezometer and depths and the coordinates (northing and easting) are presented in the table below.

TABLE A: BORING AND PIEZOMETER INFORMATION

Boring		Piezometer		Location	Northing	Easting
No.	Depth, ft.	No.	Depth, ft.			
B-1	30	PZ-1	30	Alba Road	13865214.29	3103825.23
B-2	15	--	--	Wakefield Drive	13865401.08	3103617.14
B-3	27	--	--	Alba Road	13865859.46	3103804.27
B-4	15.5	--	--	Fisher Drive	13865888.24	3103370.52
B-5	15.5	--	--	Fisher Drive	13865934.09	3104531.33
B-6	27	--	--	W. 41st ST	13866401.13	3103835.38
B-7	15.5	--	--	W. 41st ST	13866405.46	3103478.62
B-8	15.5	--	--	W. 41st ST	13866377.01	3104228.68
B-9	15	--	--	W. 41st ST	13866355.02	3104686.35
B-10	15.5	--	--	W. 41st ST	13866388.39	3105205.96
B-11	27	PZ-2	27	Alba Road	13866958.21	3103818.50
B-12	15	--	--	W. 42nd ST	13866739.91	3104412.97
B-13	15.5	--	--	La Monte Lane	13867104.60	3104858.19
B-14	26	--	--	Alba Road	13867549.31	3103914.89
B-15	26	--	--	Alba Road	13868024.04	3103947.63
B-16	15.5	--	--	Azalea St	13867907.07	3104581.61
B-17	15.5	--	--	Sue Barnett St	13868356.66	3104335.17
B-18	30	--	--	Alba Road	13868740.62	3103959.84
B-19	24	PZ-3	24	Chamboard Lane	13868810.15	3104981.19
B-20	23	--	--	Brinkman St	13869355.19	3104979.79
B-21	21.5	PZ-4	21.5	Brinkman St	13871341.58	3104883.65
B-22	20	--	--	Along Ditch	13871459.48	3105298.65
B-23	20	--	--	Along Ditch	13871488.04	3106346.08
B-24	20	--	--	On N. Shepherd Road, near Ditch	13871468.00	3106585.83

Boring locations drilled in this geotechnical exploration are shown on Figures 2a through 2d. The boreholes were drilled dry to the bottom of the boring or to a depth where a borehole started caving in, after which rotary wash boring technique was carried out. In cohesive soils, undisturbed soil samples were collected using a conventional 3-inch O.D. Shelby tube in accordance with ASTM D1587. Cohesionless soils were sampled using split spoon sampler in accordance with ASTM D1586. All soil samples were examined, classified and logged in the field. A representative portion of each sample was packed in containers to prevent moisture loss. All soil samples were properly labeled and subsequently transported to the ATL laboratory.

Boring B-1, B-11, B-19 and B-21 were converted into piezometer PZ-1 through PZ-4 after the completion of drilling and sampling. The groundwater level information encountered in the boreholes during and at completion of drilling, and the water level in the piezometer after 24 hours, 7 and 30 days are presented in Table 2. The piezometers were pulled and plugged with cement-bentonite grout after the 30-day water level reading. The piezometer installation and plugging reports are presented in Appendix 2.

Upon completion of drilling, the borings where no piezometer was to be installed were backfilled using cement-bentonite grout using a tremie. The cored PCC pavements were patched using portland cement concrete, and the augered AC pavements were patched using cold-mixed asphaltic concrete.

All soil samples were classified according to Unified Soil Classification System (ASTM D-2487). The soil and groundwater information found in each boring are shown on the individual boring logs presented in Appendix 3. A Key to Log Terms and Symbols is also presented in Appendix 3.

3.0 LABORATORY TESTING PROGRAM

Samples obtained from the field were again examined and classified in our laboratory by the

geotechnical technician under the supervision of an engineer. Laboratory testing was performed on selected soil samples collected during the field investigation. The laboratory testing program included Atterberg Limits (ASTM D-4318), Density, Moisture Content (ASTM D-2216), Unconfined Compressive Strength (ASTM D-2166), Unconsolidated Undrained Triaxial (ASTM D-2850) and Percent Finer Than No. 200 Sieve (ASTM D-1140) tests. The results of laboratory tests are presented in the boring logs in Appendix 3 and summarized in Table 3. Overall numbers and types of tests performed for this study for this project are presented below:

TABLE B: SUMMARY OF LABORATORY SOIL TESTS

TYPE OF TEST	NUMBER OF TEST
Dry Density	41
Moisture Content	236
Atterberg Limits	53
Unconfined Compression	35
Sieve Analysis through No. 200 Sieve	54
Unconsolidated Undrained Triaxial	6
Multistage Consolidated-Undrained Triaxial	1
Crumb	7
Pinhole	2

4.0 SUBSURFACE AND SITE CONDITIONS

4.1 Geology of Coastal Plain

The proposed project area is located within the Gulf Coast Structural Province, a huge sedimentary basin containing several thousand feet of sediments. In general, these sediments consist of loose sands, silts and clays which slope gently toward the Gulf of Mexico.

The site is underlain by the Beaumont Formation of Pleistocene age. This formation consists of over consolidated clays, silts and sands with some shell calcium carbonate and iron oxides. These formations are quite strong and extend to an approximate depth of 100 feet. The near surface materials are often weakened by the weathering process.

4.2 Geologic Faults

Among the geologic and geomorphological features in this region are sedimentary deposits broken by structure such as normal faults, salt domes, etc. The sedimentary deposits slope gently toward the Gulf of Mexico. They are broken by normal faults, most of which dip toward the Gulf and extend downward many thousands of feet. The earth movements that caused these faults took place within the last 50,000 years. In general, the regional faults in the Houston area trend parallel to the Gulf Coast. Only the local faults over the salt domes show a radial pattern associated with the upthrust of the salt mass. There are numerous faults and fault systems in the Greater Houston and surrounding area. The movements of many of these faults has been affected in recent history by area subsidence.

The subsidence is theorized to have been associated with the removal of oil and groundwater. As much as nine (9) feet of subsidence has occurred in the area east of Houston in the last 70 years. Conversion to surface water usage and the limiting of oil production has greatly reduced the subsidence rate in the area east of Houston.

Figure 3a shows the principal active faults in the Houston area. Figure 3b shows the active surface faults of the Houston area interpreted on LIDAR Imagery (Khan and Engelkemeir). Based on these maps, it appears that the Eureka Heights Fault is located within about ¼ miles south and east of the project area. A Phase I fault investigation is not recommended at this time.

4.3 Potentially Hazardous Material

No unusual staining or hydrocarbon-like odor was noted in the soil samples recovered from the soil borings drilled in ATL's geotechnical investigation.

4.4 Subsurface Soil Stratigraphy and Geotechnical Characterization

***Existing Pavement Material*:** Seven of the 24 borings are located within existing asphaltic concrete (AC) pavements, and four were located with existing portland cement concrete (PCC) pavements or PCC pavements with AC overlay. The existing AC pavement at this boring location was augered through using the drill rig auger; the existing PCC pavements were cored through using a pavement coring machine. A summary of the existing pavement sections encountered at each boring location is presented in Table 1.

Based on the pavement information gathered from our field investigation, the existing AC pavements consist of about 2 to 6 inches of AC surface over about 4 to 8 inches of shell, cement-stabilized shell, limestone and gravel base. The existing pavements on N. Shepherd Road (at B-24) consists of about 10 inches of PCC over about 14 inches of crushed limestone base; the existing pavements along Alba Road at B-18 consist of about 5.5 inches of PCC pavements. The existing pavements along Alba Road at Boring B-11 and Boring B-14 consist of about 2.5 and 2 inches of AC surface over about 5.5 and 6 inches of PCC, respectively. The actual pavement material and thicknesses in the field, at or near the boring locations, may differ from those described in Table 1.

***Potentially Hazardous Materials*:** No unusual staining or hydrocarbon-like odor was noted in the soil samples recovered from the soil borings drilled in ATL's geotechnical investigation.

***Subsurface Soil Stratigraphy*:** Based on our soil borings, and information from boring logs from previous investigations conducted by ATL and others (see Appendix 4), the subsurface soils along the project alignments are summarized as follows. Note that use of boring information previously conducted implies that the subsurface conditions remain unaltered since the borings were conducted, an assumption that may or may not be true.

Along Alba Road Alignment (Profile 4a): The subsurface soils below the existing AC pavements, PCC and AC over PCC pavements, and ground surface, as found in Borings B-6, B-11, B-14, B-15 and B-18, consist generally of an upper stratum of soft to hard Fat Clays (CH) and Lean Clays (CL) that exists to depths ranging from about 10 to 12 feet, and is underlain by a stratum of loose to medium dense Silty Sand (SM) that exists to a depth of about 16 to 18 feet in Borings B-6, B-11, B-14 and B-15; in Boring B-3, a loose Silty Sand (SM) stratum exists between depths of about 10 and 12 feet; in Boring B-18, a stratum of medium dense to dfense Silty Sand (SM) exists below the surface clay stratum to the bottom of the 30-ft deep boring.

Below the Silty Sand stratum in Borings B-6, B-11, B-14 and B-15, a stratum stiff to hard Clay (CH) exists to the bottom of boring at a depth of 26 to 27 feet below existing grade. Below the Silty Sand stratum in Boring B-3, a stratum of soft to stiff Lean Clays (CL) exists to a depth of about 18 feet, followed by a stratum of very stiff Clays (CH). The top 18 feet of the soils in Boring B-3 are fill.

In Boring B-1, alternating 2-foot thick stratum of Lean Clay (CL), Clayey Sand (SC) and Silty Sand (SM) stratum exist below the AC pavement to a depth of about 10 feet below existing grade. Below that, a stratum of very stiff Lean Clays (CL) exists to the bottom of the boring at 30 feet. In Boring B-2, soft to stiff Lean Clay (CL) fill exists to a depth of about 10 feet, followed by a stratum of medium dense Silty Sand (SM) to 12 feet, and then very stiff Lean Clay (CL) to the bottom of boring at 15 feet.

Along Fisher Drive Alignment (Profile 4b): The subsurface soils below the existing AC pavements and ground surface, as found in Borings B-4, B-3 and B-5, consist of a stratum of soft to very stiff Clays (CH) and Lean Clays (CL) that exists to a depth of about 10 feet. Below the surface clay stratum, loose to medium dense Silty Sand (SM) exists to the bottom of Boring B-4 and B-5 16 feet. In Boring B-3, the Silty Sands exist to a depth of about 12 feet, followed by a stratum of soft to stiff Lean Clays (CL) to a depth of about 18 feet. A stratum of very stiff Clays (CH) exists below to the bottom of boring at 27 feet. The top 18 feet of the soils in Boring B-3 are fill.

Along W. 41st Street Alignment (Profile 4c): The subsurface soils below the existing ground surface, as found in Borings B-6 through B-10, consist of an upper soft to hard Clays (CH) and Lean Clays (CL) that exists to depths ranging from about 12 to 14 feet below the existing grade. Below the clay soils stratum, loose to medium dense Silty Sands (SM) exist to the bottom of Borings B-7, through B-10 at a depth of 16, 16, 15 and 16 feet, respectively, and to a depth of about 18 feet in Boring B-6. A stratum of very stiff to hard Clays (CH) exists below the silty sands to the bottom of Boring B-6 at 27 feet.

Along 42nd Street Alignment (Profile 4d): The subsurface soils below the existing pavements and ground surface, as found in Borings B-11, B-12 and B-45 (B-45 was prepared by others in previous investigation), consist of an upper firm to hard Clays (CH) and Lean Clays (CL) that exists to a depth of about 12 and 8 feet in Boring B-11 and B-12, and to the bottom of Boring B-45 at 12 feet. Below the clay soils stratum, medium dense Silty Sands (SM) exist to a depth of about 18 feet in Boring B-11, and to the bottom of Boring B-12 at 16 feet. A stratum of stiff Clays (CH) exists below the silty sands to the bottom of Boring B-12 at 27 feet.

Along La Monte Lane Alignment (Profile 4e): The subsurface soils below the existing pavements and ground surface, as found in Borings B-13, B-37, B-14 and B-27 (B-27 and B-37 were prepared by others in previous investigation), consist of an upper firm to hard Clays (CH) and Lean Clays (CL) that exists to a depth of about 12, 10, 10 and 10 feet below existing grade. Below the clay soils

stratum, loose to medium dense Silty Sands (SM) and Clayey Sands (SC) exist to the bottom of Borings B-13, B-37 and B-27 at 16, 13 and 13 feet, respectively. A stratum of very stiff to hard Clays (CH) exists below the silty sands to the bottom of Boring B-13 at 26 feet. Silty Sand (SM) fill was found in the top one foot of Borings B-27 and B-37.

Along Azalea Street Alignment (Profile 4f): The subsurface soils below the ground surface, as found in Borings B-15, B-35 and B-16 (B-35 was prepared by others in previous investigation), consist of an upper firm to hard Clays (CH) and Lean Clays (CL) that exists to a depth of about 10, 8 and 12 feet below existing grade, respectively. Below the clay soils stratum, loose to medium dense Silty Sands (SM) and Clayey Sands (SC) exist to the bottom of Borings B-35 and B-16 at 12 and 16 feet, respectively. A stratum of very stiff to hard Clays (CH) exists below the silty sands to the bottom of Boring B-15 at 26 feet. The top 6 feet of the subsurface soils in Boring B-15 is fill. Silty Sand (SM) exist in the top one foot of Boring B-35.

Along Sue Barnett Street Alignment (Profile 4g): The subsurface soils below the existing pavements and ground surface, as found in Borings B-17 and B-33 (B-33 was prepared by others in previous investigation), consist of an upper firm to hard Clays (CH) and Lean Clays (CL) that exists to a depth of about 12 feet below existing grade. Below the clay soils stratum, loose to very dense Silty Sands (SM) and Clayey Sands (SC) exist to the bottom of Boring B-17 and B-33 at 16 and 25 feet, respectively. Two feet of Clayey Sands (SC) fill exist at the surface of Boring B-33.

Along Chamboard Lane Alignment (Profile 4h): The subsurface soils below the existing pavements and ground surface, as found in Borings B-18, B-39 and B-19 (B-39 was prepared by others in previous investigation), consist of an upper firm to very stiff Clays (CH) and Lean Clays (CL) that exists to a depth of about 10, 13 and 8 feet below existing grade, respectively. Below the clay soils stratum, medium dense to dense Silty Sands (SM) exist to the bottom of Borings B-18 and B-39 at 30 and 20 feet, respectively, and to a depth of about 20 feet of Boring B-19. A stratum of very stiff to hard Clays (CH) exists below the silty sands to the bottom of Boring B-19 at 24 feet. A stratum very

stiff Sandy-Silty Clay (CL-ML) fill exists below the existing pavements to a depth of about 3 feet in Boring B-19.

Along Brinkman Street Alignment – 1 of 2 (Profile 4i): The subsurface soils below the existing pavements and ground surface, as found in Borings B-19, GB-40, B-20, GB-22, G-15 and GB-75 (GB-40, GB-22, GB-15 and GB-75 were prepared by others in previous investigation), consist generally of an upper firm to very stiff Clays (CH) and Lean Clays (CL) that exists to a depth of about 8, 10, 11, 10 and 13 in Borings B-19, B-20, GB-22, GB-15 and GB-75, respectively, and to the bottom of Boring GB-40 at 13 feet. Below the clay soils stratum, medium dense to dense Silty Sands (SM) exist to the bottom of Borings B-20, GB-22 and GB-75 at 23, 13 and 20 feet, respectively, and to a depth of about 20 and 15 feet in Borings B-19 and GB-15, respectively. A stratum of very stiff to hard Clays (CH) exists below the silty sands to the bottom of Borings B-19 and GB-15 at 24 and 26 feet, respectively. at 24 feet. A stratum very stiff Sandy-Silty Clay (CL-ML) fill exists below the existing pavements to a depth of about 3 feet in Boring B-19. A stratum of Clayey-Silty Sand (SC-SM) exists in the top 3 feet of Boring B-19, and a stratum of stiff Lean Clays (CL) fill exists in the top 2 feet of Boring GB-75. Silty Sands (SM) exist in the top 2 feet of Boring GB-40.

Along Brinkman Street Alignment – 2 of 2 (Profile 4j): The subsurface soils below the existing pavements and ground surface, as found in Borings GB-71, GB-45, B-21 and GB-47 (GB-71, GB-45 and GB-47 were prepared by others in previous investigation), consist generally of an upper firm to hard Clays (CH) and Lean Clays (CL) that exists to a depth of about 13, 13, 8 and 14 feet 8 and 12 feet below existing grade, respectively. Below the clay soils stratum, loose to dense Silty Sands (SM) exist to the bottom of Borings GB-71, GB-45, B-21 and GB-47 at 20, 26, 22 and 20 feet, respectively. The top 2 feet of the soils at Borings GB-71 and B-21 are fill.

In Boring GB-46 (from previous investigation), a stratum of very soft Clays (CH) exists below the existing pavement to a depth of about 2 feet, followed by a stratum of medium dense Silty Sand (SM) to a depth of about 8 feet. The Silty Sands are underlain by a very stiff Lean Clays (CL)

stratum, followed by another stratum of very dense Silty Sands (SM) that exists to a depth of about 23 feet, and then by soft to stiff Lean Clays (CL) that exist to the bottom of boring at 26 feet.

Along Existing Ditch (Profile 4k): The subsurface soils, as found in Borings B-21 through B-24, consist generally of an upper firm to hard Clays (CH) and Lean Clays (CL) that exists to a depth of about 13, 13, 8 and 14 feet 8 and 12 feet below existing grade, respectively. Below the clay soils stratum, loose to dense Silty Sands (SM) exist to the bottom of Borings GB-71, GB-45, B-21 and GB-47 at 20, 26, 22 and 20 feet, respectively. The top 2 feet of the soils at Borings GB-71 and B-21 are fill.

The detailed subsurface soils and stratigraphy are shown in the individual boring logs in Appendix 3 and in the Boring Log Profile in Figures 4a through 4k. "CL", "CH", "SM", "SC" and SC-SM" are classes of soils described in the Unified Soil Classification System.

The Lean Clays (CL) found in the soil borings have liquid limits ranging between about 24 and 48%, and plasticity indices (PI) ranging between about 9 and 30%. Clean non-expansive Lean Clay soils (plasticity index between about 8 and 20) can be used as select fill in their present condition in City of Houston right-of-way. Clean excavated onsite soils classified as Lean Clays (CL) may be used as fill for construction within HCFCD right-of-way (such as the drainage ditch construction); however, imported fill shall have a LL not exceeding 49, a PI between 15 and 30, contains between 60 and 85 fines passing a No. 200 sieve, and is classified as ND-1 or ND-2 according to Pinhole Test-Method A. The fat clay (CH) soils found in the soil borings have liquid limits ranging between about 50 and 80%, and plasticity indices ranging between about 31 and 56%. High plasticity fat and lean clays (PI>20) are not suitable for use as select fill in their present condition; however, these soils in their present conditions may be used as random fill. High plasticity clay soils, if clean, can be treated with appropriate amount of lime and used as select fill; a lime dosage of 6% by weight is recommended for preliminary estimate purposes, but lime vs. pH and/or lime vs. PI series tests should be conducted to determine the optimum lime dosage.

4.4.1 Dispersive Potential of Onsite Soils

To evaluate the dispersiveness of the onsite clay soils, we conducted crumb and pinhole tests on select clay soils. Results of the crumb and pinhole tests are presented in Appendix 5 and summarized in the table below.

TABLE C SUMMARY OF CRUMB AND PINHOLE TESTS

Boring No.	Sample Depth, ft.	Crumb Test Grade			Date Tested	Pinhole Test Classification	Date Tested	Soil Classification
		2-Minute	1-Hour	6-Hour				
B-22	2 to 4	1	1	1	10/30/13	--	--	Sandy Lean Clay (CL)
B-22	4 to 6	1	1	1	10/30/13	ND-1	11/1/13	Sandy Lean Clay (CL)
B-22	8 to 10	3	4	4	10/30/13	-	-	Clayey-Silty Sand (SC-SM)
B-23	6 to 8	3	4	4	10/30/13	D1	11/1/13	Sandy Lean Clay (CL), with ferrous nodules
B-23	8 to 10	3	4	4	10/30/13	--	--	Sandy Lean Clay (CL), with ferrous nodules
B-24	4 to 6	3	4	4	10/30/13	--	--	Sandy Lean Clays (CL), with sand pockets
B-24	8 to 10	3	4	4	10/3013	--	--	Sandy Lean Clays (CL), with sand pockets

Notes: 1) Crumb test grades: 1 – Non dispersive 2 – Intermediate; 3 – Dispersive 4 – Highly dispersive

2) Pinhole test classifications: D1, D2 -- Dispersive; ND4, ND3 -- Slightly dispersive; ND2, ND1 -- Non dispersive

Results of the crumb and pinhole tests indicated that:

- The Sandy Lean Clays (CL) found at the site are non dispersive when not containing

inclusion of sands and ferrous nodules. When the Sandy Clays contains inclusion of sands, silts, ferrous and calcareous nodules, they shall be classified as dispersive.

4.4.2 Suitability of Onsite Soils As Fill Material

Clean non-expansive Lean Clay soils (plasticity index between about 8 and 20) can be used as select fill in their present condition in City of Houston right-of-way. Clean excavated onsite soils classified as Lean Clays (CL) may be used as fill for construction within HCFCD right-of-way (such as the drainage ditch construction); however, imported fill shall have a LL not exceeding 49, a PI between 15 and 30, contains between 60 and 85 fines passing a No. 200 sieve, and is classified as ND-1 or ND-2 according to Pinhole Test-Method A. Onsite Lean Clays containing inclusion of sand/silt/ferrous and calcareous nodules, due to their dispersive nature, are not recommended for use as fill in the top 2 feet of slope surface or as clay liner unless treated with an adequate amount of lime. The optimum amount of lime to be used to stabilize the sandy lean clays can be determined by conducting lime vs PI and/or pH series tests.

The on-site Fat Clays (CH) are not suitable as select fill, but they may be used as general fill for non-structural areas. The Clays (CH) may be used as select fill when treated with an adequate amount of lime. The optimum amount of lime to be used to stabilize the sandy lean clays can be determined by conducting lime vs PI and/or pH series tests.

The Silty/Clayey Sands (SC, SM, SC-SM) are not suitable as select fill, they may be used as general fill in non-structural areas that are protected from erosion.

4.5 Groundwater

Free water was encountered during drilling operation in most borings except B-5 and B-9 at depths between 10 and 27 feet; free water was measured at depths ranging from 10 to 23 feet at completion

of drilling. Borings B-1, B-11, B-19 and B-21 were converted into Piezometer PZ-1 through PZ-4 after completion of drilling and soil sampling. Water level in PZ-1 through PZ-4 was measured after 24-hour at a depth of about 17, 11, 11 and 13 feet, respectively. Water level in PZ-1 through PZ-4 was measured after 7 days at a depth of about 16, 11, 11.5 and 13 feet, respectively. Water level in PZ-1 through PZ-4 was measured after 30 days at a depth of about 15, 11, 11 and 12 feet, respectively.

The groundwater information encountered during and at the end of drilling in the boreholes, and in the piezometer after 24 hours, 7 and 30 days are presented in Table 2. It should be noted that the groundwater conditions will fluctuate according to the amount of precipitation and the environments conditions at the site.

Perched water table may exist in permeable sand/silt lenses/seams/layers within clay stratum that can form pathways for percolated and infiltrated water. The rate of flow of groundwater produced by these layers will depend upon the weather conditions such as locations of size and continuity of the permeable layers/seams/lenses, and the amount of precipitation and ambient temperature etc., at the time of construction.

5.0 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

The proposed storm and sanitary sewer line installation will involve both open cut and augering (a trenchless construction technique). Construction of access pits (auger pits) will also involve open cut/trench excavation. Based on the plan and profile drawings, the storm and sanitary sewer lines are proposed to be installed at a depth of about 8 to 17 feet below existing grade.

5.1 Proposed Storm and Sanitary Sewer Installation

5.1.1 OSHA Soil Types

At the federal level, Occupational Safety and Health Act (OSHA) requires protective systems for all trenches exceeding 5 feet in depth. OSHA has developed a soil classification system to be used as a guideline in determining sloping and protective system requirements for trench excavations. This system has set forth a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing amounts of stability.

Stable Rock: Natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A: Cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) or greater.

However, no soil is Type A if:

- The soil is fissured; or
- The soil is subject to vibrations from heavy traffic, pile driving, or similar effects; or
- The soil has been previously disturbed; or
- The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four (4) horizontal to one (1) vertical or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B:

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; or

- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
- Dry rock that is not stable; or
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C:

- Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
- Granular, including gravel, sand, and loamy sand; or
- Submerged soil or soil from which water is freely seeping; or
- Submerged rock that is not stable;. or
- Material is a sloped, layered system where the layers dip into the excavation on a slope of four (4) horizontal to one (1) vertical or steeper.

Based on the soil conditions from the borings and groundwater information from the borings and piezometers, ATL recommends classifying the top 10 feet of the onsite stiff to hard clay soils (CL/CH) as OSHA Soil Type "B" for the determination of allowable maximum slope or selection and design of the protective system. All onsite clay soils below a depth of 10 feet, and soft to firm clays, shall be classified as OSHA Soil Type "C". Any soft/wet soils, sands (SP/SM/SC), silts (ML), silty clays (CL-ML), and any soils that are saturated or are subject to seepage pressure or vibrations shall be classified as OSHA Soil Type "C". In mixed soils conditions, the most critical soil classification shall be used.

5.1.2 Open Cut/Trench Excavation

The proposed storm and sanitary sewer line installation will involve construction using both open cut/trenching and tunneling (trenchless installation) technique. The approximate flow line depths and

the subsurface conditions found in the soil borings are shown in the Boring Log Profile on Figures 4a through 4k. Accordingly, the storm and sanitary sewer line installation excavation will be advanced in both clay soils and sands.

The approximate flow line depths and the subsurface conditions found in the soil borings are shown in the Boring Log Profiles on Figures 4a through 4k. Accordingly, the sewer line installation excavation will be advanced in both clay and sandy soils. The locations identified in Table D below (but not limited to) will likely or may encounter granular soils during the construction excavation:

TABLE D: LOCATION WHERE SEWER LINE INSTALLATION WILL LIKELY OR MAY ENCOUNTER SANDS

At/Near Boring	Maximum Sewer Line Invert Depth, ft.	Depth of Sand Stratum	
		From	To
B-1	20	0**	4**
		6**	8**
		10**	12**
B-2	10	10	12
B-3	17	10***	12**
B-4	10	10	15.5*
B-5	10	10	15.5*
B-6	17	12**	18
B-9	10	12*****	14
B-10	10	12*****	15.5*
B-11	17	12**	18
B-12	10	8	15.5*
B-13	10	12	15.5*
B-37 (old data)	10	10	13*
B-14	16	10**	18
B-27 (old data)	10	10	13*
B-15	16	10**	16****
B-35 (old data)	10	8**	12
B-16	10	12*****	15.5*
B-17	10	12*****	15.5*
B-33 (old data)	10	12	25*
B-18	15	10**	30*

At/Near Boring	Maximum Sewer Line Invert Depth, ft.	Depth of Sand Stratum	
		From	To
GB-39 (old data)	14.5	13	20*
B-19	14	0	3**
		8**	20
B-20	13	10**	23*
GB-22 (old data)	13	11	13*
GB-15 (old data)	12.5	10	15
GB-75 (old data)	12.5	13***	20*
GB-71 (old data)	11	13*****	20*
GB-45 (old data)	11	13*****	26*
B-21	11	8**	21.5*
GB-46 (old data)	11	2**	8**
		13*****	23

* denotes bottom of boring

** denotes sands exist above the proposed flow line, and may be encountered during open cut and/or auger pit excavation

*** denotes sands exist right below the flow line; the possibility that sands may be encountered during water line installation exists depending on mode/size of excavation and/or potential for variations in soil stratigraphy and other factors

**** denotes sands exist within one foot of the flow line; the possibility that sands may be encountered during water line installation exists depending on mode/size of excavation and/or potential for variations in soil stratigraphy and other factors

***** denotes sands exist within two foot of the flow line; the possibility that sands may be encountered during water line installation exists depending on mode/size of excavation and/or potential for variations in soil stratigraphy and other factors

In addition, the following locations identified in Table E may encounter soft clay soils:

TABLE E: LOCATION WHERE SEWER LINE INSTALLATION WILL LIKELY OR MAY ENCOUNTER SOFT CLAY SOIL

At/Near Boring	Maximum Sewer Line Invert Depth, ft.	Depth of Sand Stratum	
		From	To
B-2	10	2	10
B-3	17	2	10
		16	18
B-6	17	10	12

The trench excavations can be made using cut slopes stepped back to stable slope, vertical cuts supported with sheet piles or other properly designed retaining system. The excavation should be performed in accordance with the current OSHA 29 CFR Part 1926 of OSHA (Trench Safety System) and City of Houston Standard Specification, Section 02317 – Excavation and Backfill for Utilities.

Trenches should be provided with a proper trench support system. For the trench supporting system, the lateral pressures exerted on trench walls by stiff clays and cohesionless soils are presented in Figure 5a. Where soft to firm cohesive soils are encountered, the lateral pressure may be computed as given in Figure 5b. Where cohesive soils are underlain by sandy soils, the lateral pressure may be computed as given in Figure 5c. Temporary earth retaining walls are sometimes designed assuming an equivalent fluid pressure, in such cases, a lateral earth pressure equivalent imposed by a 84 PCF and 102 PCF fluid is recommended for clay soils above and below the water table, respectively; in sandy soils, a lateral earth pressure equivalent imposed by a 48 PCF and 85 PCF fluid is recommended for soils above and below the water table, respectively. Timber shoring as outlined in 29 CFR Part 1926 of OSHA recommendation may be used in the construction of trench supporting system. Trench boxes are commonly used for trench safety without shoring or bracing in open-cut excavations with vertical walls. In all cases, excavations should conform to OSHA guidelines.

Vehicular and Other Surcharge Loadings: Under normal loading conditions, a surcharge magnitude of q psf can result in lateral earth pressure of about 0.5q in cohesive soils and about 0.4q in sandy soils. All surcharge loads to a distance of 0.5 times the wall height should be considered. Due to the likely presence of roadways along the proposed pipeline alignment, the effects of vehicular traffic should be considered while designing the lateral supporting systems. The highway loading imposed by a H20 truck on a pipe under various depths of soil cover is presented in Figure 6. Figure 7 presents Boussinesq's equation for computing both horizontal and vertical stresses imposed by a surface surcharge load.

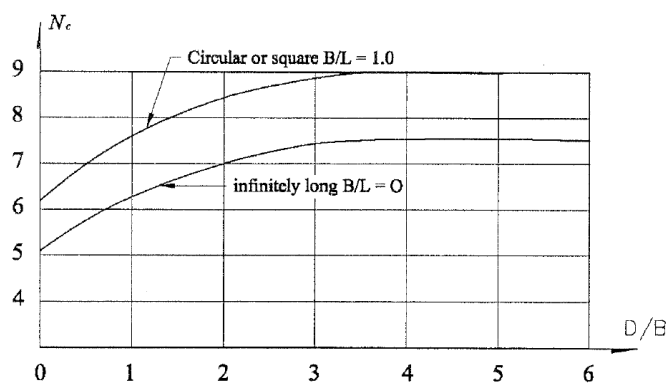
Stockpiling of excavated material should not be allowed near the excavation. Generally, a distance of at least one-half the excavation depth on both sides of the trench should be kept clear of any excavated material and height of stockpile should be limited to no more than 3 feet. If this is not possible due to space limitations then the retaining system design should be designed to take into account the surcharge loads.

In stable cohesive soils and where groundwater is lowered at least 3 feet below the excavation bottom, and if the sheeting terminates at the base of cut, the trench bottom stability can be evaluated in the following manner:

$$\text{Factor of safety } (F_s) = \frac{(N_c)\,C}{(\Upsilon)\,D + q}$$

Where,

N_c = Bearing capacity factor that depends on dimensions of the excavation:



N_c rectangular = (0.84 + 0.16B/L)N_c square

C = Average undrained shear strength of clay in failure zone beneath and surrounding base of cut, psf.

Υ' = Average effective unit weight of soils above trench bottom, pcf.

q = Surface surcharge, psf.

D = Depth of trench, ft.

L = Length of trench, ft.

B = Width of trench, ft.

If the factor of safety is less than 1.5, sheeting should be extended below the base of the cut to insure stability. The extended sheeting depth should be at least 1.5 times the trench width.

5.1.3 Groundwater Control

Groundwater information gathered from the soil borings during, at completion of drilling, as well as after 24 hours, 7 and 30 days water level readings in the piezometers are presented in Section 4.5. It should also be noted that groundwater levels will fluctuate as a result of seasonal rainfall variations.

The approximate flow line depths and the subsurface conditions as found in the soil borings are shown in the Boring Log Profile on Figures 4a through 4k. Based on the proposed invert elevation and the groundwater information gathered during our field investigation, the storm and sanitary sewer line construction excavations will likely to encounter groundwater when the excavation depths approaches or exceeds about 10 feet. It should be noted that groundwater level will fluctuate with the amount of precipitation and the prevailing environmental conditions prior to and during construction.

Seepage rate in clay soils, if exists, will likely be low, but seepage rate in sands (if exists) will be higher. Groundwater control for excavation in cohesive soils up to a depth of 15 feet, if required, can usually be accomplished by sump and pump arrangements because the seepage is relatively slow. For dewatering below the depth of about fifteen (15) feet multi-staged pumps will be required. When excavations extend into water-bearing sands/silts (not found in soil borings drilled in this investigation, but may be present away from the borings drilled or after heavy rainfalls), then dewatering using well points will be necessary. Criteria and requirements of City of Houston Standard Specification, Section 01578 – Control of Ground Water and Surface Water should be followed.

Seams and pockets of sand, silt, ferrous nodules, and calcareous nodules that may exist in cohesive soil layers may form communicative drainage paths for the groundwater, leading to potential water-bearing/perched water condition, and as a result, accelerated the rate of seepage. If such phenomenon is observed during the trench excavation and construction, appropriate measures, such as proper

dewatering and shoring methods, may have to be implemented under supervision of a Professional Civil/Geotechnical Engineer.

5.1.4 Bedding Criteria

For storm sewers, in areas where dry subgrade is encountered, the trench bottom should be excavated to a minimum of 12 inches below the pipe placement depth. The space should be filled with cement stabilized sand to a depth of pavement base/subgrade depth if the pipe is under the pavement. For concrete pavement this should be 12-inches below the pavement. If the pipe is outside the pavement area, then the cement stabilized sand should be filled to a depth of 12-inches above the pipe top. The trench bottom should be shaped to receive the pipe. The bedding details should be in accordance with the latest City of Houston Specifications. City of Houston Drawing No. 02317-03 should be used for the storm sewer bedding and backfill for dry stable trench conditions; in areas where wet subgrade is encountered, City of Houston Drawing No. 02317-02 crushed stone foundation should be provided for the storm sewer bedding. City of Houston Drawing No. 02317-01 should be used for the sanitary sewer bedding and backfill for both dry and wet stable trench conditions.

Soft and/or wet soils, if encountered at trench bottom, should be handled according to requirements specified in City of Houston Standard Specifications Section 02317, Subsection 3.07.

5.1.5 Trench Backfill

The backfill should conform to standard City of Houston Specification, Section 02317 – Excavation and Backfill for Utilities. The backfill materials should conform to standard City of Houston Specification, Section 02320 – Utility Backfill Materials.

For sewers, as trench zone backfill in paved areas for streets and to one-feet back of curbs and

pavements, cement stabilized sand should be used. Select backfill should be used within one-foot below pavement subgrade for rigid pavements. Any cut pavement should be replaced to match the existing pavement type and the thickness should be equal or greater then the existing pavement thickness. The finished pavement surface must be even with existing pavement elevation. For trench excavations outside pavement areas, random backfill may be used and compacted as specified in City of Houston Standard Specification Section 02317 -Excavation and Backfill for Utilities. The backfill material should conform to Standard City of Houston specification, Section 02320 – Utility Backfill Materials.

5.1.6 Loads on Buried Conduits

The pipelines placed at depths under the ground will be subject to loads due to backfill (earth loads) and loads due to vehicular traffic (live loads).

Earth Load: The earth loads on a buried pipe can be calculated based on Marston's formulae (Ref: 1 through 3). The Marston's equation for buried conduits are generally given as:

$$W_d = C_d \Upsilon B_d^2 \quad \text{- for rigid pipes}$$

$$W_d = C_d \Upsilon B_d B_c \quad \text{- for flexible pipes}$$

Where, W_d = fill load, in pounds per linear foot of pipe

C_d = Marston's soil coefficient

Υ = Unit weight of fill material, pcf (use 120 pcf)

B_d = Width of trench at or slightly below top of pipe, in feet

B_c = Width of pipe, in feet

The above equation is valid when the conduit is placed in a trench not wider than 2.0 to 3.0 times its

outside width. Marston's soil coefficient C_d can be obtained from Table 4. K is the active earth pressure coefficient and μ is the coefficient of sliding friction between the fill material and the sides of the trench. The height of fill and the horizontal width of trench should be considered from the top of the conduit. For the above equation for flexible pipes, an assumption of equal stiffness of soil and pipe has been used for its development and the equation generally gives a minimum load value. Hence, for flexible pipes including ones installed using trenchless construction, the earth loads may be conservatively calculated using the prism load theory. The prism load (Ref: 1 through 3) determines the weight of the soil column directly above the pipe and neglecting factors such as side wall friction and/or the cohesion of the soils. The prism load (in psf) may be calculated by multiplying the total unit weight of soil above the pipe (say 120 pcf) by the height, H (ft) of the soil fill. The prism load generally gives higher loading on the pipe and simulates the long term load imposed on the pipe.

Vehicular Load: For calculation of live loads, the width of the loaded area should be taken as the outside horizontal width of the pipe. Loading due to H20 vehicle should be considered for vehicular traffic. The estimated highway loading on a buried conduit imposed by a H20 truck, under various soil cover, is presented on Figure 6.

Surcharge Load: The stresses imposed by a surcharge load can be estimated using Boussinesq's Equation presented on Figure 7.

5.1.7 Trenchless Construction

Augering is one of the trenchless technique, it may involve dry auger or slurry auger method. In the dry auger method, the casing is advanced by jacking while soils are excavated at the advancing end of the casing. In the slurry auger method, a small diameter pilot hole is first drilled between the access shafts, followed by reaming the pilot hole to full diameter by augering with slurry and

installing casing or pipe by pull-back or jacking techniques. Requirements of City of Houston Standard Specification, Section 02448 – Pipe and Casing Augering for Sewers, should be followed.

The storm and sanitary sewer line will be installed mostly in both clays and sands. Table D in Section 5.2 identifies locations where granular soils will likely or may be present (but not limited to locations listed).

Excavations in clay soils are anticipated to be stable. Groundwater conditions observed in open boreholes during the field investigation and in piezometers are presented in Section 4.5. Excavation face in granular soils (sand/silt/gravel), clay soils with slight/low plasticity or containing a significant amount of sands, and other caving soils, if encountered at/near the excavation face, will likely to experience some degree of instability if the excavation face is unsupported, especially when these soils are saturated and/or subject to seepage pressure. In such cases, the following mitigating measures can be employed to improve the excavation stability:

1) Lower the groundwater table to at least 3 feet below the excavation bottom, and use colloidal drilling fluid (usually bentonite slurry) under controlled pressure to improve stability of the excavation.
2) In conditions where mitigation measures employed in Item 1 above cannot adequately provide the excavation stability, a casing can be installed at the same time of the slurry augering to provide stability of the excavation and reduce settlement at the surface.
3) In ground conditions where highly unstable soils and/or high inflow rate/pressure exist, microtunneling machine equipped with face shield and pressure-balancing colloidal drilling fluid may be used to maintain the stability of the excavation face.
4) Alternatively, open cut with shoring or other methods approved by City of Houston Department of Public Works and Engineering, along with groundwater control, and other stabilizing techniques such as chemical grouting, may be used at locations with difficult subsurface conditions or site constraints.

It is the responsibility of the Contractor to select a trenchless technique for the installation of the proposed storm and sanitary sewer line by taking into account the soil types and stratigraphy and the groundwater conditions as found in the soil borings; the Contractor should have a work crew experienced in working with the selected trenchless construction technique in subsurface conditions similar to those found along the project alignments. If necessary, the Contractor may conduct additional geotechnical investigation to provide more detailed subsurface conditions.

Auger pit construction criteria provided in City of Houston Standard Specification, Section 02448 – Pipe and Casing Augering for Sewers,, should be followed. Shoring systems for the auger pits and tunnel shafts may be designed based on the lateral earth pressures and other considerations discussed in Section 5.1.2.

5.1.8 Effects of Trenchless Construction on Surrounding Structures

A properly designed and controlled trenchless construction operation can reduce immediate soil movement and subsidence to a tolerable level. Nevertheless, some ground loss should be expected during any trenchless construction operations. With good construction techniques, ground loss can be mitigated to acceptable levels. Trenchless construction below pavement and buried utilities may lead to some future settlement due to loosening of the subgrade or bedding condition. Large ground loss can result from uncontrolled flowing ground. Such conditions may occur if water-bearing sands or other soils that are cohesionless or have limited cohesion were encountered (see Table D and Boring Log Profiles for potential locations) in the excavations along the trenchless construction alignment. Measures to mitigate ground loss and other impacts of trenchless construction were addressed in Section 5.1.7.

The zone of influence of the augering/trenchless construction roughly extends to a distance equal to the invert depth on each side of the centerline of the trenchless construction alignment. The amounts

of settlement due to trenchless construction are difficult to estimate. We anticipate that if good construction practices and control are exercised, the amount of ground settlements should be small. Establishing monitoring points on existing roadways, buildings and other important structures along the trenchless construction alignments, and record coordinates and elevations prior to, during and after construction to monitor the amount of settlements or lateral movements due to trenchless construction, and adjust trenchless construction technique accordingly to mitigate the movements as necessary. Existing damages to the surrounding structures should be documented prior to starting of the trenchless construction operations.

5.1.9 Thrust Restraint

Unbalanced thrust forces result from changes in flow directions and/or velocity in a pressurized pipe system (see Figure 8). The unbalanced thrust force and magnitude of thrust block force T is defined as follows:

$$T = 2\ PA\ \mathrm{Sin}\ (\theta/2)$$

Where,
- P = internal fluid pressure (psi);
- A = cross-sectional area of pipe (in^2);
- θ = deflection angle of bend; and,
- T = thrust force (pounds)

Adequate restraint may be achieved by using thrust blocks, restraint joints, tie rods, or a combination of these systems. The unbalanced force acting on a pipe system is transmitted by a thrust block and resisted by the bearing area between the pipe and the foundation soils. The unbalanced force acting on a pipe system with restraint joints are resisted by the frictional forces between the pipe/soil interface across the pipe sections restrained to act integrally.

Thrust Blocks: Thrust blocks are commonly used to increase the bearing area to allow the fittings to

resist movement. The procedures for thrust block design are given in detail in AWWA M9 (Ref. 1). The required thrust block bearing area is calculated based on the bearing capacity of the soil:

$$\text{Required Bearing Area of Thrust Block} = T/F$$

Where, T = thrust force (lb); and,

F = safe bearing value for soil (lb/sq.ft)

A safe bearing value of 1,500 psf can be used for thrust block design bearing on compacted soils. This value includes a factor of safety of 3. The blocks must be placed against undisturbed or compacted soils and the face of the block must be perpendicular to the direction of and centered on the line of action of the thrust. Proper care must be exercised after construction to prevent failure due to any future excavations behind the blocks.

Restrained Joints: Restrained joints are typically used to avoid the uncertainties of thrust blocking like future excavations, etc. A detailed procedure for designing restrained joints including example calculations is outlined in the AWWA design manual M9 (Ref. 1). The following soil parameters are recommended for the design of the restrained joint(s):

Average unit weight of soil, γ = 120 pcf

Cohesion of soils, C = 250/500/1000 psf (for soft/firm/stiff clays)

For coefficient of friction between pipe and granular soils, f, use 0.25 for smooth PVC and steel pipes, and use 0.3 for concrete pipes.

5.1.10 Flexible Pipe Deflection

The deflection of a flexible pipe may be determined using the modified Iowa formula of Watkins and Spangler (Ref. 2) as given below:

$$\Delta x = D_l \, [\, KWr^3 / (EI + 0.061 \, E' \, r^3) \,]$$

Here EI is the pipe wall stiffness (in-lb.), r is the radius (in.) and W is the load per unit of pipe length (lb/in. in. of pipe). Where prism loads (i.e. weight of soil above the pipe) are used for pipe earth loads, a deflection lag factor, D_l of 1.0 may be used. Otherwise, deflection lag factor, D_l of 1.5 should be used. The bedding constant, K, may be taken as 0.1. The following typical soil parameters are recommended:

Soil Type	**Soil Consistency**	**Unit Weight, pcf**	**Shear Strength (c), psf or SPT Blow Counts, blows/ft**	**Modulus of Soil Reaction, psi/in**
Fat Clays and Lean Clays	Soft	120	$c \leq 250$	100
	Firm	124	$c \leq 500$	300
	Stiff	128	$c \leq 1{,}000$	600
	Very Stiff	130	$c \leq 2{,}000$	1,000
	Hard	132	$c > 2{,}000$	2,000
Granular Soils: Sands, Silts and Gravel	Loose	110	$2 \leq N_{SPT} \leq 7$	300
	Loose to Medium Dense	113	$8 \leq N_{SPT} \leq 15$	600
	Medium Dense	115	$16 \leq N_{SPT} \leq 30$	1,000
	Dense	118	$N_{SPT} > 30$	2,000

* Buoyant soil unit weight is computed by subtracting unit weight of water from the soil unit weight

5.1.11 <u>Buoyant Uplift</u>

Portion of a buried structure located below the water table is subject to an upward hydrostatic pressure, called the *buoyant uplift pressure*. Resistance to buoyant uplift pressure is provided by the following components:

- *Weight of the structure (W)*
- *Weight of the soil above the base extension beyond the wall(Ws)*
- *Frictional force between the soil and foundation (Fs).*

Buoyant Uplift Resistance = W + Ws + Fs

W and Ws are can be readily computed. The computation of the buoyant uplift, and the skin friction resistance are shown in Figure 9. If base extension option is used, we recommend using a buoyant unit weight of backfill soil above the base extension of 65 pcf when computing Ws.

5.1.12 Street Cut and Repair

Any street cut necessary for this project should be restored to its original condition using material similar in nature and thickness to the existing streets. Recommendations outlined in City of Houston Standard Specification, Section 02951 – Pavement Repair and Resurfacing should be followed. The top 8 inches of the subgrade soils in the pavement repair areas should be stabilized. See Section 5.3.3 for recommended subgrade soils stabilization.

The lime and lime-fly ash stabilization should be carried out in accordance with City of Houston Standard Specifications Section 02336 and 02337, respectively.

5.2 Slope Stability Analyses for Proposed Ditch Improvements

5.2.1 Existing Conditions and Proposed Improvements

The existing HCFCD Ditch E101-10-01 between Lehman Street and Janisch Road is approximately 5 to 6 feet deep (approximately 10 feet at local areas with high banks), and is covered with vegetation and small trees. The top width of the existing ditch range is about 20 feet, and the earth slopes appear to be stable.

The ditch is proposed to be improved and maintained by City of Houston, ATL assumes that the expanded ditch will have approximately the same depth. Possible improvement options include providing stable earth slopes with vegetation cover, stable earth slopes protected by concrete liner or

articulating concrete blocks (ACB). *At a later design stage, it is decided that the slope improvements will consist of 2H:1V earth slopes protected by ACB with bottom width ranging between 6 and 18 feet; the proposed layout and cross-section of the ditch protected by ACB are presented in Figures 10a and 10b.* Borings B-22 and B-23 were drilled along the existing ditch, and Borings B-21 and B-24 were drilled on Brinkman Street and North Shepherd Drive near the ends of the ditch.

5.2.2 ***Slope Stability Analyses***

To evaluate the slope stability for the proposed ditch improvements, we considered a 10 feet deep earthen ditch with a slope inclination of 3H:1V, a bottom width of 18 feet, and a 2H:1V with a concrete liner and articulating concrete blocks (ACB). Considering the subsurface soil information from Borings B-21 through B-24, we developed a composite soil profile representative of the subsurface soil stratigraphy of the area (see Section 5.2.2 for the soil stratigraphy and parameters).

We conducted the slope stability analyses to evaluate the global slope stability of the earth slopes using Modified Bishop Method and the computer program SLIDE 6.0. The earth slopes were analyzed for the short term, long term and rapid drawdown conditions.

- End-of-Construction Condition - This condition models loading condition at the end of construction where there is no time for the consolidation of the soils to occur and the load-induced excess pore water pressure to dissipate. Unconsolidated-undrained shear strength parameters were used for this analysis. For this analysis, a piezometric surface at a depth of 10 feet was assumed for the proposed ditch improvements slope stability analyses. The piezometic surface was based on piezometer water level observations.
- Long Term Condition - This condition models the long-term steady-state seepage case for the long term stability of the earth slopes, where the slope soils are allowed to consolidate under self-weight and sustained loading and the load-induced pore water pressure is allowed to dissipate over time. For this analysis, a piezometric surface at a depth of 10 feet was assumed for the proposed ditch improvements slope stability analyses. The piezometic surface was

based on piezoemter water level observations.

- Rapid Drawdown Condition - The majority of slope failures in the Harris County/Houston area occur under rapid drawdown loading conditions. This condition models the loading condition where the entire slope soils are fully saturated due to a sustained period of rain or flood, then subject to rapid drawdown, resulting in stress increase created by the rapid drawdown of the basin/channel water, with no time for dissipation of excess pore pressure. For this analysis, a piezometric surface located at the top of bank, along the slope surface, and along the basin/channel bottom was assumed.

The shear strength parameters for the short term loading condition used in the slope stability analyses were based on the soils' index properties, in-situ shear strength estimates (hand penetrometer and Standard Penetration), as well as unconfined compression, and the triaxial of unconsolidated-undrained test results. In our long term and rapid drawdown analyses, we used shear strength parameters derived based on the soils' index and strength properties, results of triaxial consolidated-undrained tests on soils with pore pressure measurement, as well as consideration of mobilized shear strength due to soil softening/weathering effects as reported in publications by Mesri, et. al. and Stephen Wright. Based on information from Borings B-21 through B-24, a composite *soil stratigraphy and the corresponding shear strength parameters was developed for the slope stability analyses, as summarized in the table below.*

COMPOSITE SOIL PROFILE FOR PROPOSED DITCH IMPROVEMENTS
(Using Borings B-21 through B-24 Information)

Depth (ft)	Soil Type	$\gamma^{(1)}$ (pcf)	SHORT-TERM		LONG-TERM		RAPID DRAWDOWN	
			$C^{(2)}$ (psf)	$\varphi^{(2)}$ (deg)	$C_{CD}'^{(3)}$ (psf)	$\varphi_{CD}'^{(3)}$ (deg)	$C_{cu}'^{(4)}$ (psf)	$\varphi_{cu}'^{(4)}$ (deg)
0 to 4	Silty/Clayey Sand (SM/SC)	112	0	28	0	28	0	28
4 to 8	Firm to hard Sandy Lean Clays (CL)	125	1,000	0	338	28	338	28
8 to	Medium dense to dense Silty Sand	115	0	30	0	30	0	30

22	(SM)							
Varies	Sandy Lean Clay (CL) Liner	125	1500	0	100	25	100	25

Notes: (1) γ = total unit weight of soils
(2) C = undrained cohesion of clayey soils, estimated from information such as hand penetratometer readings, unconfined compression, and trixial unconsolidated undrained tests; φ = soil frictional angle (0 for clay soils; estimated from Standard Penetration blow counts for granular soils)
(3) C_{CD}' = effective cohesion, φ_{CD}' = effective friction angle for consolidated-drained condition, estimated based on in-situ soil properties, available results of CU tests with pore pressure measurements, and considering published correlations from literatures, with consideration of weathering effects (as necessary)
(4) C_{cu}' = effective stress cohesion, φ_{cu}' = effective stress friction angle for consolidated-undrained condition, estimated from the effective shear strength parameters derived from triaxial consolidated-undrained tests with pore water measurements, and considering published correlations from literatures, with consideration of weathering effects (as necessary)

A ground surface surcharge load of 250 psf was assumed in our analysis to simulate traffic and other incidental loading for the end of construction and long term loading case. If surcharge higher than those assumed in this analysis is anticipated, please inform us. The target minimum Safety Factor (SF) is 1.3 for the short-term condition, 1.5 for the long-term condition, and 1.25 for the rapid drawdown.

The slope configuration, soil profile, shear strength parameters, and piezometric and surcharge loading conditions considered in each case of the slope stability analyses are presented in the slope stability analyses outputs in Appendix 6.

5.2.2.1 ***Results of Slope Stability Analyses***

The following are summary of the results of the slope stability analyses of the proposed 3H:1V earthen slope, a 2H:1V earth slope with concrete liner and a 2H:1V earth slope with articulating concrete blocks (ACB) for the ditch improvements.

Location	**Slope Description**	**Slope Stability Factor of Safety**		
		Rapid Drawdown Condition (Target FS: ≥1.25)	**Long Term Condition (Target FS: ≥1.5)**	**Short Term Condition (Target FS: ≥1.3)**
Proposed Improvement of HCFCD Ditch E-101-10-01	3H:1V Earth Slope	1) Shallow depth sloughing failure within the Silty-Clayey Sand stratum with FS=0.61 2) Global stability FS of the slope soils is 3.46, above the target value of 1.25 **[see Figure 6-1]**		

Location	Slope Description	Slope Stability Factor of Safety		
		Rapid Drawdown Condition (Target FS: ≥1.25)	**Long Term Condition (Target FS: ≥1.5)**	**Short Term Condition (Target FS: ≥1.3)**
Proposed Improvement of HCFCD Ditch E-101-10-01 (cont'd)	3H:1V Earth Slope, with 1-ft Thick Sandy Lean Clay Liner at Slope Surface with Silty-Clayey Sand Soils	1) No shallow depth sloughing slip circle with FS<1.25 exists 2) Local slope stability FS=1.54, above target value of 1.25 2) Global stability FS of the slope soils is 3.40, above the target value of 1.25 **[see Figure 6-2]**	1) No shallow depth sloughing slip circle with FS<1.5 2) No local slip circles with FS<1.5 2) Global stability FS of the slope soils is 3.80, above the target value of 1.5 **[see Figure 6-3]**	1) No shallow depth sloughing slip circle with FS<1.5 2) No local slip circles with FS<1.5 2) Global stability FS of the slope soils is 4.43, above the target value of 1.3 **[see Figure 6-4]**
	2H:1V Earth Slope with 5-inch Thick Concrete Liner	1) No shallow depth sloughing circle with FS<1.25. 2) Local slip circle FS=1.72, above the target value 3) Global stability FS of the slope soils is 3.48, above the target value. **[see Figure 6-5]**	1) No shallow depth sloughing circle with FS < 1.5. 2) Local slip circle FS=2.64, above target value. 3) Global stability FS of the slope soils is 4.56, above the target value. **[see Figure 6-6]**	1) No shallow depth sloughing with FS < 1.3. 2) No local slip circle with FS < 1.3. 3) Global stability FS of the slope soils is 6.05, above the target value. **[see Figure 6-7]**
	2H:1V Earth Slope with Articulating Concrete Blocks	1) No shallow depth sloughing circle with FS<1.25. 2) Local slip circle FS=1.3, above the target value 3) Global stability FS of the slope soils is 3.30, above the target value. **[see Figure 6-8]**	1) No shallow depth sloughing circle with FS < 1.5. 2) Local slip circle FS=2.17, above target value. 3) Global stability FS of the slope soils is 4.38, above the target value. **[see Figure 6-9]**	1) No shallow depth sloughing with FS < 1.3. 2) Local slip circle FS=2.17, above target value. 3) Global stability FS of the slope soils is 5.82, above the target value. **[see Figure 6-10]**

5.2.2.2 ***Conclusion***

Based on results of the slope stability analyses, we can surmise the following:

- 3H:1V earth slopes for proposed ditch improvements, with 1-ft thick sandy lean clay liner placed at the slope surface of the silty-clayey sand stratum, based on subsurface conditions of Borings B-21 through B-24, are theoretically stable in term of slope stability, when subject to short- and long-term and the rapid drawdown loading conditions.

- 2H:1V earth slopes, protected with a 5-inch thick concrete liner, for the proposed ditch improvements, based on subsurface conditions of Borings B-21 through B-24, are theoretically stable in term of slope stability when subject to the short- and long term and the rapid drawdown loading conditions.
- 2H:1V earth slopes, protected with properly designed and constructed cabled and interlocking ACB, for the proposed ditch improvements, based on subsurface conditions of Borings B-21 through B-24, are theoretically stable in term of slope stability when subject to the short- and long term and the rapid drawdown loading conditions. ATL recommends that cabled interlocking ACB in conjunction with filter geofabric be provided and the ACB shall be designed in accordance with criteria in HCFCD "Design Manual for Articulating Concrete Block Systems" and the standard details drawings for ACB.

5.2.3 Ditch Improvement Construction

The site preparation should be conducted in according to requirements as outlined in HCFCD Standard Specifications Section 02200, or accepted equivalent. Clearing and grubbing and selective clearing should meet requirements of HCFCD Standard Specifications Section 02323 and 02322, respectively, or accepted equivalent. The construction excavation and backfilling as well as care and control of surface and groundwater (if needed) for the proposed ditch improvements shall meet requirements of HCFCD Standard Specifications Section 02315 and 02241, or accepted equivalent.

1) Excavate the ditch to be improved to the design slopes. The exposed soil surface along the slope and bank as a result of the detention pond and/or ditch improvement construction shall be protected by immediate vegetation cover by sodding, or other approved measures.
2) Any CL-ML/SM/SC type soils exposed during excavation on the slopes, as well as near the toe or bank of the slopes (if any), when not protected by concrete liner or ACB with filter geotextile, should be replaced with a minimum 1-foot thick non-dispersive lean clay liner meeting HCFCD imported select fill criteria, or accepted equivalent.

3) Grade ground surface within the ditch right-of-way to intercept and direct surface runoff towards protected inlets/swales/ditches that discharge into the drainage ditch.
4) Grade bottom of ditch/channel to design elevations.
5) All surface flow collection and discharge structures (including swales, discharge points, pilot channels, emergency overflow, etc.) should be protected from erosion as per HCFCD standard details, or accepted equivalent.
6) Exposed soil surface along the slope and bank as a result of the ditch improvement construction shall be protected by immediate vegetation cover by sodding, or other approved measures.

5.3 Pavement Design

The existing Alba Street and Brinkman Street will be reconstructed along the project alignment. The reconstructed Alba Street will be of asphaltic concrete (AC) and the Brinkman Street will be of portland cement concrete (PCC). Our design recommendations for new concrete pavement are given in the following sections.

5.3.1 Traffic Information

Currently available City of Houston Traffic Counts (2000) information indicated average daily traffic (ADT) counts between 2001 and 2006 along Alba Street and Brinkman Street range between about 1,440 and 3,370. As a comparison, the ADT counts along the nearby North Shepherd Drive in 2010 was at 35,740.

Forecast Future Traffic: Assuming the projected traffic on the improved Alba Street and Brinkman Street will increase with higher percentage of truck traffic after the roadway improvements, we assumed an annual traffic growth rate of 5 percent, 5% truck traffic with an average 18K Equivalent Single Axle Load (ESAL) factor of 1.0, and a directional and lane distribution factor of 0.5 and 1.0,

we estimated the a 20- and 30-year design traffic loading of approximately 1.58 and 3.17 millions repetitions of 18K ESAL, respectively. If the future traffic is projected to be significantly different from the above, we should be contacted. We will then revise our recommendations based on the actual anticipated traffic information.

Estimated Temporary Roadway Traffic During Construction: ATL understands that an asphaltic concrete temporary roadway will be constructed to convey the traffic during construction of the new PCC roadway. ATL estimated the traffic loading on the temporary roadway during construction period to be on the order of 360,000 repetitions of 18Kk ESAL.

5.3.2 Pavement Subgrade Preparation

The surface soils along project alignments consist mostly of fat and lean clays, with some areas with surface sands. These soils should provide an acceptable base for pavement construction when properly prepared as following:

- Remove existing pavements and structures per requirements of City of Houston Standard Specification Section 0222. Clear and grub existing vegetation and debris according to requirements of City of Houston Standard Specifications Section 02233. Excavate to grade and prepare and compact the pavement subgrade according to City of Houston Standard Specifications Section 02315 requirements. Proof roll the subgrade to detect any wet, soft, or pumping areas; remove and replace them with acceptable fill material. Compact the subgrade soils at a moisture content between 0 and +3 percent of optimum, to at least 95 and 90 percent of the maximum dry density at as determined by the Standard Proctor Compaction Test (ASTM D 698) for areas inside and outside the pavement and shoulder area, respectively.
- Good surface drainage should be provided away from the edges of paved areas to minimize lateral moisture transmission into the subgrade.

5.3.3 Pavement Subgrade Stabilization

Our field and laboratory exploration indicated that the subgrade soils below the existing pavement consisted of mostly of clay soils, with some areas where sandy soils were found at ground surface.

- For pavements to be constructed in areas with surface clay soils, scarify and stabilize the top 8 inches of the subgrade clay soils with lime, and compact the lime-stabilize soils at a moisture content between 0 and +3 percent of optimum, to at least 95 percent of the maximum dry density at as determined by the Standard Proctor Compaction Test (ASTM D 698). The lime stabilization should be in accordance with City of Houston Standard Specification, Section 02336. The lime-fly ash stabilization should be in accordance with City of Houston Standard Specification, Section 02337.
- For pavements to be constructed in areas with surface sands and silts and clays with PI less than 10, scarify the soilss to a depth of 8 inches and treat the soils with lime and fly ash, and compact the lime-fly ash stabilize soils at a moisture content between 0 and +3 percent of optimum, to at least 95 percent of the maximum dry density at as determined by the Standard Proctor Compaction Test (ASTM D 698). The lime-fly ash stabilization should be in accordance with City of Houston Standard Specification, Section 02337.
- Based on properties of the surface soils at borings drilled along the project alignments, ATL recommends the following pavement subgrade soil stabilization. Optimum amount of lime and lime-fly ash stabilization shall be determined by conducting laboratory testing. Note that the borings were drilled at spacing of 500 feet or more, thus the potential for variations in surface soil properties and soil stabilization exists.

Surface Soils PI Range	Boring Location	Recommended Subgrade Stabilization, % on Weight Basis
PI<10 and Soils Containing 50% or more Sand plus Gravel	B-7, B-18, B-19, B-21, B-22, B-23	3% lime and 7% fly ash
10≤PI≤20	B-1, B-2, B-8, B-9, B-14, B-17, B-24	5% lime
21<PI≤40	B-3, B-5, B-6, B-10, B-11, B-12, B-14, B-15, B-16, B-20	6% lime
PI>40	B-4, B-11, B-13,	7% lime

5.3.4 New PCC Pavement

The new PCC pavement for Brinkman Street was designed based on the AASHTO procedure, and assuming an 8-inch stabilized soil subbase as recommended. The following design parameters were used in the concrete pavement design for the proposed pavement.

Reliability, R : 95 %

Overall Standard Deviation, So : 0.35

Load Transfer Coefficient, J : 3.2

Drainage Coefficient, Cd : 1.2

Design Serviceability Loss, ΔPSI : 2.0

Loss of Support : 1.0

Traffic : (1) 1,261,937 18-k ESAL for a 20-year design life

(2) 2,535,587 18-k ESAL for a 30-year design life

Concrete Modulus of Rupture : 600 psi

Modulus of Elasticity of Concrete, Ec = 3.725 x 10^6 psi

Effective Modulus of Subgrade Reaction, k = 70 pci

Based on the above design parameters, the recommended concrete pavement section thickness are as follows:

Design Life = 20 Year

(Design Traffic Loading = 1.58 x 10^6 18-k ESAL)

8" Jointed Reinforced Concrete Pavement
8" Stabilized Subgrade

Design Life = 30 Year

(Design Traffic Loading = 3.17 x 10^6 18-k ESAL)

9" Jointed Reinforced Concrete Pavement
8" Stabilized Subgrade

If the projected traffic is going to be significantly different from that assumed, then we should be contacted for revised recommendation based on the actual traffic.

Design and construction of the concrete pavements, including reinforcement and jointing details, should meet the COHDPWE Standard Specifications Section 02751 and 02752, as well as the standard details drawings No. 02751-1 and 02752-1, as applicable.

5.3.5 Asphaltic Concrete Pavements

ATL understands that temporary Alba Street will be reconstructed with AC pavements, and the temporary roadway proposed to divert traffic during the new pavement construction will also be AC pavements. The flexible asphaltic concreter (AC) pavements is designed based on the AASHTO procedure. The following design parameters were used in the concrete pavement design for the proposed pavement.

Reliability:	95
Overall Standard Deviation:	0.45
Drainage Coefficient:	1.2
Design Serviceability Loss:	1.7
Design Traffic (18-kips ESAL):	1,261,937 18-k ESAL (20-year design life)
	2,535,587 18-k ESAL (30-year design life)
	360,000 repetitions (temporary road)
Effective Roadbed Soil Modulus	2,900 psi

New AC Road for Alba Street: Based on the above design parameters, the computed Structural Number (SN) required to sustain the design traffic loading for the new AC road for Alba Street is 5.5 and 5.86 for a design life of 20 and 30 years, and the recommended pavement section thickness for the two alternative base materials considered are as follow:

FOR 20-YEAR DESIGN LIFE

Pavement Section	SN Coefficient	Alternative Design No. 1	Alternative Design No. 2
AC Surface	0.44	2	2
AC Base (Black Base)	0.34	9	4
Cement Stabilized Crushed Stone Base Course	0.23	0	7
Stabilized Subgrade	0.11	8	8
Structural Number		5.78	5.68

FOR 30-YEAR DESIGN LIFE

Pavement Section	SN Coefficient	Alternative Design No. 1	Alternative Design No. 2
AC Surface	0.44	2	2
AC Base (Black Base)	0.34	10	4
Cement Stabilized Crushed Stone Base Course	0.23	0	8
Stabilized Subgrade	0.11	8	8
Structural Number		6.19	5.95

Temporary AC Road: Based on the above design parameters, the computed Structural Number (SN) required to sustain the design traffic loading for the temporary AC road is 4.45, and the recommended pavement section thickness for the two alternative base materials considered are as follow:

Pavement Section	SN Coefficient	Alternative Design No. 1	Alternative Design No. 2	Alternative Design No. 3
AC Surface	0.44	1.5	1.5	1.5
AC Base (Black Base)	0.34	7	0	0
Cement Stabilized Crushed Stone Base Course	0.23	0	10	0
Flexible Base Course for Temporary Driveways	0.14	0	0	16
Stabilized Subgrade	0.11	8	8	8
Structural Number		4.70	4.61	4.54

Subgrade preparation and stabilization, design and construction of the asphaltic concrete pavements should meet the COHDPWE Standard Specifications Section 02741, as well as the standard details drawings No. 02751-1 and 02752-1, as applicable. Cement treated base shall meet criteria of Cement Stabilized Base Course (COHDPWE Standard Specifications Section 02712). Flexible base course for temporary driveways shall be in accordance with COHDPWE Standard Specifications Section 02714.

6.0 CONSTRUCTION CONSIDERATION

The proposed storm and sanitary sewer line installation will involve mostly trenchless construction techniques and some open cut/trenching construction. Accordingly, the storm and sanitary sewer line installation excavations will be installed mostly in both clays and sands (see Table D and Boring Log Profiles for potential locations).

Excavation face in granular soils (sand/silt/gravel) and other soils with slight cohesion, if encountered, will likely to experience some degree of instability if the excavation face is unsupported, especially when these soils are saturated and/or subject to seepage pressure. In such cases, mitigating measures as discussed in Section 5.1.7 of this report can be employed to improve the excavation stability.

Based on the proposed invert elevation and the groundwater information gathered during our field investigation, the proposed storm and sanitary sewer line construction excavations will likely to encounter groundwater when the excavation depth approaches or exceeds about 10 feet. However, it should be noted that groundwater level will fluctuate with the amount of precipitation and the amount of precipitations prior to and during construction. For storm and sanitary sewer line installation excavation advanced in clay soils, the seepage rates are usually low, and groundwater control can usually be controlled by sump and pumping. However, for excavations advanced in water-bearing sands/silts stratum (not encountered in our soil borings, but may be present away from

our soil borings and/or after heavy rainfalls), where water inflow rate is high, dewatering using well points will be required to provide a dry working platform and to prevent soil boiling.

It is the responsibility of the Contractor to select a trenchless technique for the installation of the proposed storm and sanitary sewer line by taking into account the soil types and stratigraphy and the groundwater conditions as found in the soil borings; the Contractor should have a work crew experienced at working with the selected trenchless construction technique in subsurface conditions similar to those found in along the project alignments. If necessary, the Contractor may conduct additional geotechnical investigation to provide more detailed subsurface conditions.

6.1 Quality Control

Associated Testing Laboratories, Inc. (ATL) recommends implementation of a comprehensive quality control program under the supervision of a Professional Engineer due to the fact that a considerable amount of excavation and back filling may be required in the proposed project area. Structural integrity and stability is particularly dependent on quality foundation installation, bedding and subgrade preparations. An independent testing laboratory should be assigned to test and inspect construction materials during the construction phase.

To ensure that excavation will remain stable, to provide sufficient headroom for working, to provide worker's safety and to protect adjacent structures, the excavations will have to be provided with sufficient side slopes or shored in accordance with OSHA "Trench Safety Systems" (29 CFR Part 1926), as published in the Federal Register, Vol. 52, No.72, Section 1926-650 through 1926-653. Excavation of the trenches and access pits should be carried out under the supervision of an experienced construction supervisor and necessary shoring and/or bracing of the trenches should be properly installed. In temporary braced or shored excavations and in access pits where the sheeting terminates at the base of the trench, lateral earth pressure, surcharge, and seepage pressure caused by a differential hydrostatic head moving upward to the bottom of the trench can cause trench bottom

instability. Therefore, it is recommended that, if the bottom stability evaluation yields a factor of safety less than 1.5, the sheeting should be extended below the base of cut. Before filling operations take place, representative samples of the proposed fill material should be tested by an independent laboratory to determine the compaction and classification characteristics.

6.2 Monitoring

Despite the thoroughness of this geotechnical exploration, there is always the possibility that actual subsurface conditions may differ from the predicted conditions because conditions between soil borings can be different from those at specific boring locations.

Any excessive ground movements like settlement and lateral movement should be monitored and controlled. This can be done by performing a preconstruction survey including photography and documentation of existing conditions like elevations, cracks, etc., and by installing ground movement monitoring devices such as inclinometers, crack monitors, and establishing elevation monitor stations along the storm and sanitary sewerline alignment to monitor the ground movement after commencement of the excavation.

Associated Testing Laboratory, Inc. (ATL) recommends a regular inspection and overall project monitoring by a geotechnical engineer during the construction phase. The purpose of inspection is to provide sound engineering and judgement alternatives during construction, if unanticipated conditions occur.

7.0 LIMITATIONS

The information, findings and recommendations contained in this report are based on data obtained from test borings at the locations shown in Figures 2a through 2d, a reasonable volume of laboratory tests, and professional interpretation and evaluation of the field and laboratory data, and consideration of the project information furnished. Should it become apparent during construction that soil conditions differ significantly from those discussed in this report, this office should be notified immediately so that further evaluation and any necessary adjustments can be made.

8.0 ***REFERENCES***

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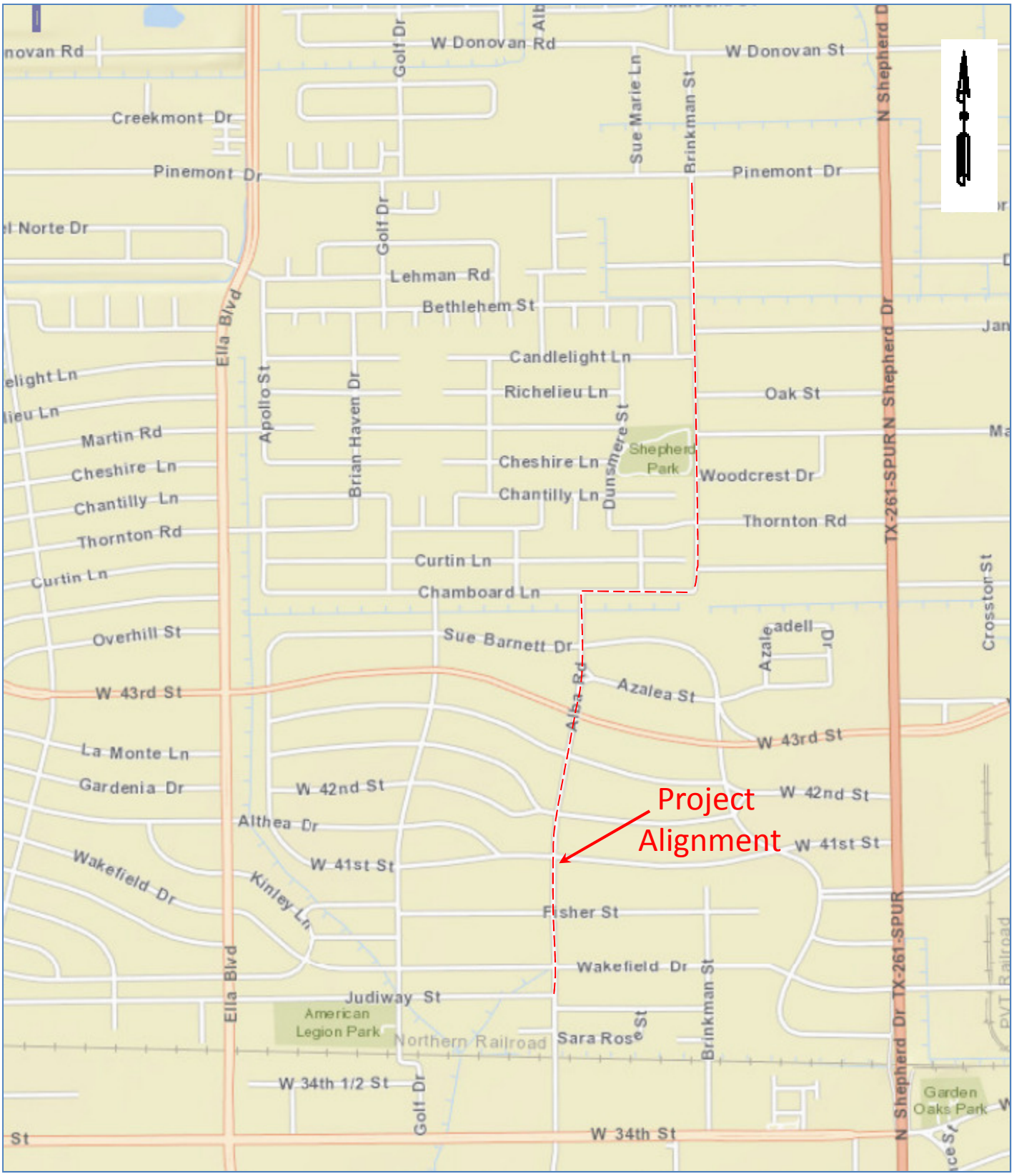
12. Groundwater Quality in Texas; Texas Natural Resources Conservation Commission.
13. CFR PART 1926.

LIST OF FIGURES

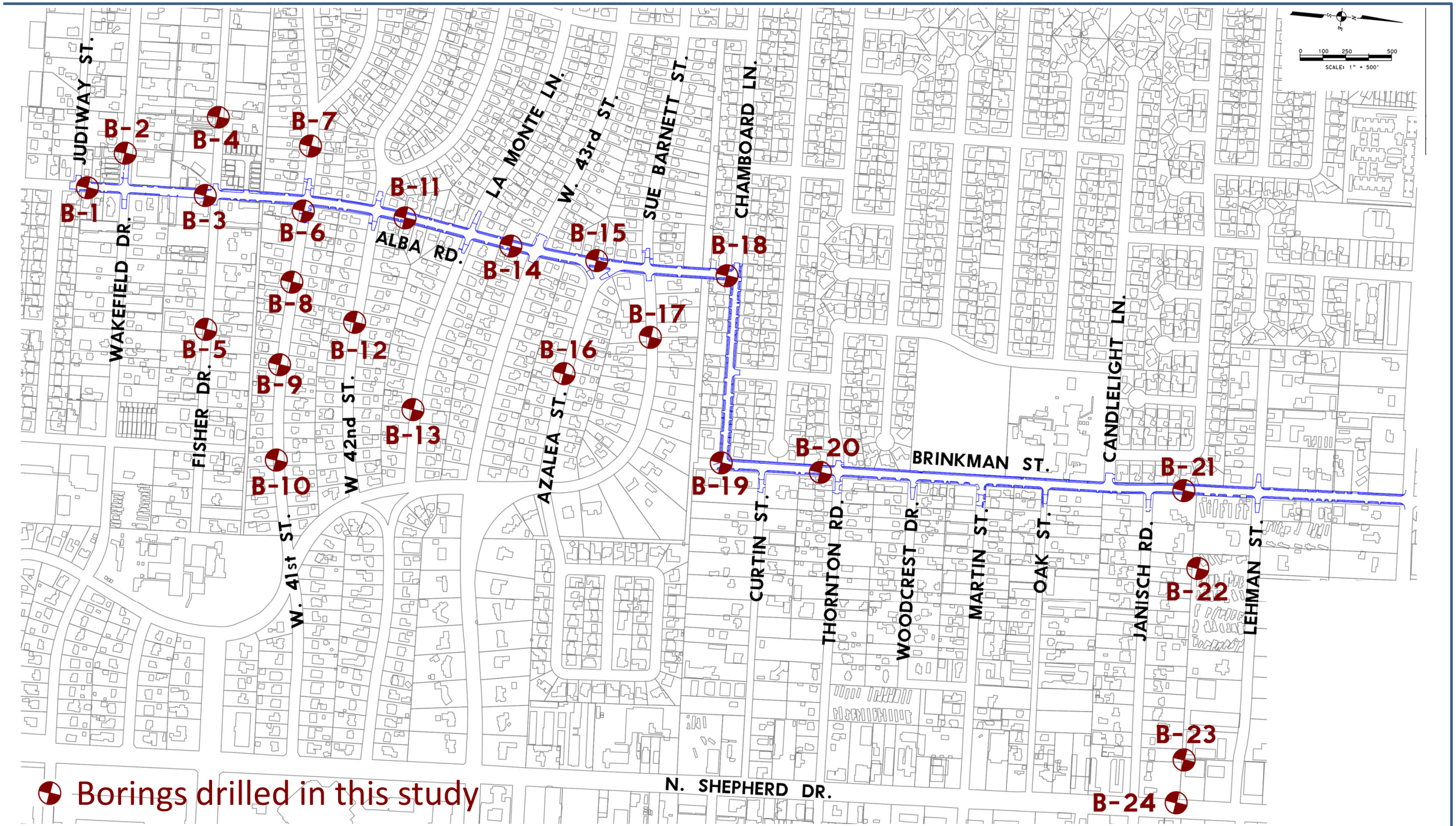
FIGURE 1	SITE VICINITY MAP
FIGURES 2a to 2d	LOCATION OF BORINGS
FIGURE 3a	PRINCIPAL ACTIVE FAULTS IN HOUSTON AREA
FIGURE 3b	ACTIVE SURFACE FAULTS ON LIDAR IMAGERY
FIGURES 4a to k	BORING LOG PROFILE
FIGURES 5a to 5c	TRENCH SUPPORT EARTH PRESSURE DIAGRAMS
FIGURE 6	HIGHWAY LOADING ON A PIPE UNDER VARIOUS SOIL COVER
FIGURE 7	BOUSSINESQ'S EQUATION FOR POINT LOAD SURCHARGE
FIGURE 8	THRUST FORCE AT A PIPE BEND
FIGURE 9	BUOYANT UPLIFT RESISTANCE OF A BURIED STRUCTURE
FIGURES 10a & 10b	PROPOSED CROSS-SECTION OF DITCH PROTECTED BY ACB



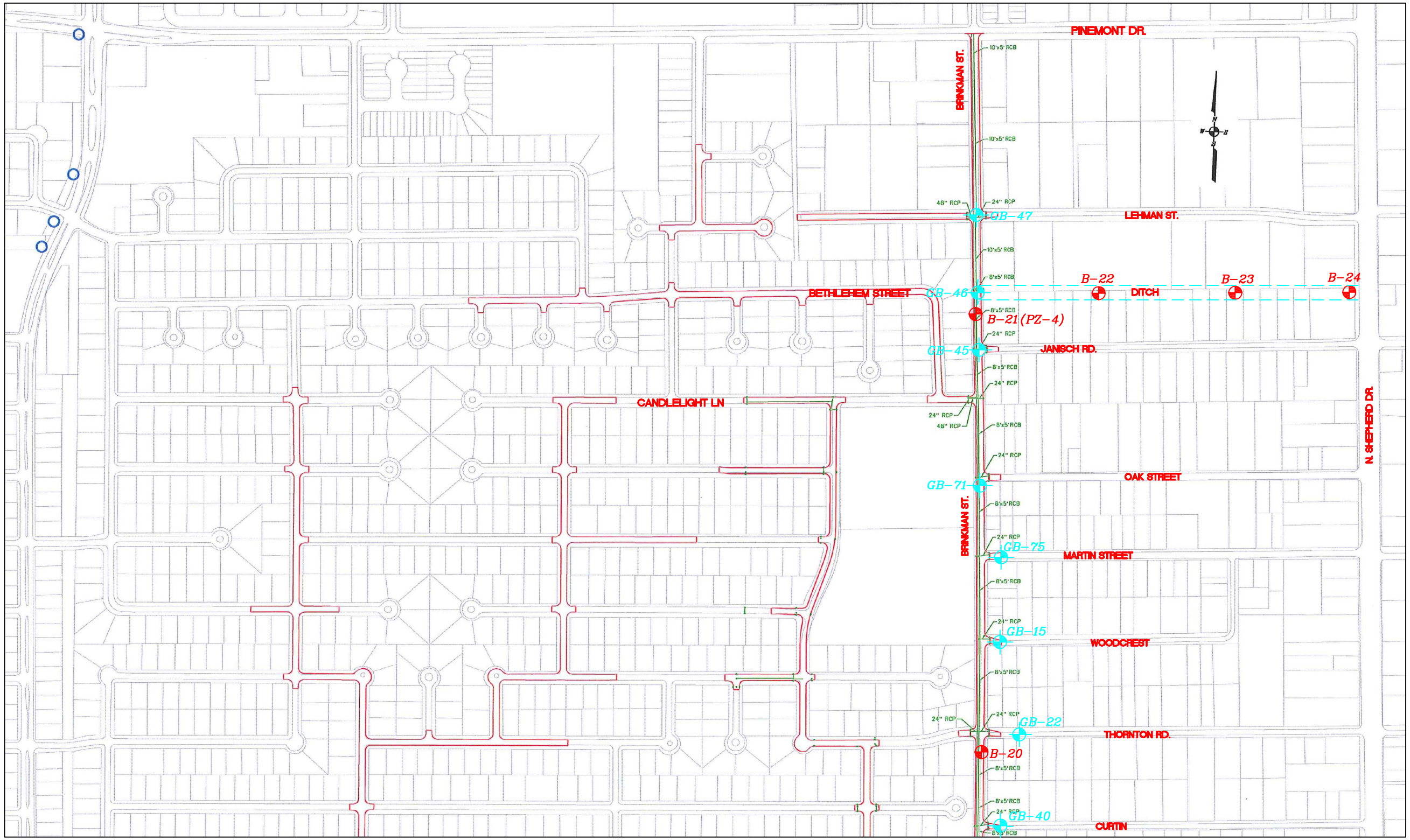
Note: Base map is from COH GIMS

SITE VICINITY MAP	ASSOICATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4
	PROJECT NO. : G13-211 / FIGURE 1

PST 8/28/12



LOCATION OF BORINGS	ASSOICATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS No. M-000285-0001-4
	PROJECT NO. : G13-211 / FIGURE 2a



BORINGS PREVIOUSLY DRILLED

PROPOSED BORINGS

0 450'

1"=450'

LOCATION OF BORINGS

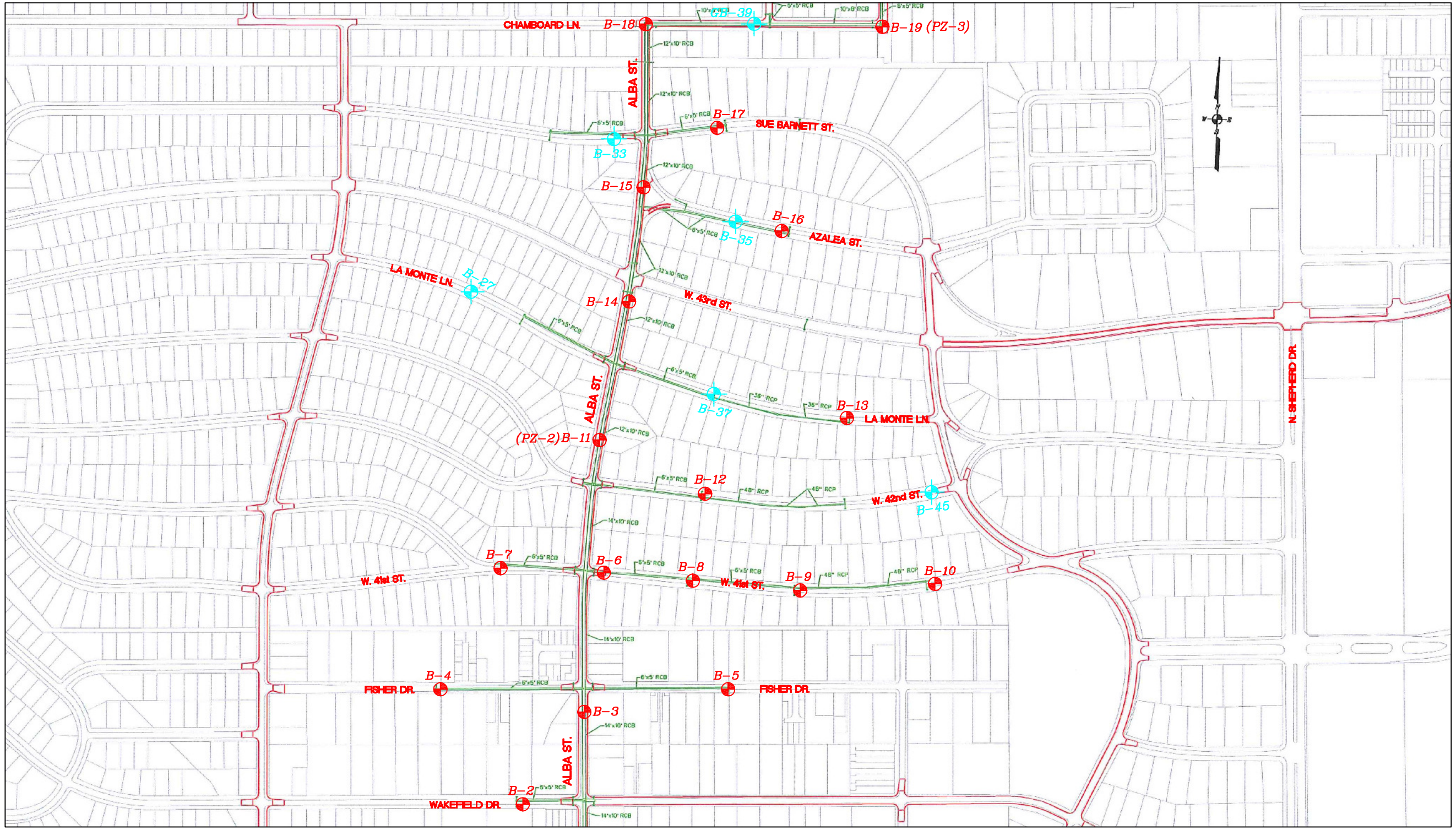
GARDEN OAKS & SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd. Houston, Texas
Tel: (713) 748-3717 Fax: (713) 748-3748

WBS No.: M-000285-0001-4

PROJECT NO.; G13-211

FIGURE. 2d



BORINGS PREVIOUSLY DRILLED

PROPOSED BORINGS

0 450'

1"=450'

LOCATION OF BORINGS

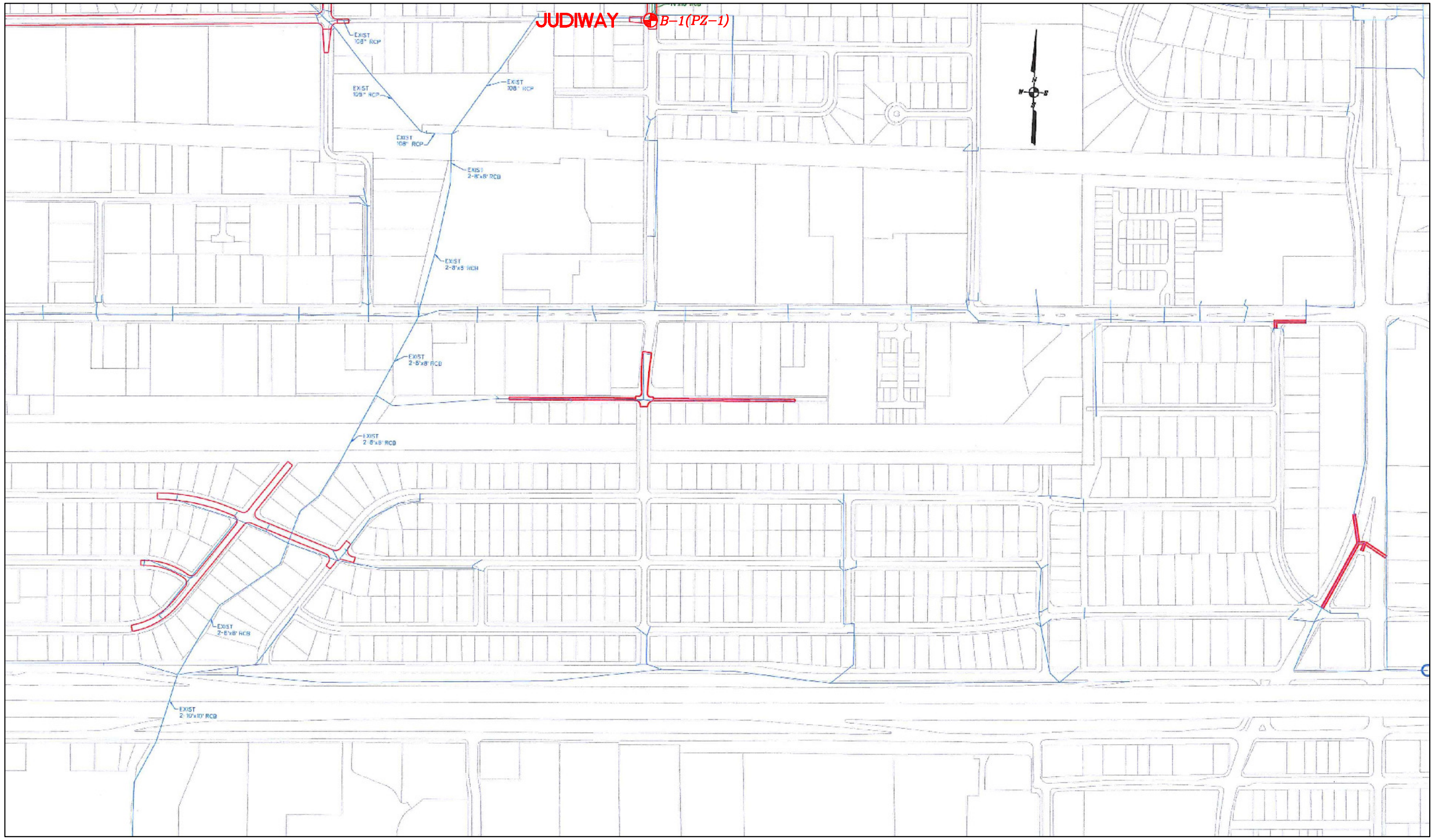
GARDEN OAKS & SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd. Houston, Texas
Tel: (713) 748-3717 Fax: (713) 748-3748

WBS No.: M-000285-0001-4

PROJECT NO.; G13-211

FIGURE. 2c



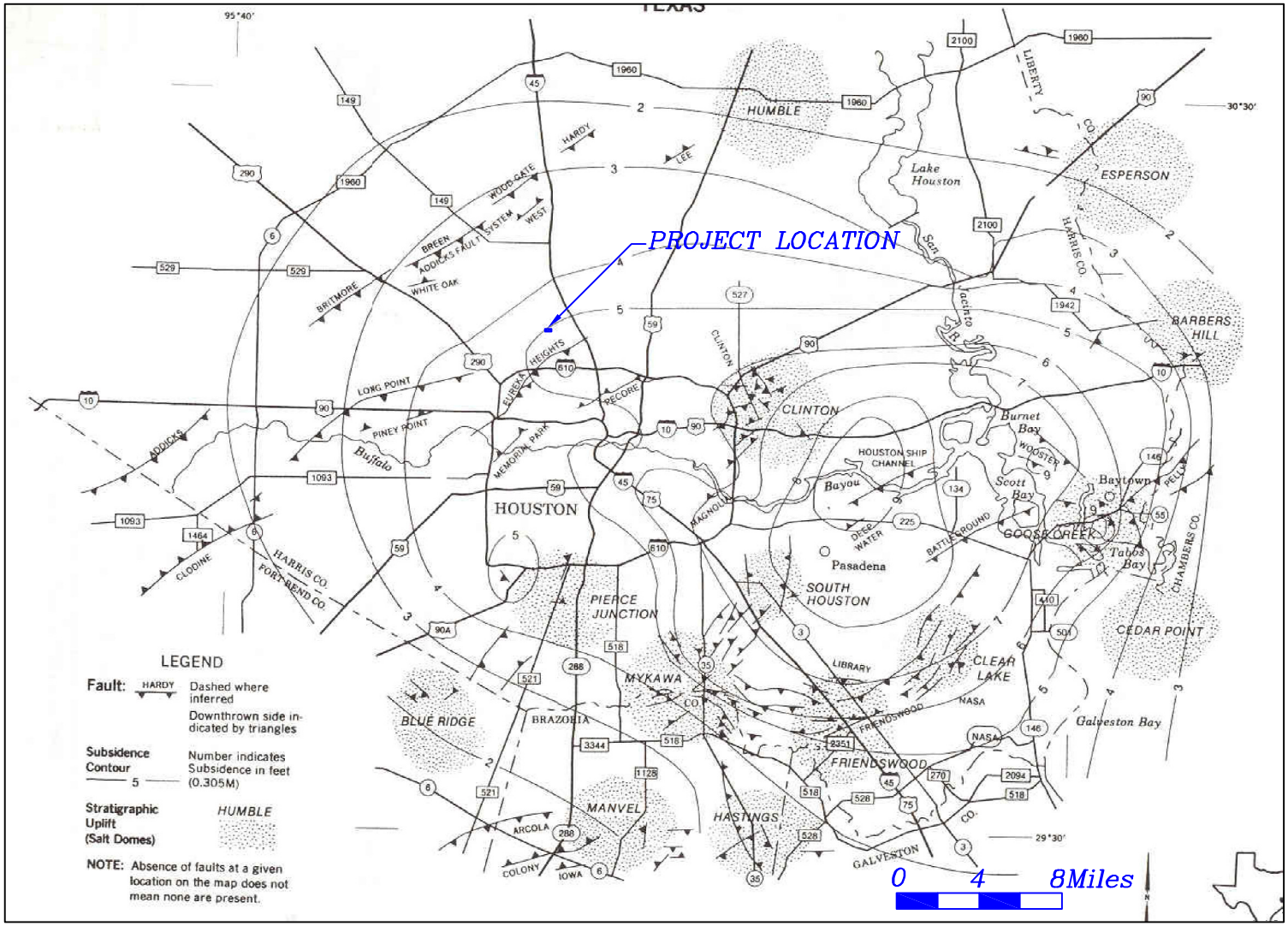
BORINGS PREVIOUSLY DRILLED

PROPOSED BORINGS

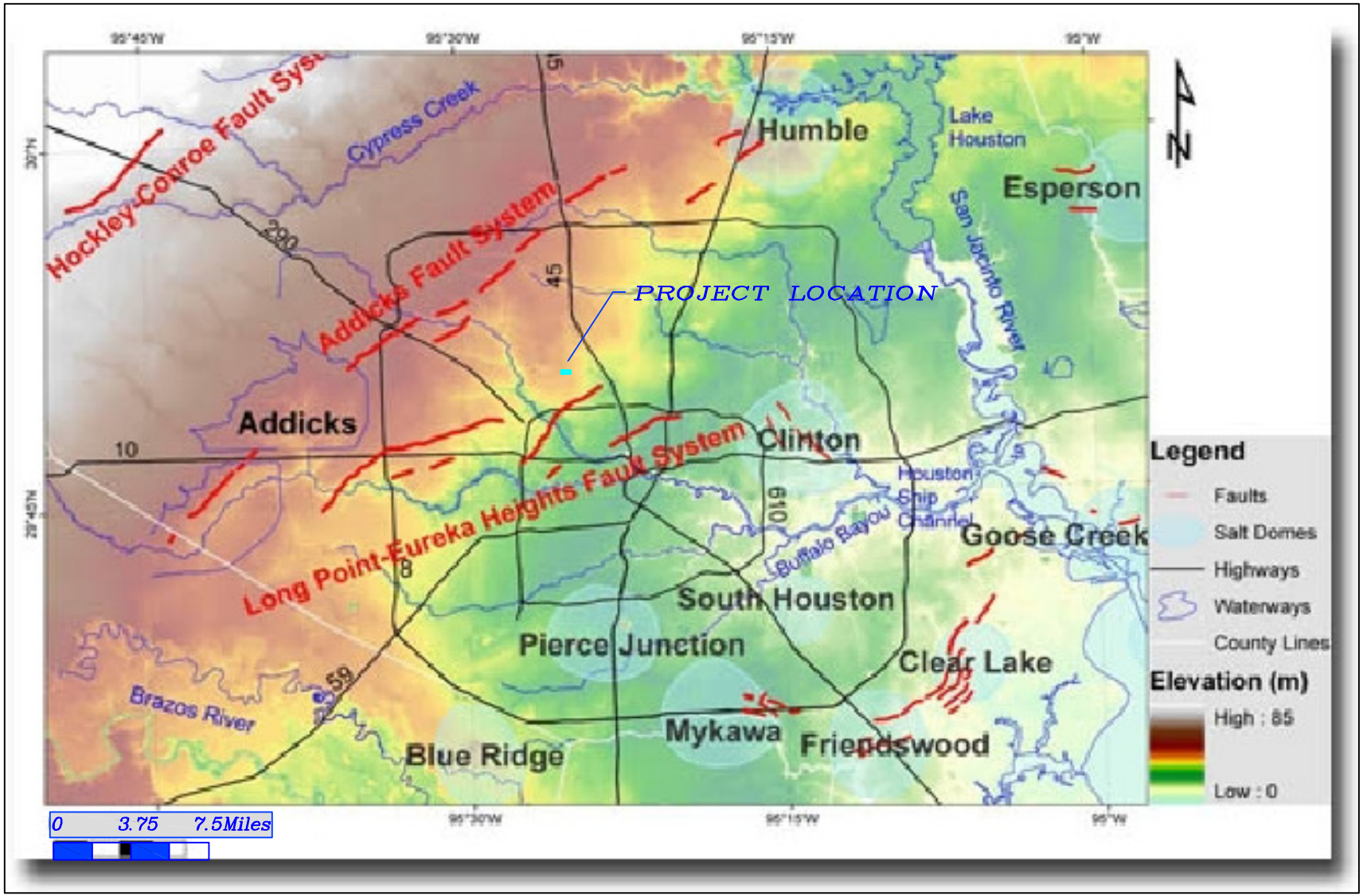
0 450'

1"=450'

LOCATION OF BORINGS	Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd. Houston, Texas Tel: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS & SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS No.: M-000285-0001-4
	PROJECT NO.; G13-211 — FIGURE. 2b



PRINCIPAL ACTIVE FAULTS IN HOUSTON AREA	Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd. Houston, Texas Tel: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS No.: M-000285-0001-4
	PROJECT NO. G13-211 FIGURE. 3a



ACTIVE SURFACE FAULTS ON LIDAR IMAGERY	Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd. Houston, Texas Tel: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS No.: M-000285-0001-4
	PROJECT NO. G13-211 — FIGURE. 3b

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO.: G13-211**

WBS No. M-000285-0001-4

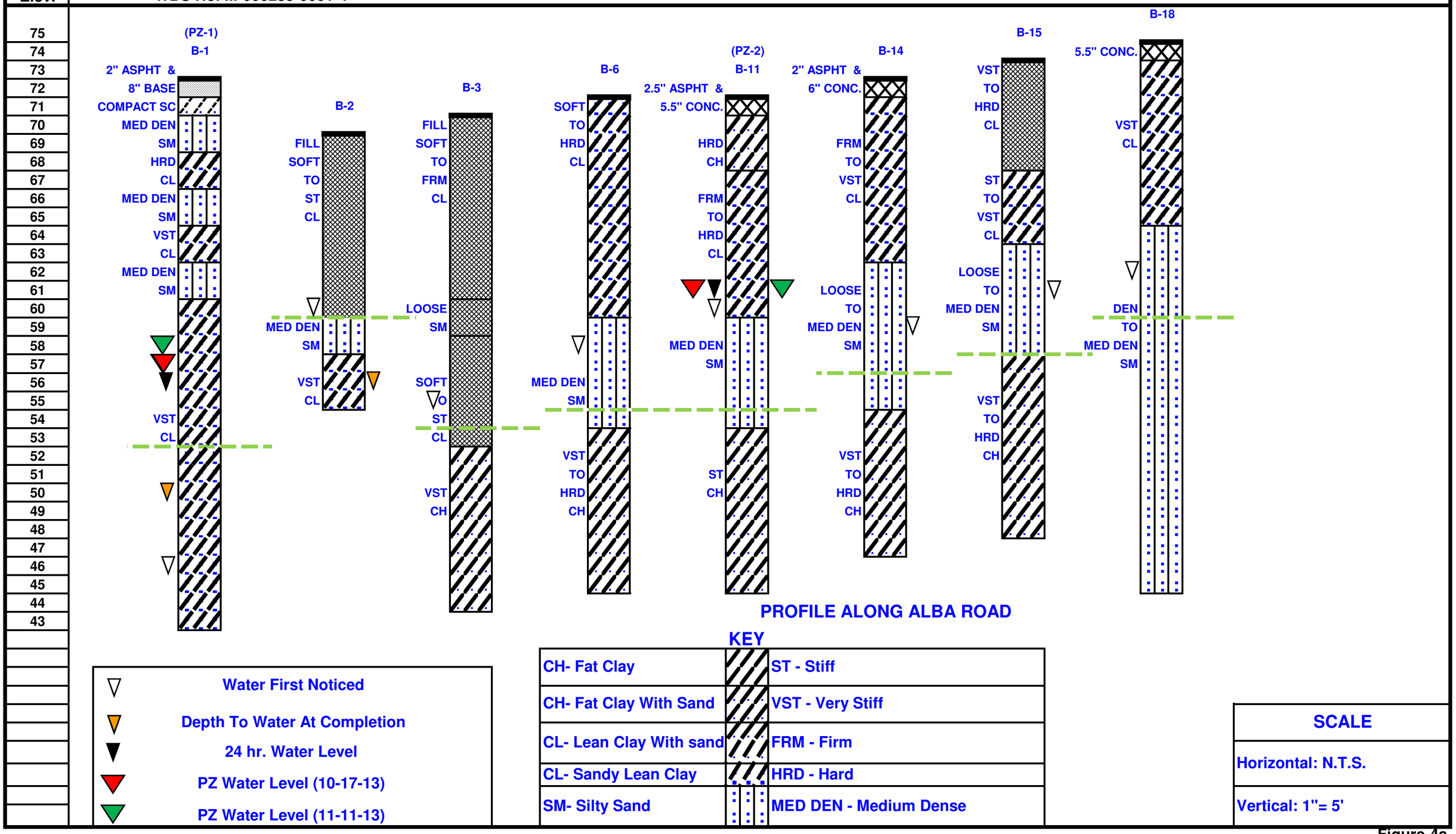
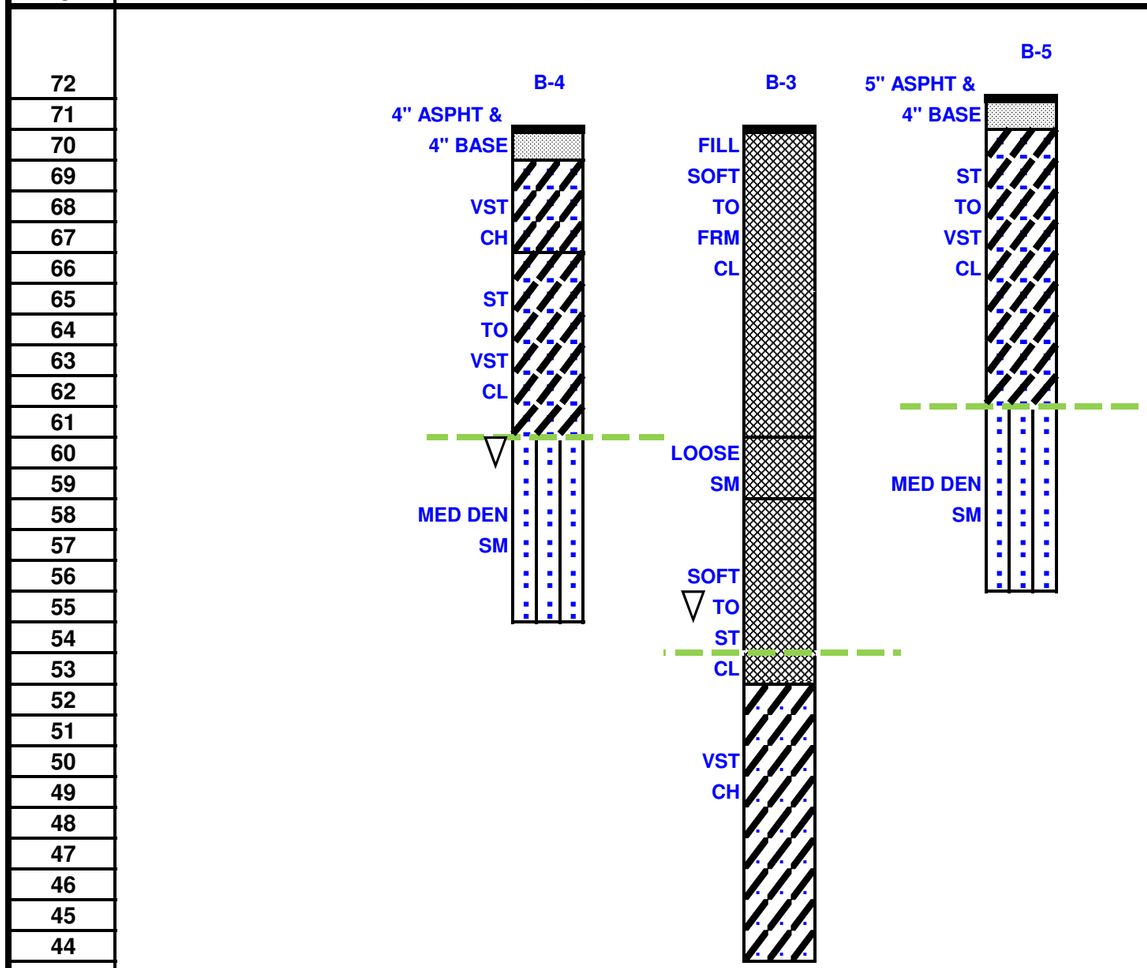


Figure-4a

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO. G13-211**

WBS No. M-000285-0001-4



PROFILE ALONG FISHER DRIVE

Water First Noticed

Depth To Water At Completion

KEY

CH- Fat Clay		ST - Stiff
CH- Fat Clay With Sand		VST - Very Stiff
CL- Lean Clay With sand		FRM - Firm
CL- Sandy Lean Clay		HRD - Hard
SM- Silty Sand		MED DEN - Medium Dense

SCALE

Horizontal: N.T.S.

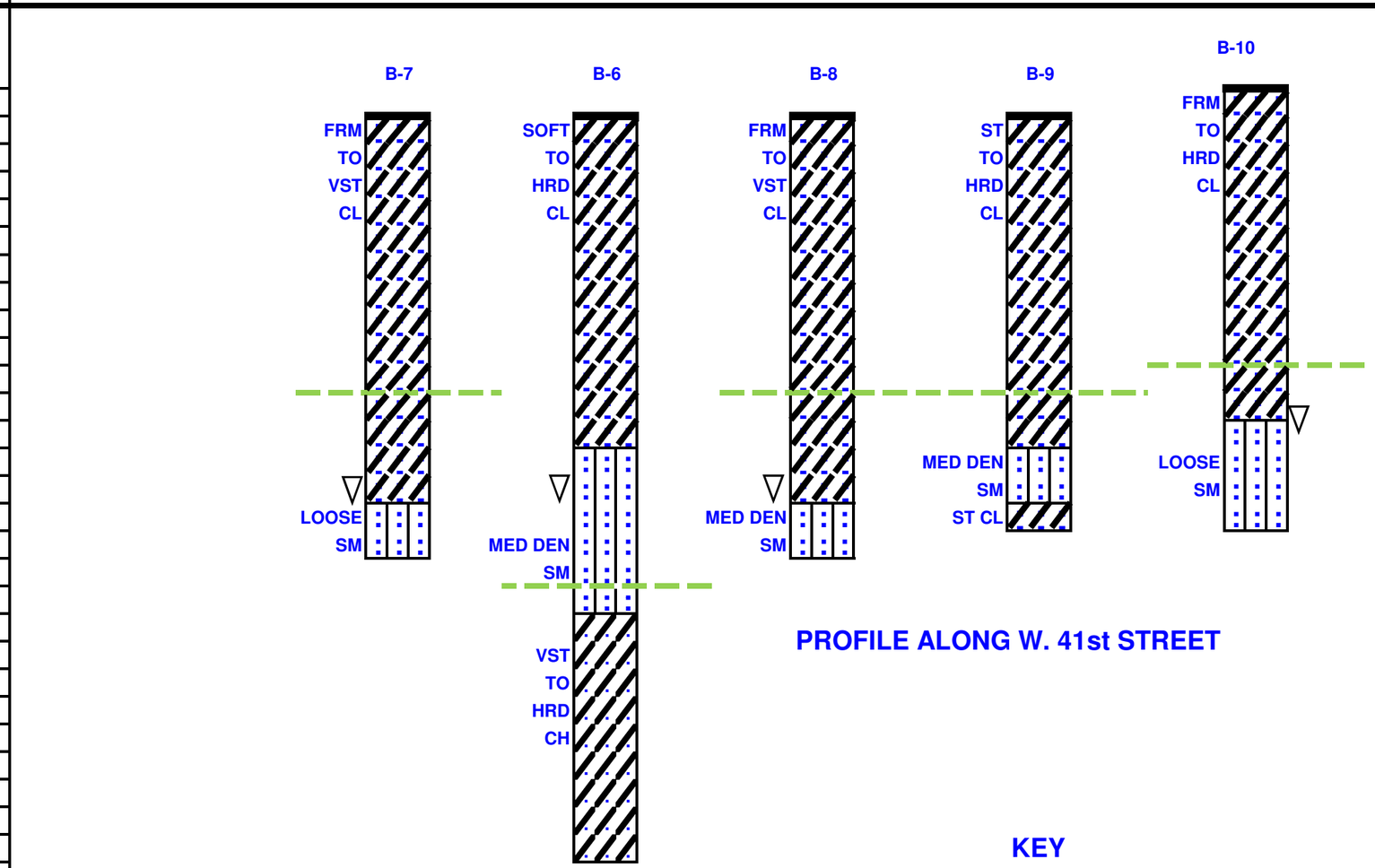
Vertical: 1"= 5'

Figure-4b

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING | PROJECT NO. G13-211

Elev. | WBS No. M-000285-0001-4



PROFILE ALONG W. 41st STREET

Water First Noticed

Depth To Water At Completion

KEY

CH- Fat Clay	ST - Stiff
CH- Fat Clay With Sand	VST - Very Stiff
CL- Lean Clay With sand	FRM - Firm
CL- Sandy Lean Clay	HRD - Hard
SM- Silty Sand	MED DEN - Medium Dense

SCALE

Horizontal: N.T.S.

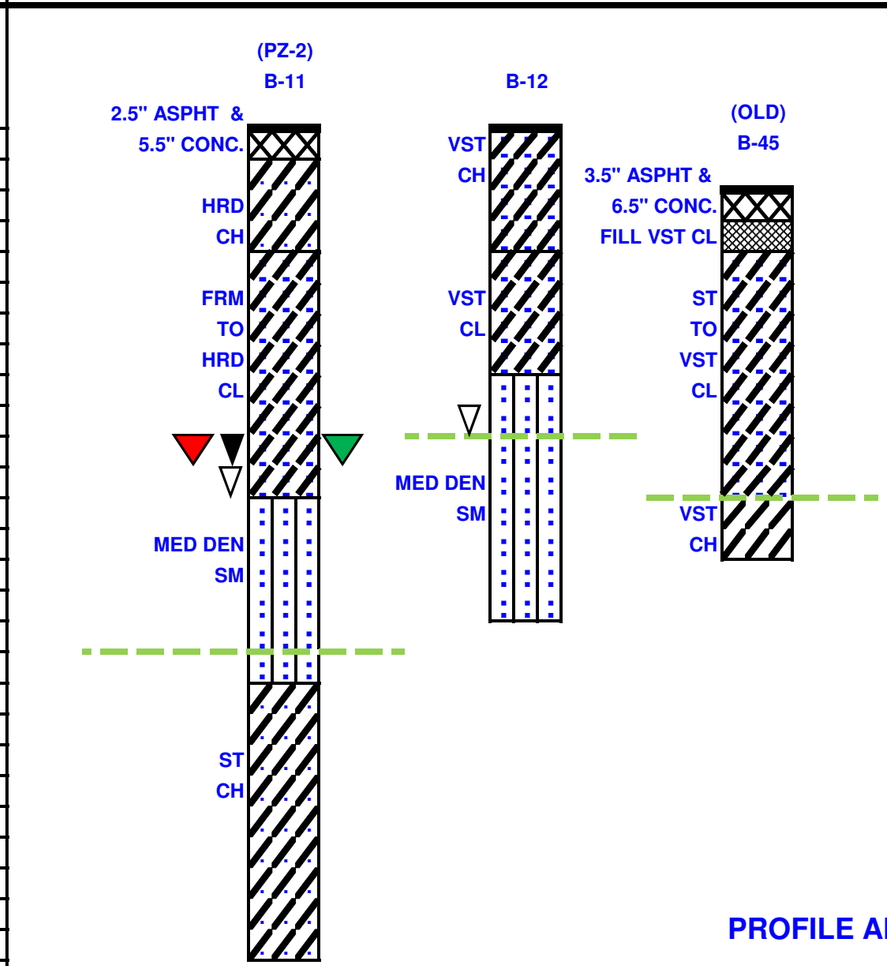
Vertical: 1"= 5'

Figure-4c

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO. G13-211**

WBS No. M-000285-0001-4



PROFILE ALONG 42nd STREET

KEY

CH- Fat Clay	ST - Stiff
CH- Fat Clay With Sand	VST - Very Stiff
CL- Lean Clay With sand	FRM - Firm
CL- Sandy Lean Clay	HRD - Hard
SM- Silty Sand	MED DEN - Medium Dense

- Water First Noticed
- Depth To Water At Completion
- 24 hr. Water Level
- PZ Water Level (After 7 days)
- PZ Water Level (After 30 days)

SCALE

Horizontal: N.T.S.

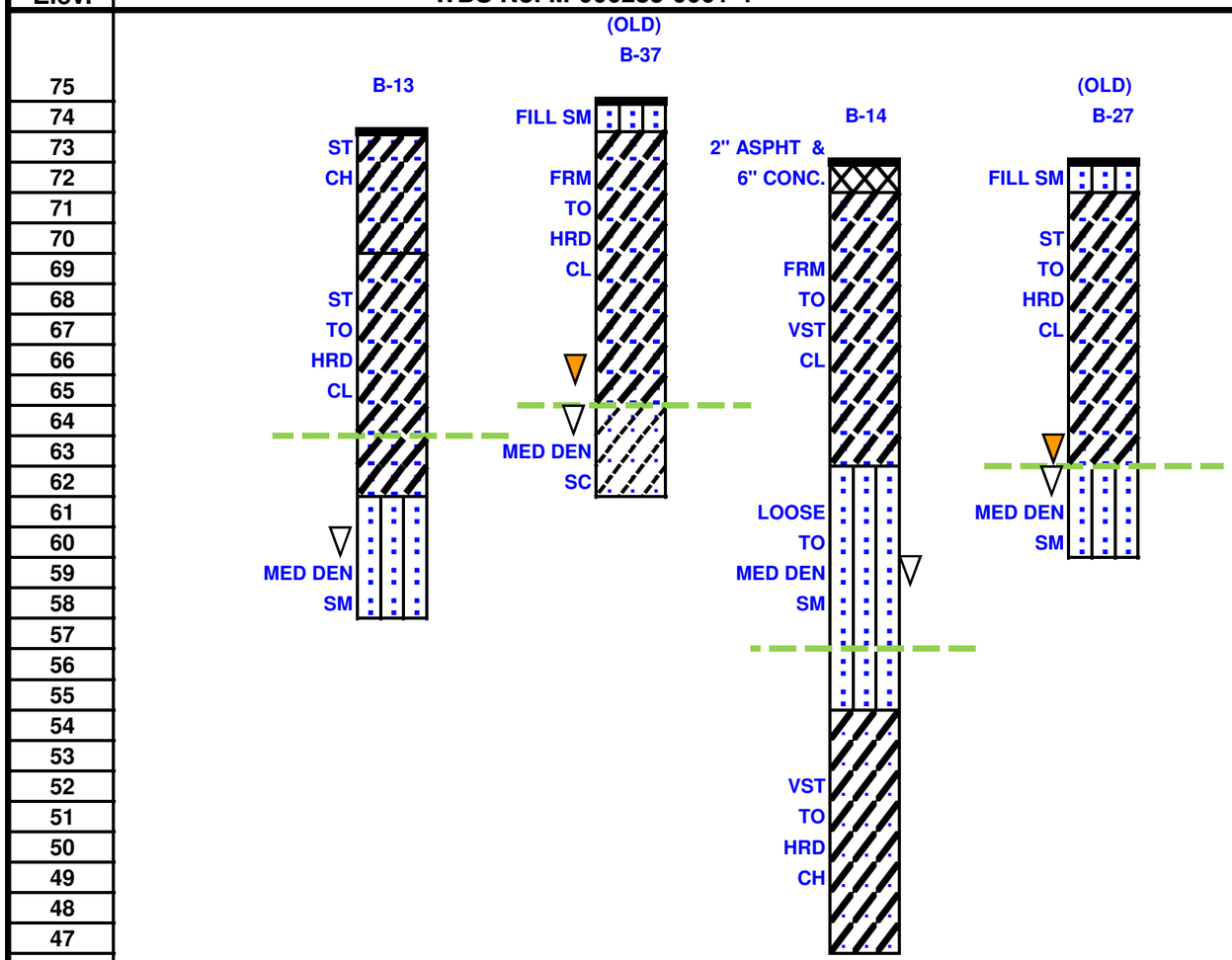
Vertical: 1"= 5'

Figure-4d

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO. G13-211**

WBS No. M-000285-0001-4



PROFILE ALONG LA MONTE LANE

▽	Water First Noticed
▼	Depth To Water At Completion

KEY

CH- Fat Clay		ST - Stiff
CH- Fat Clay With Sand		VST - Very Stiff
CL- Lean Clay With sand		FRM - Firm
CL- Sandy Lean Clay		HRD - Hard
SM- Silty Sand		MED DEN - Medium Dense

SCALE

Horizontal: N.T.S.

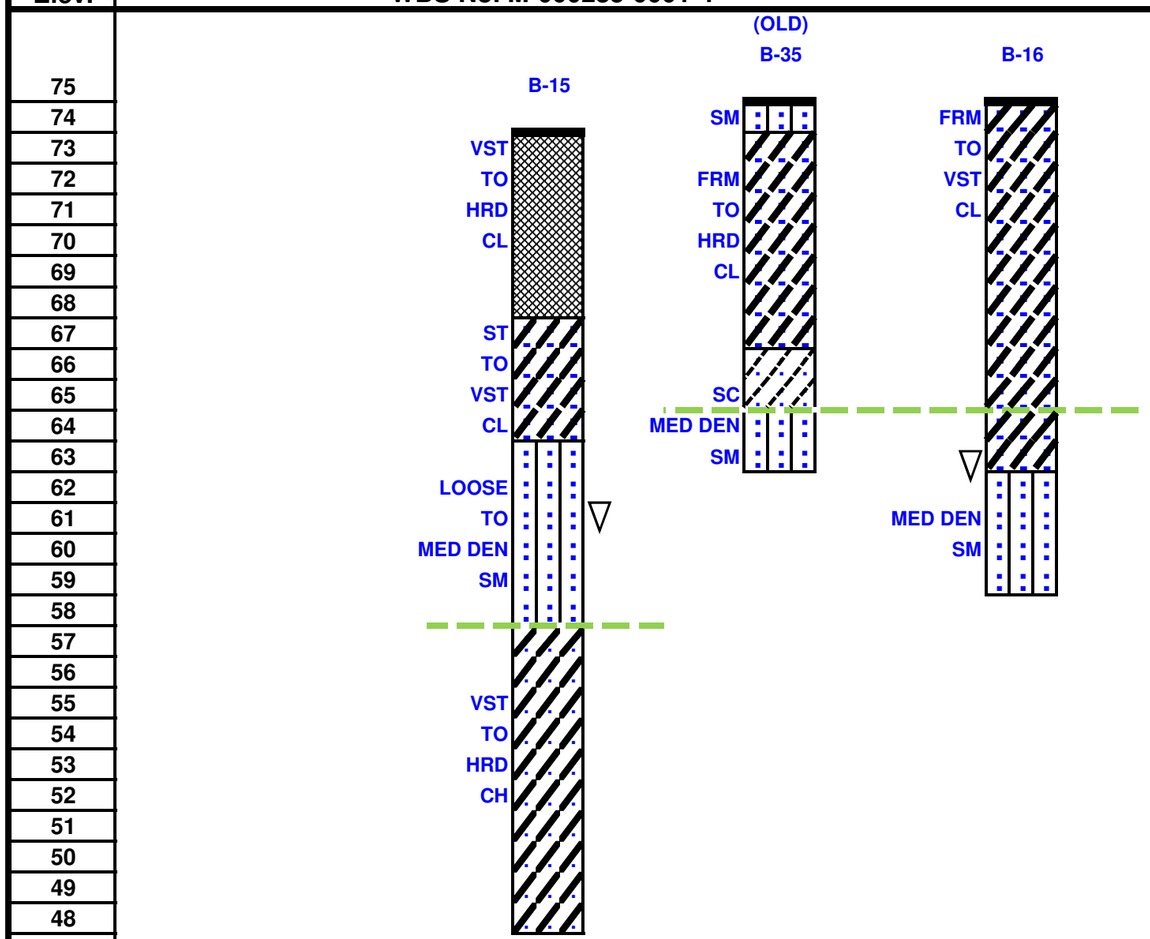
Vertical: 1"= 5'

Figure-4e

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO. G13-211**

WBS No. M-000285-0001-4



PROFILE ALONG AZALEA STREET

Water First Noticed

Depth To Water At Completion

KEY

CH- Fat Clay		ST - Stiff
CH- Fat Clay With S		VST - Very Stiff
CL- Lean Clay With		FRM - Firm
CL- Sandy Lean Cl		HRD - Hard
SM- Silty Sand		MED DEN - Medium Dense

SCALE

Horizontal: N.T.S.

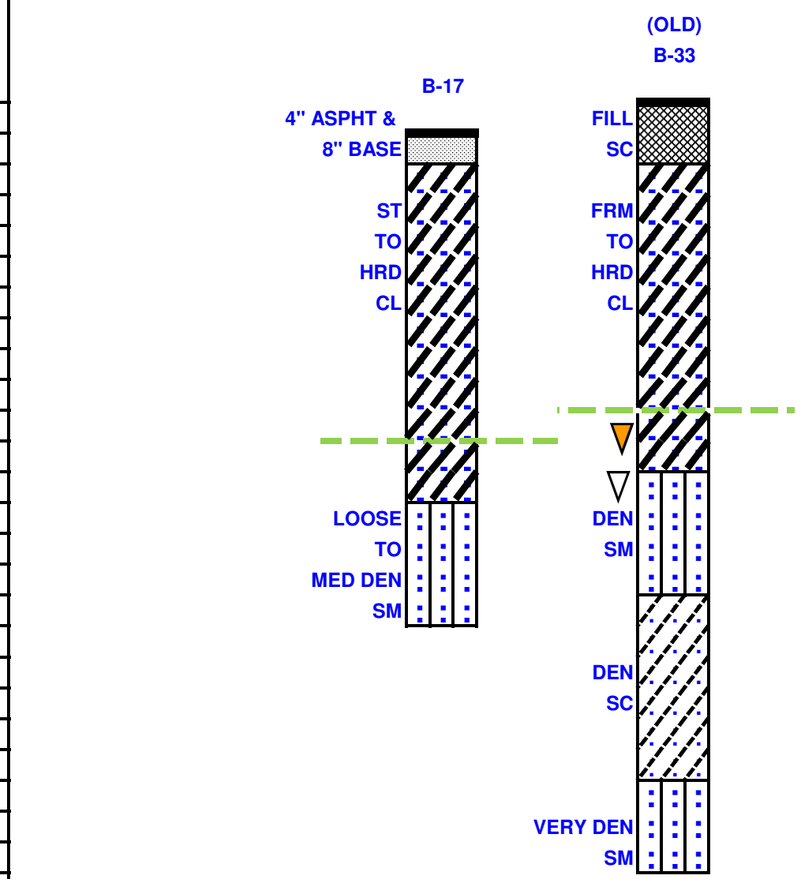
Vertical: 1"= 5'

Figure-4f

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO. G13-211**

WBS No. M-000285-0001-4



PROFILE ALONG SUE BARNETT STREET

KEY

CH- Fat Clay	ST - Stiff
CH- Fat Clay With Sand	VST - Very Stiff
CL- Lean Clay With sand	FRM - Firm
CL- Sandy Lean Clay	HRD - Hard
SM- Silty Sand	MED DEN - Medium Dense

▽ Water First Noticed

▼ Depth To Water At Completion

SCALE

Horizontal: N.T.S.

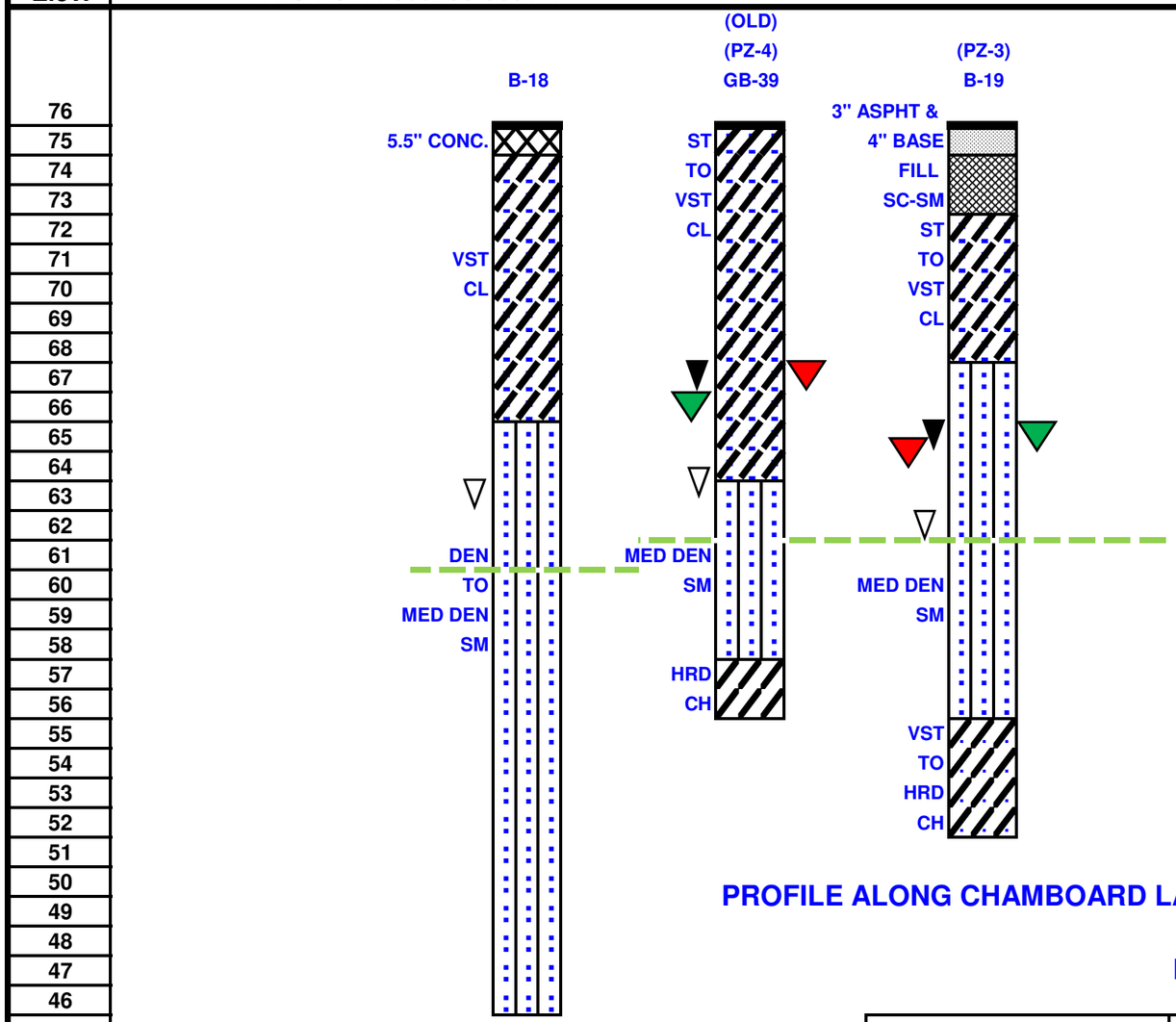
Vertical: 1"= 5'

Figure-4g

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING — **PROJECT NO. G13-211**

WBS No. M-000285-0001-4



NOTE: GB-39 (PZ-4) HAS NO ELEVATION.

PROFILE ALONG CHAMBOARD LANE

- Water First Noticed
- Depth To Water At Completion
- 24 hr. Water Level
- PZ Water Level (After 7 days)
- PZ Water Level (After 30 days)

KEY

CH- Fat Clay	ST - Stiff
CH- Fat Clay With Sand	VST - Very Stiff
CL- Lean Clay With sand	FRM - Firm
CL- Sandy Lean Clay	HRD - Hard
SM- Silty Sand	MED DEN - Medium Dense

SCALE

Horizontal: N.T.S.

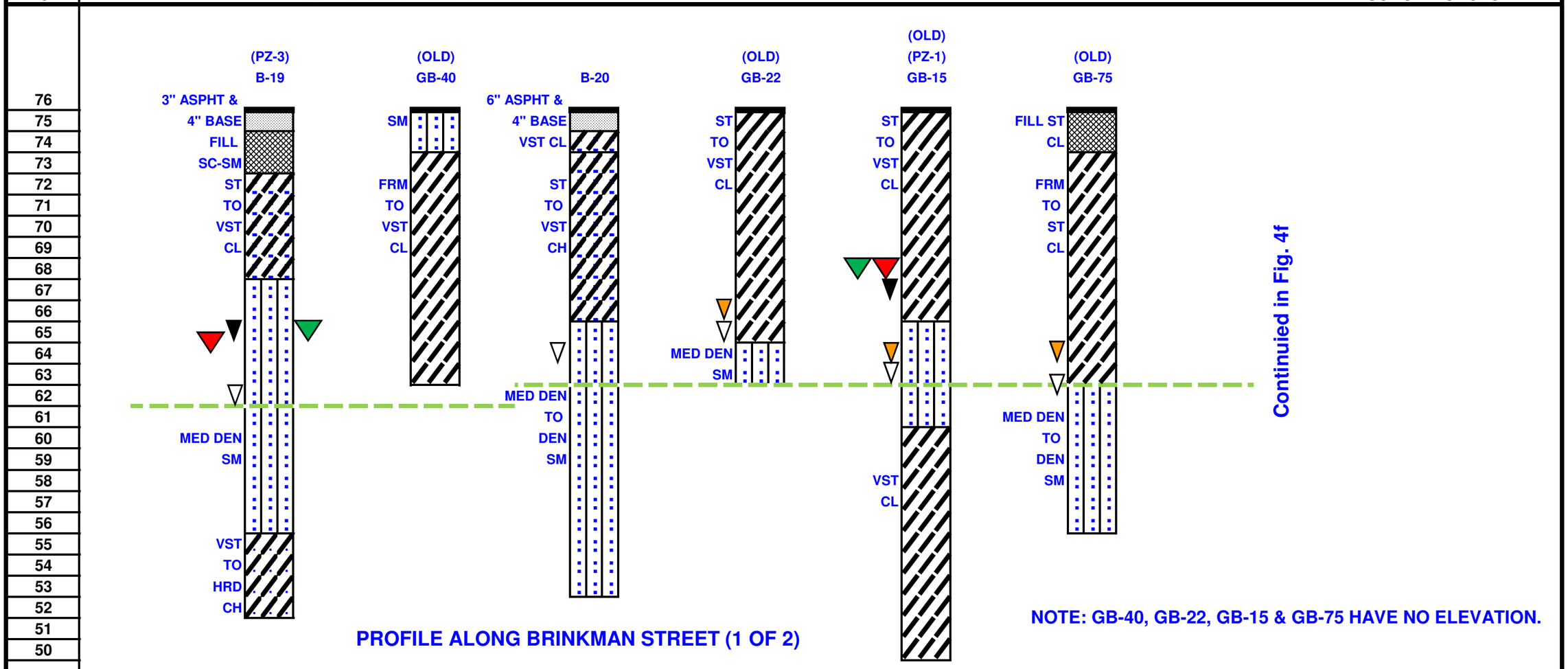
Vertical: 1"= 5'

Figure-4h

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

WBS No. M-000285-0001-4 | **PROJECT NO. G13-211**



PROFILE ALONG BRINKMAN STREET (1 OF 2)

NOTE: GB-40, GB-22, GB-15 & GB-75 HAVE NO ELEVATION.

▽	Water First Noticed
▼	Depth To Water At Completion
▼	24 hr. Water Level
▼	PZ Water Level (After 7 days)
▼	PZ Water Level (After 30 days)

KEY

CH- Fat Clay			ST - Stiff
CH- Fat Clay With Sand			VST - Very Stiff
CL- Lean Clay With sand			FRM - Firm
CL- Sandy Lean Clay			HRD - Hard
SM- Silty Sand			MED DEN - Medium Dense

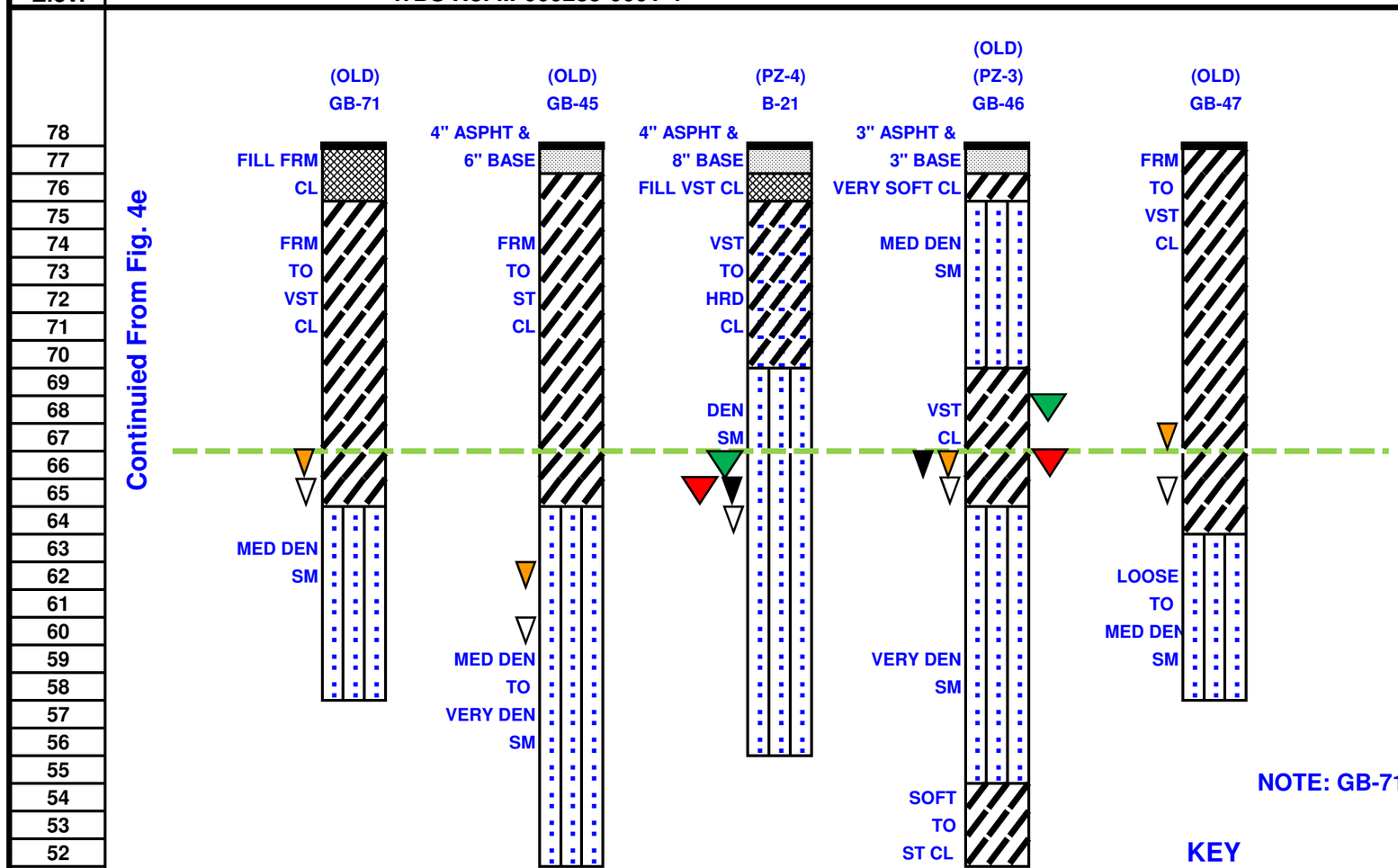
SCALE
Horizontal: N.T.S.
Vertical: 1"= 5'

Figure-4i

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

WBS No. M-000285-0001-4 | PROJECT NO. G13-211



NOTE: GB-71, GB-45, GB-46 & GB-47 HAVE NO ELEVATION.

PROFILE ALONG BRINKMAN STREET (2 OF 2)

▽	Water First Noticed
▼	Depth To Water At Completion
▼	24 hr. Water Level
▼	PZ Water Level (After 7 days)
▼	PZ Water Level (After 30 days)

KEY

CH- Fat Clay	ST - Stiff
CH- Fat Clay With Sand	VST - Very Stiff
CL- Lean Clay With sand	FRM - Firm
CL- Sandy Lean Clay	HRD - Hard
SM- Silty Sand	MED DEN - Medium Dense

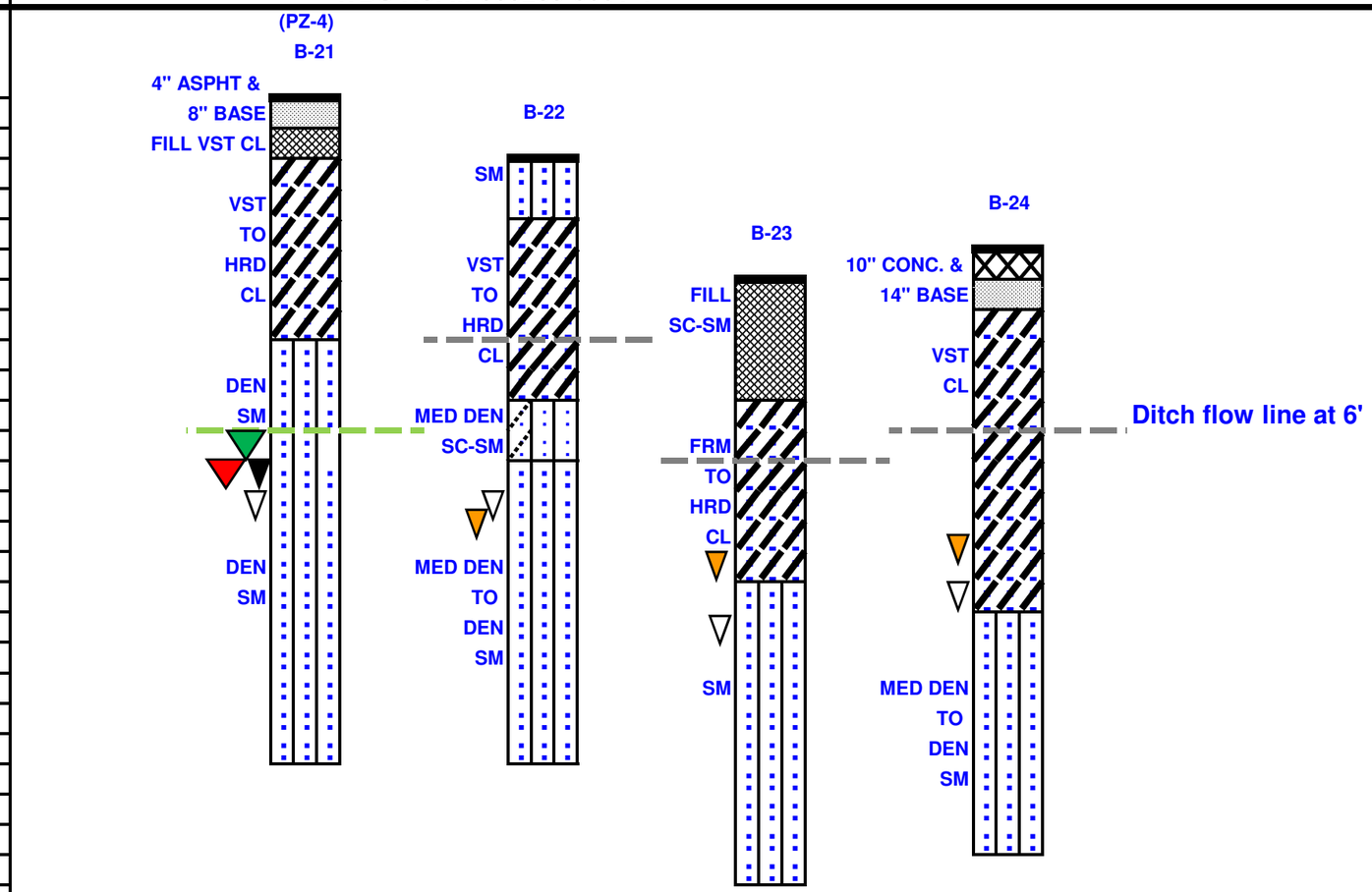
SCALE
Horizontal: N.T.S.
Vertical: 1"= 5'

Figure-4j

ASSOCIATED TESTING LABORATORIES, INC.

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

WBS No. M-000285-0001-4 | **PROJECT NO. G13-211**



PROFILE ALONG EXISTING DITCH

KEY

Water First Noticed	
Depth To Water At Completion	
24 hr. Water Level	
PZ Water Level (After 7 days)	
PZ Water Level (After 30 days)	

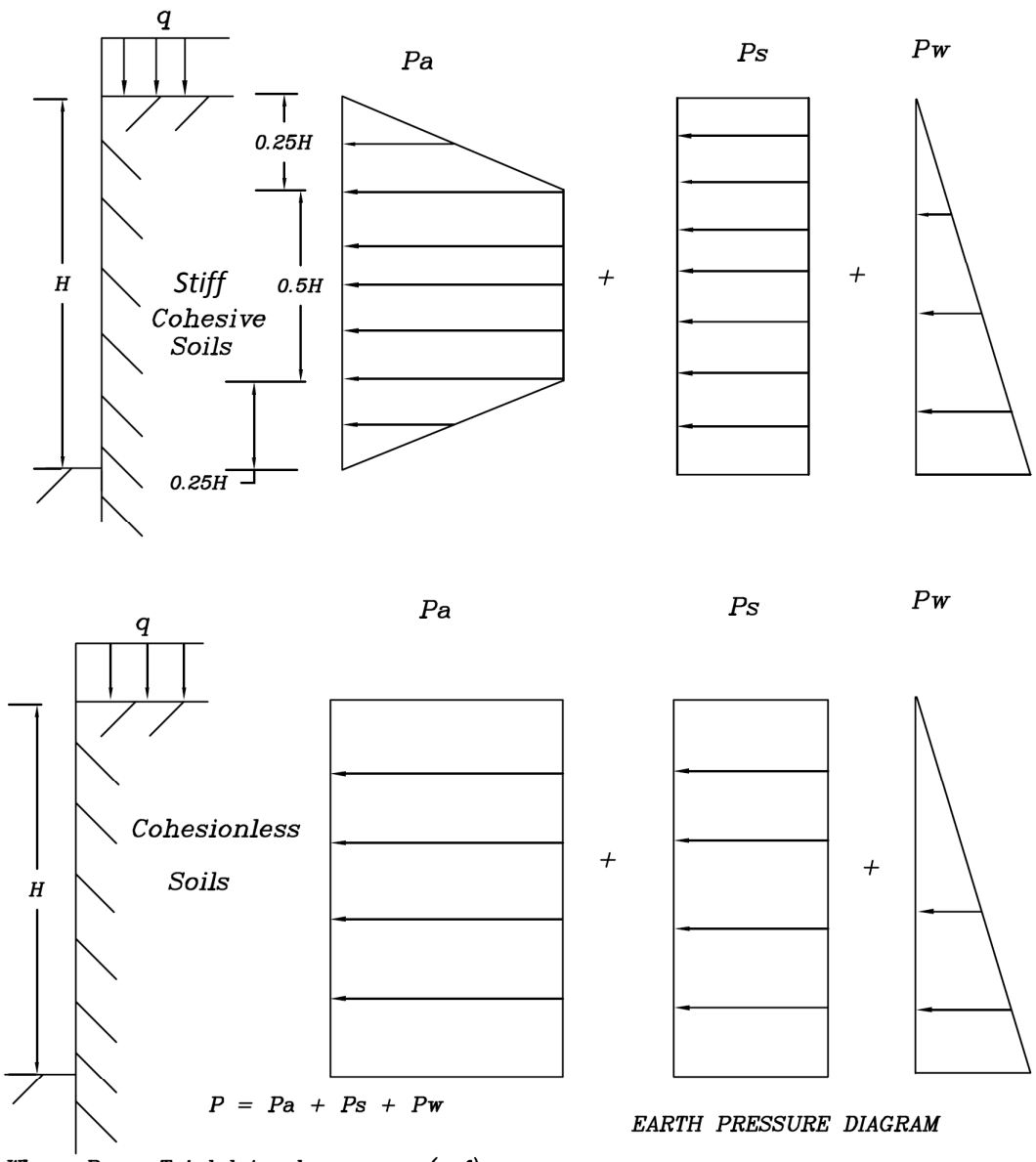
CH- Fat Clay	ST - Stiff
CH- Fat Clay With Sand	VST - Very Stiff
CL- Lean Clay With sand	FRM - Firm
CL- Sandy Lean Clay	HRD - Hard
SM- Silty Sand	MED DEN - Medium Dense

SCALE

Horizontal: N.T.S.

Vertical: 1"= 5'

Figure-4k



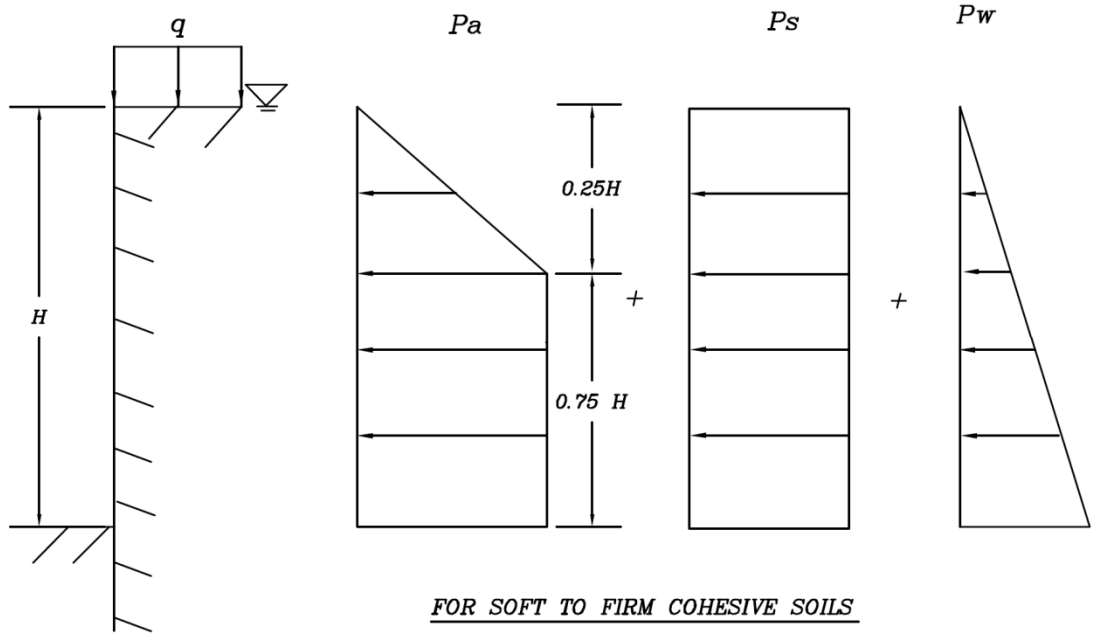
EARTH PRESSURE DIAGRAM

Where P = Total lateral pressure (psf)
Pa = Active earth pressure(psf) = $K_A \gamma H = 0.4 \gamma H$ for Stiff Clays
= 0.65 $K_A \gamma H$ = 0.25γH for cohesionless Sands (0.33 γH–for loose sand)
Ps = Lateral pressure due to surcharge load (psf) = 0.5q for Clays
= 0.4q for Sands
(0.5q for loose Sands)
Pw = Hydrostatic pressure (psf) = 62.4* water depth
H = Depth of braced excavation (ft)
q = Surcharge load (psf) usually taken as 500 psf
γ = Submerged density of soils (pcf) = use 60 pcf (use 50 pcf for loose Sands)

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

EARTH PRESSURE DIAGRAM	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4
	PROJECT NO. : G13-211 / FIGURE 5a

PST 8/28/12



FOR SOFT TO FIRM COHESIVE SOILS

Where P = Total lateral pressure (psf)

Pa = Active earth pressure(psf) = $1.0 K_a \gamma H$ for soft clays

K_a = Active Earth pressure coefficient

$= 1 - m \frac{2 q_u}{\gamma H} = 1 - m \frac{4C}{\gamma H}$ (taking $C = \frac{q_u}{2}$)

Here $m=1$ for $N<4$ and $m=0.4$ for $N>5$

N= Stability number $= \gamma H / C$

Ps = Lateral pressure due to surcharge load (psf) = K_a for clays

Pw = Hydrostatic pressure (psf) = 62.4* water depth

H = Depth of braced excavation (ft)

q = Surcharge load (psf) usually taken as 500 psf

γ = density of soils (pcf) = use 50 pcf below groundwater and 110 pcf above groundwater

q_u = Unconfined compressive strength, psf

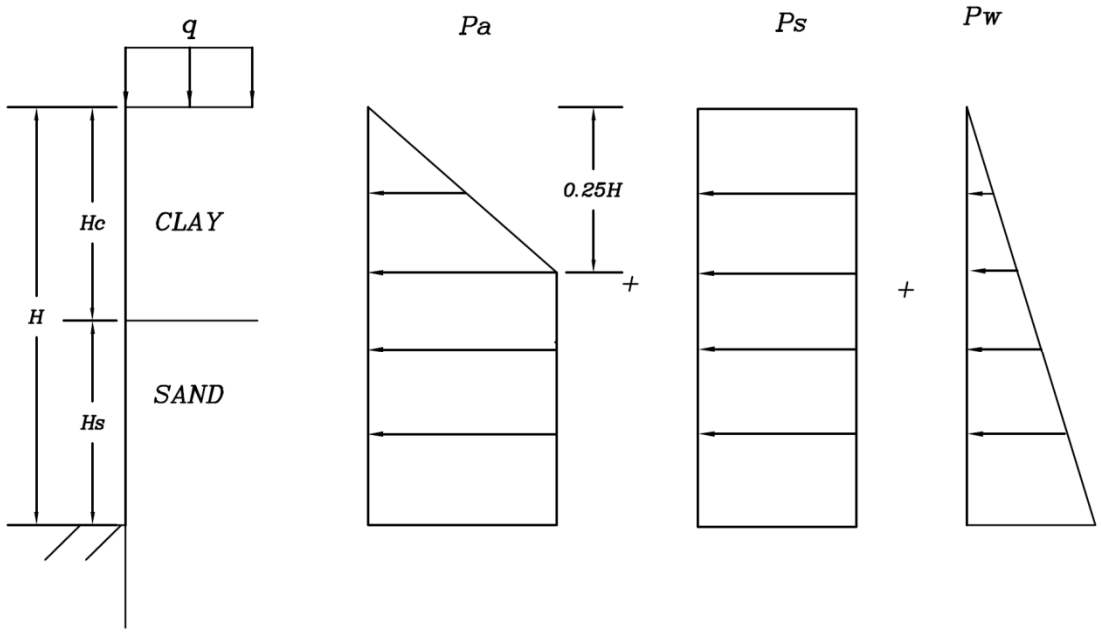
C = Undrained shear strength, psf

Note: Neglect hydrostatic pressure above groundwater level

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

EARTH PRESSURE DIAGRAM	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748	
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4	
	PROJECT NO. : G13-211	FIGURE 5b

PST 8/28/12



$$P = Pa + Ps + Pw$$

Where P = Total lateral pressure (psf)

Pa = Active earth pressure(psf) = $K_A \gamma H = 0.4 \gamma H$

Ps = Lateral pressure due to surcharge load (psf) = $0.5q$

Pw = Hydrostatic pressure (psf) = 62.4* water depth

H = Depth of braced excavation (ft)

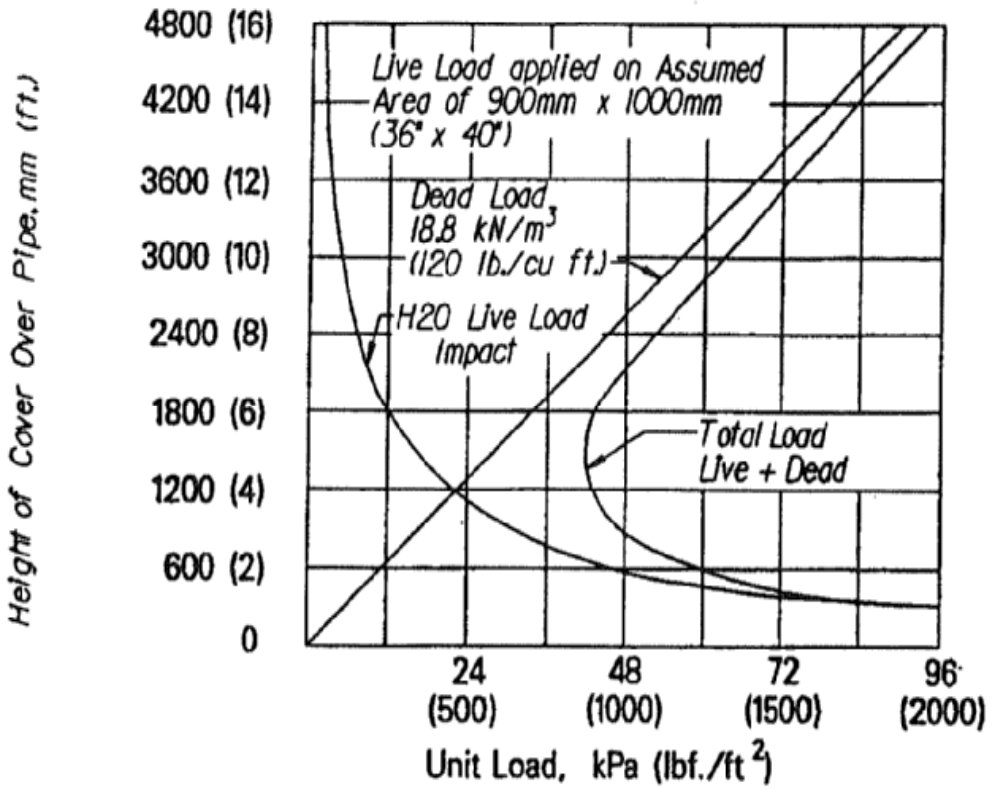
q = Surcharge load (psf) usually taken as 500 psf

γ = Submerged density of soils (pcf) = use 60 pcf

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

EARTH PRESSURE DIAGRAM	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748	
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4	
	PROJECT NO. : G13-211	FIGURE 5c

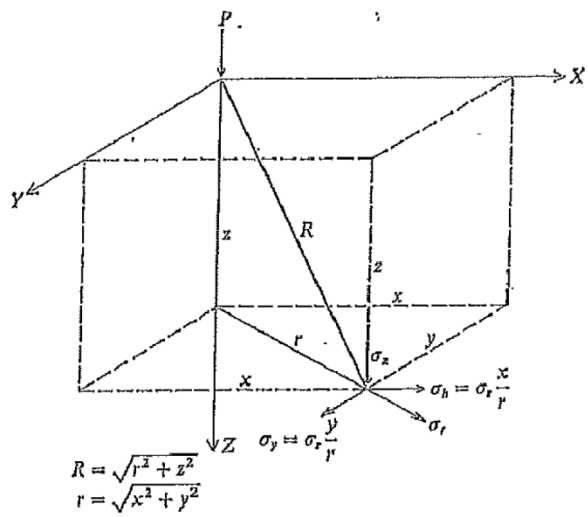
PST 8/28/12



Combined H20 highway live load and dead load is a minimum at about 1500mm (5 ft.) of cover, applied through a pavement 300mm (1 ft.) thick.

HIGHWAY LOADING ON A PIPE UNDER VARIOUS SOIL COVER	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4
	PROJECT NO. : G13-211 / FIGURE 6

PST 8/28/12



Later Pressure, σ_r:

$\sigma_r = (P/2\pi)\ \{3r^2Z/R^5) - ([1-2\mu]/R[R+z]\}$

For $\mu = 0.5$,

$\sigma_r = P/2\pi\ (2r^2z/R^5)$

Vertical Pressure, σ_z :

$\sigma_z = 3\ P\ z^3 / 2\pi R^5$

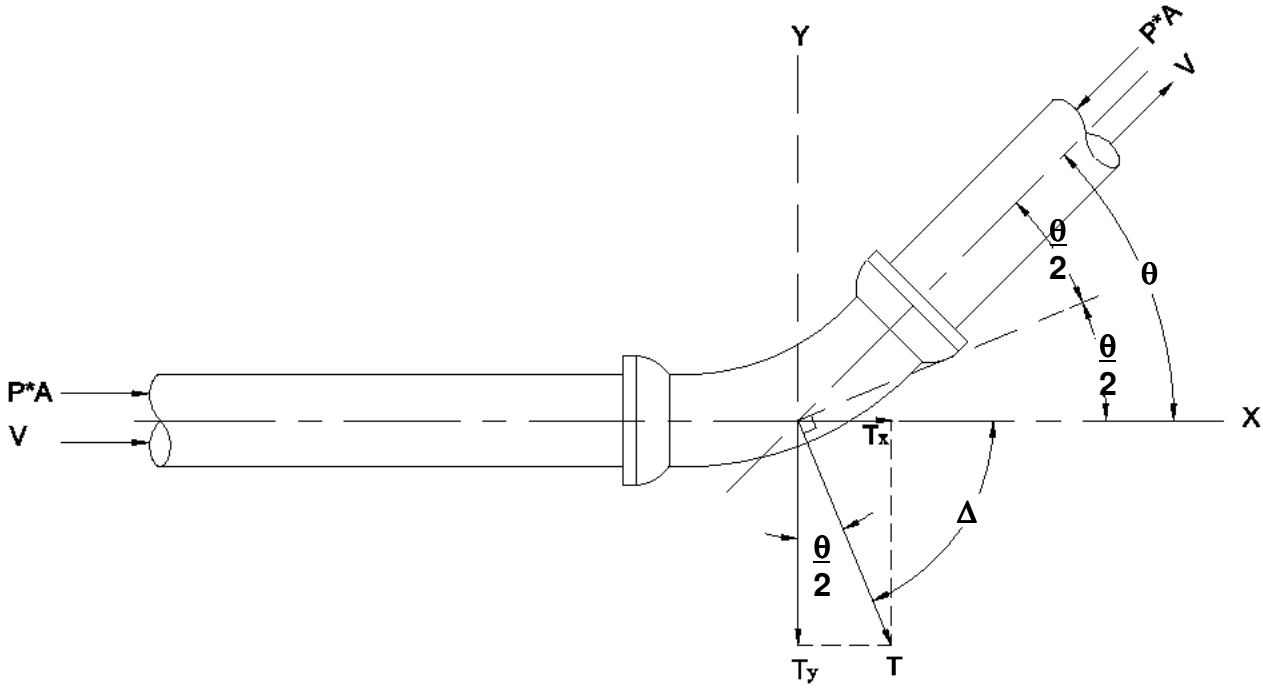
P = Point load surcharge

μ = Poisson's ratio if soils, use 0.5

X, y, z = distance in x, y and z direction, respectively

BOUSSINESQ'S EQUATION FOR POINT LOAD SURCHARGE	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4
	PROJECT NO. : G13-211 / FIGURE 7

PST 8/28/12



$$T = 2\,P\,A \sin\frac{\theta}{2}$$

$$T_x = P\,A\,(1 - \cos\theta)$$

$$T_y = P\,A \sin\theta$$

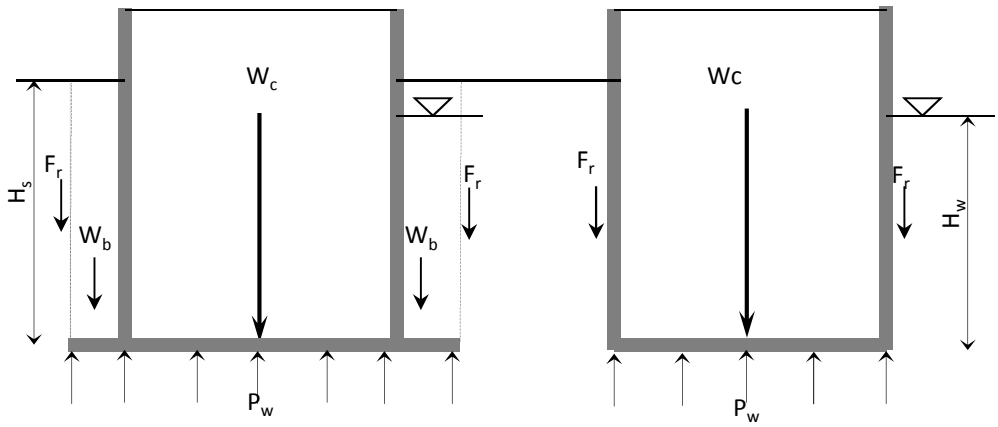
Where:

T	=	Resultant thrust force, lbs
T_x	=	Resultant thrust force component along x-axis, lbs
T_y	=	Resultant thrust force component along y-axis, lbs
P	=	Maximum sustain pressure of fluid in pipe, psi
A	=	Cross-section area of pipe, square inches
D	=	Inside diameter of pipe, inches
θ	=	Angle of the pipe bend, degrees
Δ	=	Angle between x-axis and resultant force
	=	$\tan^{-1}(T_y/T_x)$, degrees
V	=	Fluid velocity

Source: American Water Works Association, "Concrete Pressure Pipes", AWWA Manual M9.

THRUST FORCE AT A PIPE BEND	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748	
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4	
	PROJECT NO. : G13-211	FIGURE 8

PST 8/28/12



Dead Weight of Structure + Dead Weight of Backfill Above Base Extension + Frictional Resistance

$P_w = H_w\gamma_w$
$F_u = A_bP_w$
$W_c/S_{fa}+W_b/S_{fb}+ F_r/S_{fc} \geq F_u$
(S_{fa} = 1.1; S_{fb} = 1.5; S_{fc} = 3.0)

Dead Weight of Structure + Frictional Resistance

$P_w = H_w\gamma_w$
$F_u = A_bP_w$
$W_c/S_{fa}+F_r/S_{fc} \geq F_u$
(S_{fa} = 1.1; S_{fc} = 3.0)

For cohesive soils:
$F_r = \alpha c_nA_n$

For cohesionless soils,
$Fr = p_nK\tan\delta_nA_n$

Where,

H_s	=	Buried depth of wall, ft
H_w	=	Height of water table above base of structure, ft
P_w	=	Total uplift pressure = 62.4 x Hw, psf
F_u	=	Total uplift force exerted on base of structure = Pw x A_b
W_c	=	Dead weight of structure, lbs
W_b	=	Weight of backfill above base of structure, lbs
A_b	=	Area of base, ft^2
F_r	=	Friction resistance developed at the soil/wall interface, lbs
A_n	=	Contact area between the soil/wall interface in layer"n"
c_n	=	Undrained shear strength of cohesive soils at layer "n" at soil/wall interface. See individual boring logs. c_n for the top 8 ft of clays with PI higher than 20 percent should be discounted because of the shrink-swell characteristics of high plasticity clays.
α	=	Adhesion factor, to be multiplied with c_n to obtain the adhesion between the soil/wall interface. Use 0.75 if c_n is less than 0.25 tsf, use 0.67 if c_n is between 0.25 and 0.5 tsf, use 0.5 if c_n is greater than 0.5 tsf but limit the adhesion to 1.5 ksf.
K	=	Coefficient of lateral earth pressure of cohesionless soils. Use 0.4.
p_n	=	Average overburden stress at the mid-depth of cohesionless soil layer "n", psf
δ_n	=	Average frictional angle between cohesionless soil layer "n" and the walls of the structure, use 0.75 of the angle of internal friction (ϕ) of the cohesionless soil. A ϕ of 28 degrees may be used if no specific value is given.
$S_{fa,b,c}$	=	Factors of safety against buoyant uplift force.

BUOYANT UPLIFT RESISTANCE OF A BURIED STRUCTURE	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748	
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS NO. M-000285-0001-4	
	PROJECT NO. : G13-211	FIGURE 9

PST 8/28/12

LIST OF TABLES

TABLE 1	SUMMARY OF EXISTING PAVEMENT MEASUREMENTS
TABLE 2	SUMMARY OF GROUNDWATER MEASUREMENTS
TABLE 3	SUMMARY OF TEST RESULTS
TABLE 4	MARSTON SOIL COEFFICIENT (Cd) FOR TRENCH CONDUITS

TABLE 1

SUMMARY OF PAVEMENT MEASUREMENTS
GARDEN OAKS AND SHEPHERD PARK (CENTRAL)
DRAINAGE AND PAVING
WBS NO. M-000285-0001-4

ATL PROJECT NO. G13-211

Boring Number	Boring Depth (ft)	Piezometer		Asphalt Paving (inch)	Concrete Paving (inch)	Base Material (inch)
		No.	Depth (ft)			
B-1	30	PZ-1	30	2	--	8” Shell
B-2	15	--	--	--	--	--
B-3	27	--	--	--	--	--
B-4	15.5	--	--	4	--	4” Lime stabilized shell
B-5	15.5	--	--	5	--	4” Crushed imestone
B-6	27	--	--	--	--	--
B-7	15.5	--	--	--	--	--
B-8	15.5	--	--	--	--	--
B-9	15	--	--	--	--	--
B-10	15.5	--	--	--	--	--
B-11	27	PZ-2	27	2.5	5.5	--
B-12	15	--	--	--	--	--
B-13	15.5	--	--	--	--	--
B-14	26	--	--	2	6	--
B-15	26	--	--	--	--	--
B-16	15.5	--	--	--	--	--
B-17	15.5	--	--	4	--	8” Crushed limestone
B-18	30	--	--	--	5.5	--
B-19	24	PZ-3	24	3	--	4” Crushed gravel
B-20	23	--	--	6	--	4” Crushed gravel
B-21	21.5	PZ-4	21.5	4	--	8” Crushed gravel
B-22	20	--	--	--	--	--
B-23	20	--	--	--	--	--
B-24	20	--	--	--	10	14” Limestone

TABLE 2

SUMMARY OF GROUNDWATER MEASUREMENTS
GARDEN OAKS AND SHEPHERD PARK (CENTRAL)
DRAINAGE AND PAVING
WBS NO. M-000285-0001-4

ATL PROJECT NO. G13-211

Boring Number	Location	Ground water during drilling	Ground water upon completion of drilling	Ground water in Piezometer (after 24 hrs)	Ground water in Piezometer (after 7 days)	Ground water in Piezometer (after 30 days)
B-1 (PZ-1)	Alba Road	27’	23’	(10/9/2013) 17’	(10/17/2013) 16’	(11/11/2013) 15’
B-2	Wakefield Drive	10’	14’	--	--	--
B-3	Alba Road	16’	N/A	--	--	--
B-4	Fisher Drive	11’	N/A	--	--	--
B-5	Fisher Drive	Dry	Dry	--	--	--
B-6	W. 41st ST	14’	N/A	--	--	--
B-7	W. 41st ST	14’	N/A	--	--	--
B-8	W. 41st ST	14’	N/A	--	--	--
B-9	W. 41st ST	Dry	Dry	--	--	--
B-10	W. 41st ST	12.5’	N/A	--	--	--
B-11 (PZ-2)	Alba Road	12’	N/A	(10/11/2013) 11’	(10/17/2013) 11’	(11/11/2013) 11’
B-12	W. 42nd ST	10’	N/A	--	--	--
B-13	La Monte Lane	14’	N/A	--	--	--
B-14	Alba Road	14	Dry	--	--	--
B-15	Alba Road	13’	N/A	--	--	--
B-16	Azalea St	12.5’	N/A	--	--	--
B-17	Sue Barnett St	12’	N/A	--	--	--
B-18	Alba Road	13’	N/A	--	--	--
B-19 (PZ-3)	Chamboard Lane	14’	N/A	(10/9/2013) 11’	(10/17/2013) 11.5’	(11/11/2013) 11’
B-20	Brinkman St	12’	N/A	--	--	--
B-21 (PZ-4)	Brinkman St	14’	N/A	(10/9/2013) 13’	(10/17/2013) 13’	(11/11/2013) 12’
B-22	Along Ditch	12’	12.5’	--	--	--
B-23	Along Ditch	12’	10’	--	--	--
B-24	On N. Shepherd Road, near Ditch	12’	10.5’	--	--	--

TABLE 3

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-1	1	0-2	UD		11		31	16	15	40				4.00	Clayey Sand (SC)
	2	2-4	SS	12	5										Silty Sand (SM)
	3	4-6	UD		8									4.50	Sandy Lean Clay (CL)
	4	6-8	SS	16	9										Silty Sand (SM)
	5	8-10	UD		10	113					1.80			4.00	Sandy Lean Clay (CL)
	6	10-12	SS	25	10					22					Silty Sand (SM)
	7	12-14	UD		14		31	16	15					3.00	Sandy Lean Clay (CL)
	8	14-16	UD		17									3.50	Sandy Lean Clay (CL)
	9	16-18	UD		18	115						1.91(0.86)		4.00	Sandy Lean Clay (CL)
	10	18-20	UD		18									3.50	Sandy Lean Clay (CL)
	11	23-25	UD		22	111					1.60			4.00	Sandy Lean Clay (CL)
	12	28-30	UD		20		28	15	13					3.00	Sandy Lean Clay (CL)
B-2	1	0-2	UD		17		30	16	14	56				1.50	Sandy Lean Clay (CL) fill
	2	2-4	UD		17	107					0.20			1.00	Sandy Lean Clay (CL) fill
	3	4-6	UD		22									0.50	Sandy Lean Clay (CL) fill
	4	6-8	UD		18									0.50	Sandy Lean Clay (CL) fill
	5	8-10	UD		24		31	16	15					0.50	Sandy Lean Clay (CL) fill
	6	10-12	SS	15	19					20					Silty Sand (SM)
	7	12-14	UD		15	119					1.30			4.00	Sandy Lean Clay (CL)
	8	14-15	UD		15									3.50	Sandy Lean Clay (CL)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-3	1	0-2	AU		20		41	17	24						Sandy Lean Clay (CL) fill
	2	2-4	UD		20									0.75	Sandy Lean Clay (CL) fill
	3	4-6	UD		19									0.75	Sandy Lean Clay (CL) fill
	4	6-8	UD		18	111					0.35			1.00	Sandy Lean Clay (CL) fill
	5	8-10	UD		19									1.00	Sandy Lean Clay (CL) fill
	6	10-12	SS	9	21										Silty Sand (SM) fill
	7	12-14	UD		17		40	17	23	63				1.75	Sandy Lean Clay (CL) fill
	8	14-16	UD		20									1.00	Sandy Lean Clay (CL) fill
	9	16-18	UD		22		76	23	53					0.25	Sandy Lean Clay (CL) fill
	10	18-20	UD		23	103						1.40(0.94)		4.00	Fat Clay with Sand (CH)
	11	23-25	UD		26	99					1.75			4.00	Fat Clay with Sand (CH)
	12	25-27	UD		32									3.50	Fat Clay with Sand (CH)
B-4	1	0-2	UD		25		79	23	56	66				2.50	Sandy Fat Clay (CH)
	2	2-4	UD		20	103					1.00			3.50	Sandy Fat Clay (CH)
	3	4-6	UD		16									2.75	Sandy Lean Clay (CL)
	4	6-8	UD		17									2.50	Sandy Lean Clay (CL)
	5	8-10	UD		14	116	29	15	14		0.85			2.00	Sandy Lean Clay (CL)
	6	10-12	SS	23	21										Silty Sand (SM)
	7	12-14	SS	20	21					19					Silty Sand (SM)
	8	14-15.5	SS	20	21										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample NO.	Sample DEPTH (ft)	Sample TYPE	SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	TYPE OF MATERIAL
B-5	1	0-2	UD		26									1.50	Sandy Lean Clay (CL)
	2	2-4	UD		18		40	17	23	57				2.75	Sandy Lean Clay (CL)
	3	4-6	UD		19	112					1.05			3.50	Sandy Lean Clay (CL)
	4	6-8	UD		19		48	18	30					3.00	Sandy Lean Clay (CL)
	5	8-10	UD		20	109					0.85			2.50	Sandy Lean Clay (CL)
	6	10-12	SS	27	16					37					Silty Sand (SM)
	7	12-14	SS	20	16										Silty Sand (SM)
	8	14-15.5	SS	11	17										Silty Sand (SM)
B-6	1	0-2	UD		14									2.00	Sandy Lean Clay (CL)
	2	2-4	UD		12		40	17	23	61				4.50	Sandy Lean Clay (CL)
	3	4-6	UD		15									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		16									4.50	Sandy Lean Clay (CL)
	5	8-10	UD		14									4.00	Sandy Lean Clay (CL)
	6	10-12	UD		13									0.75	Sandy Lean Clay (CL)
	7	12-14	SS	15	19					16					Silty Sand (SM)
	8	14-16	SS	12	20										Silty Sand (SM)
	9	16-18	SS	24	21										Silty Sand (SM)
	10	18-20	UD		26	103					1.30			3.50	Fat Clay with sand (CH)
	11	23-25	UD		20		57	20	37					3.25	Fat Clay with sand (CH)
	12	25-27	UD		20	110					2.25			4.50	Fat Clay with sand (CH)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-7	1	0-2	UD		13		24	15	9	55				1.50	Sandy Lean Clay (CL)
	2	2-4	UD		16									1.50	Sandy Lean Clay (CL)
	3	4-6	UD		16									3.00	Sandy Lean Clay (CL)
	4	6-8	UD		16									3.50	Sandy Lean Clay (CL)
	5	8-10	UD		17									3.00	Sandy Lean Clay (CL)
	6	10-12	UD		16		25	15	10					2.00	Sandy Lean Clay (CL)
	7	12-14	UD		16	111					0.40			1.50	Sandy Lean Clay (CL)
	8	14-15.5	SS	9	20					15					Silty Sand (SM)
B-8	1	0-2	UD		14		34	16	18	56				2.00	Sandy Lean Clay (CL)
	2	2-4	UD		15									2.50	Sandy Lean Clay (CL)
	3	4-6	UD		14									4.00	Sandy Lean Clay (CL)
	4	6-8	UD		16									2.50	Sandy Lean Clay (CL)
	5	8-10	UD		18	112					1.70			4.00	Sandy Lean Clay (CL)
	6	10-12	UD		18	111						0.99(0.50)		2.00	Sandy Lean Clay (CL)
	7	12-14	UD		18		29	15	14					1.00	Sandy Lean Clay (CL)
	8	14-15.5	SS	17	19					22					Silty Sand (SM)

Legend:

UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed

AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-9	1	0-2	UD		13									2.00	Sandy Lean Clay (CL)
	2	2-4	UD		7		30	16	14	53				3.50	Sandy Lean Clay (CL)
	3	4-6	UD		12									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		12									4.50	Sandy Lean Clay (CL)
	5	8-10	UD		14	118					2.05			4.50	Sandy Lean Clay (CL)
	6	10-12	UD		13		33	16	17					4.50	Sandy Lean Clay (CL)
	7	12-14	SS	21	15					35					Silty Sand (SM)
	8	14-15	UD		13	113					0.75			2.00	Sandy Lean Clay (CL)
B-10	1	0-2	UD		15									4.00	Sandy Lean Clay (CL)
	2	2-4	UD		12		39	17	22	59				4.50	Sandy Lean Clay (CL)
	3	4-6	UD		13									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		14									3.75	Sandy Lean Clay (CL)
	5	8-10	UD		20	108	39	17	22		0.85			2.00	Sandy Lean Clay (CL)
	6	10-12	UD		18									1.00	Sandy Lean Clay (CL)
	7	12-14	SS	6	20					14					Silty Sand (SM)
	8	14-15.5	SS	7	20										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample NO.	Sample DEPTH (ft)	Sample TYPE	SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	TYPE OF MATERIAL
B-11	1	0-2	UD		13									4.50	Fat Clay with Sand (CH)
	2	2-4	UD		14		61	21	40	72				4.50	Fat Clay with Sand (CH)
	3	4-6	UD		12									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		20									4.50	Sandy Lean Clay (CL)
	5	8-10	UD		20									4.50	Sandy Lean Clay (CL)
	6	10-12	UD		19	110	25	15	10		0.35			1.00	Sandy Lean Clay (CL)
	7	12-14	SS	18	24										Silty Sand (SM)
	8	14-16	SS	19	24										Silty Sand (SM)
	9	16-18	SS	22	22										Silty Sand (SM)
	10	18-20	UD		22	108						2.00(0.94)		2.00	Fat Clay with Sand (CH)
	11	23-25	UD		28	97	65	21	44		1.05			3.50	Fat Clay with Sand (CH)
	12	25-27	UD		20									4.00	Fat Clay with Sand (CH)
B-12	1	0-2	UD		18		54	19	35	60				3.50	Sandy Fat Clay (CH)
	2	2-4	UD		14									3.50	Sandy Fat Clay (CH)
	3	4-6	UD		13		41	17	24					3.75	Sandy Lean Clay (CL)
	4	6-8	UD		13	120					1.45			3.50	Sandy Lean Clay (CL)
	5	8-10	SS	16	16										Silty Sand (SM)
	6	10-12	SS	20	22										Silty Sand (SM)
	7	12-14	SS	19	21										Silty Sand (SM)
	8	14-15.5	SS	21	19					28					Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample NO.	Sample DEPTH (ft)	Sample TYPE	SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	TYPE OF MATERIAL
B-13	1	0-2	UD		26		80	24	56	62				2.00	Sandy Fat Clay (CH)
	2	2-4	UD		17									4.00	Sandy Fat Clay (CH)
	3	4-6	UD		14									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		14									4.50	Sandy Lean Clay (CL)
	5	8-10	UD		16		33	16	17					3.00	Sandy Lean Clay (CL)
	6	10-12	UD		16	113					0.65			2.00	Sandy Lean Clay (CL)
	7	12-14	SS	15	17										Silty Sand (SM)
	8	14-15.5	SS	18	16					22					Silty Sand (SM)
B-14	1	0-2	UD		13									3.00	Sandy Lean Clay (CL)
	2	2-4	UD		13									3.75	Sandy Lean Clay (CL)
	3	4-6	UD		13									4.00	Sandy Lean Clay (CL)
	4	6-8	UD		14		28	15	13	51				2.00	Sandy Lean Clay (CL)
	5	8-10	UD		15									1.00	Sandy Lean Clay (CL)
	6	10-12	SS	9	19										Silty Sand (SM)
	7	12-14	SS	14	19										Silty Sand (SM)
	8	14-16	SS	21	19					15					Silty Sand (SM)
	9	16-18	SS	20	21										Silty Sand (SM)
	10	18-20	UD		19	104						0.89(0.94)		3.50	Fat Clay with Sand (CH)
	11	23-25	UD		20	109	53	19	34		1.45			3.50	Fat Clay with Sand (CH)
	12	25-26	UD		25									4.50	Fat Clay with Sand (CH)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-15	1	0-2	UD		11									3.75	Sandy Lean Clay (CL) fill
	2	2-4	UD		8	117					2.25			4.50	Sandy Lean Clay (CL) fill
	3	4-6	UD		8		38	17	21	52				4.50	Sandy Lean Clay (CL) fill
	4	6-8	UD		12									3.00	Sandy Lean Clay (CL)
	5	8-10	UD		15									1.50	Sandy Lean Clay (CL)
	6	10-12	SS	7	20										Silty Sand (SM)
	7	12-14	SS	11	19					14					Silty Sand (SM)
	8	14-16	SS	14	22										Silty Sand (SM)
	9	16-18	UD		16	113						2.43(0.86)		3.50	Fat Clay with Sand (CH)
	10	18-20	UD		17	110					2.10			4.50	Fat Clay with Sand (CH)
	11	23-25	UD		17		52	19	33					4.50	Fat Clay with Sand (CH)
	12	25-26	UD		22									3.50	Fat Clay with Sand (CH)
B-16	1	0-2	UD		20									1.50	Sandy Lean Clay (CL)
	2	2-4	UD		17		48	18	30	52				2.00	Sandy Lean Clay (CL)
	3	4-6	UD		16									2.50	Sandy Lean Clay (CL)
	4	6-8	UD		15									3.00	Sandy Lean Clay (CL)
	5	8-10	UD		15									2.00	Sandy Lean Clay (CL)
	6	10-12	UD		16	114	33	16	17		0.70			2.00	Sandy Lean Clay (CL)
	7	12-14	SS	21	20					23					Silty Sand (SM)
	8	14-15	SS	26	21										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample NO.	Sample DEPTH (ft)	Sample TYPE	SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	TYPE OF MATERIAL
B-17	1	0-2	UD		14		33	16	17	51				3.00	Sandy Lean Clay (CL)
	2	2-4	UD		13									4.50	Sandy Lean Clay (CL)
	3	4-6	UD		13									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		15									3.50	Sandy Lean Clay (CL)
	5	8-10	UD		14		36	17	19					2.00	Sandy Lean Clay (CL)
	6	10-12	UD		16	111					0.45			1.50	Sandy Lean Clay (CL)
	7	12-14	SS	9	22					16					Silty Sand (SM)
	8	14-15.5	SS	11	21										Silty Sand (SM)
B-18	1	0-2	UD		8		24	15	9	51				3.50	Sandy Lean Clay (CL)
	2	2-4	UD		15	118					1.50			4.00	Sandy Lean Clay (CL)
	3	4-6	UD		15									2.75	Sandy Lean Clay (CL)
	4	6-8	UD		15		33	16	17					4.00	Sandy Lean Clay (CL)
	5	8-10	UD		17	114					1.00			3.50	Sandy Lean Clay (CL)
	6	10-12	SS	26	17										Silty Sand (SM)
	7	12-14	SS	29	22										Silty Sand (SM)
	8	14-16	SS	32	19										Silty Sand (SM)
	9	16-18	SS	35	21										Silty Sand (SM)
	10	18-20	SS	33	21										Silty Sand (SM)
	11	23-25	SS	34	22					17					Silty Sand (SM)
	12	28-30	SS	37	20										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-19	1	0-2	UD		6		20	14	6	46				3.50	Clayey-Silty Sand (SC-SM) Fill
	2	2-4	UD		12									4.00	Sandy Lean Clay (CL)
	3	4-6	UD		15									3.00	Sandy Lean Clay (CL)
	4	6-8	UD		14	114					0.50			2.00	Sandy Lean Clay (CL)
	5	8-10	SS	22	14										Silty Sand (SM)
	6	10-12	SS	25	14										Silty Sand (SM)
	7	12-14	SS	30	22					15					Silty Sand (SM)
	8	14-16	SS	27	21										Silty Sand (SM)
	9	16-18	SS	25	38										Silty Sand (SM)
	10	18-20	SS	13	33										Silty Sand (SM)
	11	20-22	UD		15	119						1.90 (1.01)		4.00	Fat Clay with Sand (CH)
	12	22-24	UD		15	119					2.20			4.50	Fat Clay with Sand (CH)
B-20	1	0-2	UD		12									2.50	Sandy Lean Clay (CL)
	2	2-4	UD		27		59	20	39	60				3.00	Sandy Fat Clay (CH)
	3	4-6	UD		15									4.50	Sandy Fat Clay (CH)
	4	6-8	UD		15									4.50	Sandy Fat Clay (CH)
	5	8-10	UD		17	113	56	20	36		0.50			2.00	Sandy Fat Clay (CH)
	6	10-12	SS	30	18										Silty Sand (SM)
	7	12-14	SS	28	20										Silty Sand (SM)
	8	14-16	SS	34	20										Silty Sand (SM)
	9	16-18	SS	34	20										Silty Sand (SM)
	10	18-20	SS	38	22					25					Silty Sand (SM)
	11	22-23	SS	40	22										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-21	1	0-2	UD		14		24	15	9	51				3.75	Sandy Lean Clay (CL) fill
	2	2-4	UD		8	115					1.00			3.50	Sandy lean Clay (CL)
	3	4-6	UD		10									4.50	Sandy Lean Clay (CL)
	4	6-8	UD		9		39	17	22					4.50	Sandy Lean Clay (CL)
	5	8-10	SS	36	4										Silty Sand (SM)
	6	10-12	SS	44	13										Silty Sand (SM)
	7	12-14	SS	43	8					34					Silty Sand (SM)
	8	14-16	SS	36	24										Silty Sand (SM)
	9	16-18	SS	33	24										Silty Sand (SM)
	10	18-20	SS	37	23										Silty Sand (SM)
	11	20-21.5	SS	41	26										Silty Sand (SM)
B-22	1	0-2	AU		8		14	13	1	34					Silty Sand (SM)
	2	2-4	UD		7					51				2.75	Sandy Lean Clay (CL)
	3	4-6	UD		9		39	17	22	51				4.50	Sandy Lean Clay (CL)
	4	6-8	UD		5	115					2.25			4.50	Sandy Lean Clay (CL)
	5	8-10	SS	26	9		22	14	8	23					Clayey-Silty Sand (SC-SM)
	6	10-12	SS	26	18					16					Silty Sand (SM)
	7	12-14	SS	40	20										Silty Sand (SM)
	8	14-16	SS	29	23										Silty Sand (SM)
	9	16-18	SS	26	28					15					Silty Sand (SM)
	10	18-20	SS	30	26										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

TABLE 3 (cont'd)

ASSOCIATED TESTING LABORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS 77052
TEL: (713) 748-3717 FAX: (713) 748-3748

PROJECT NAME : GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING (WBS NO. N-000285-0001-4)

CONSULTANT PROJECT NUMBER: G13-211

BORING NO.	Sample			SPT (blows/ft)	WATER CONTENT (%)	DRY DENSITY (pcf)	Atterberg Limits			PERCENT PASSING SIEVE 200 (%)	UNDRAINED SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (ft)	TYPE				LL	PL	PI		UNCONFINED COMPRESSION TEST (TSF)	UU TEST (CONFINING PRESSURE) (TSF)	TORVANE	POCKET PENETRO-METER	
B-23	1	0-2	AU		14		18	14	4	44					Clayey-Silty Sand (SC-SM) FILL
	2	2-4	AU		10										Clayey-Silty Sand (SC-SM) FILL
	3	4-6	UD		12	114	39	17	22	53	2.05			4.50	Sandy Lean Clay (CL)
	4	6-8	UD		13									4.50	Sandy Lean Clay (CL)
	5	8-10	UD		15	106	33	16	17	51	0.45			1.50	Sandy Lean Clay (CL)
	6	10-12	AU		24										Silty Sand (SM)
	7	12-14	AU		23					23					Silty Sand (SM)
	8	14-16	AU		24										Silty Sand (SM)
	9	16-18	AU		28					15					Silty Sand (SM)
	10	18-20	AU		27										Silty Sand (SM)
B-24	1	0-2	AU		7					32					Lime Stone Base
	2	2-4	UD		13									4.00	Sandy Lean Clay (CL)
	3	4-6	UD		15	112	28	15	13		0.55			2.00	Sandy Lean Clay (CL)
	4	6-8	UD		15									2.75	Sandy Lean Clay (CL)
	5	8-10	UD		18		31	16	15					3.00	Sandy Lean Clay (CL)
	6	10-12	UD		18									2.00	Sandy Lean Clay (CL)
	7	12-14	SS	15	24					15					Silty Sand (SM)
	8	14-16	SS	39	21										Silty Sand (SM)
	9	16-18	SS	15	22					48					Silty Sand (SM)
	10	18-20	SS	21	19										Silty Sand (SM)

Legend:
UD - Undisturbed Sample Extruded in Field
UL - Undisturbed Sample Extruded in Lab
Designates consolidation test Performed
AG - Auger Cutting in Field
SS - Split Spoon Sample
SPT - Standard Penetration Test

APPENDIX 1

PHOTOGRAPHS OF THE PROJECT SITE

PHOTOGRAPHS OF THE PROJECT SITE
ATL PROJECT No.: G13-211 WBS No: M-000285-0001-4
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

Looking North On Alba Road From Judiway

Looking East On W. 41st Street From Alba Road

PHOTOGRAPHS OF THE PROJECT SITE
ATL PROJECT No.: G13-211 WBS No: M-000285-0001-4
GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING

Looking North On Brinkman Street From Chamboard Lane

Looking West On HCFCD Ditch From N. Shepherd Drive

APPENDIX 2

PIEZOMETER INSTALLATION AND PLUGGING REPORTS

PIEZOMETER INSTALLATION REPORT

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING WBS No.: M-000285-0001-4	PIEZOMETER NO.: B-1 (PZ-1)
GEOTECHNICAL CONSULTANT ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT PGAL, INC.
	CITY OF HOUSTON

COMPLETION DATE: 10-9-13

DRY AUGERED 0 TO 30 FT

WASH BORED _____ TO _____ FT

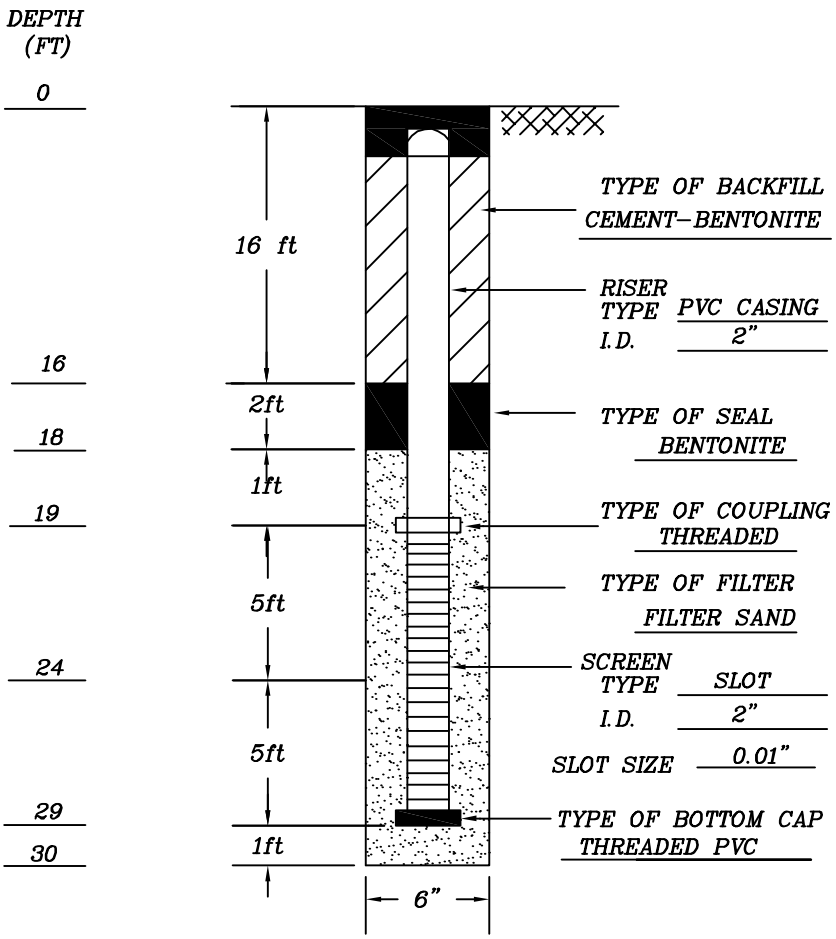
DRILING FLUID: _____

DEVELOPMENT DATE: 10-9-13

METHOD OF DEVELOPMENT: BAILING

WATER LEVEL READING:

DATE	READING
10-10-13	17'
10-17-13	16'
11-11-13	15'



(NOT TO SCALE)

REMARKS:

NOTES:

DRILLED BY: VAN & SON	STARTED: 10-9-13	ATL job No. G13-211
LOGGED BY: PV	COMPLETED: 10-9-13	
CHECKED BY: JITU	APPROVED BY: PST	SHEET 1 OF 4

ASSOCIATED TESTING LABORATORIES, INC.

PIEZOMETER INSTALLATION REPORT

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING WBS No.: M-000285-0001-4	PIEZOMETER NO.: B-11 (PZ-2)
GEOTECHNICAL CONSULTANT ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT PGAL, INC.
	CITY OF HOUSTON

COMPLETION DATE: 10-10-13

DRY AUGERED 0 TO 27 FT

WASH BORED _____ TO _____ FT

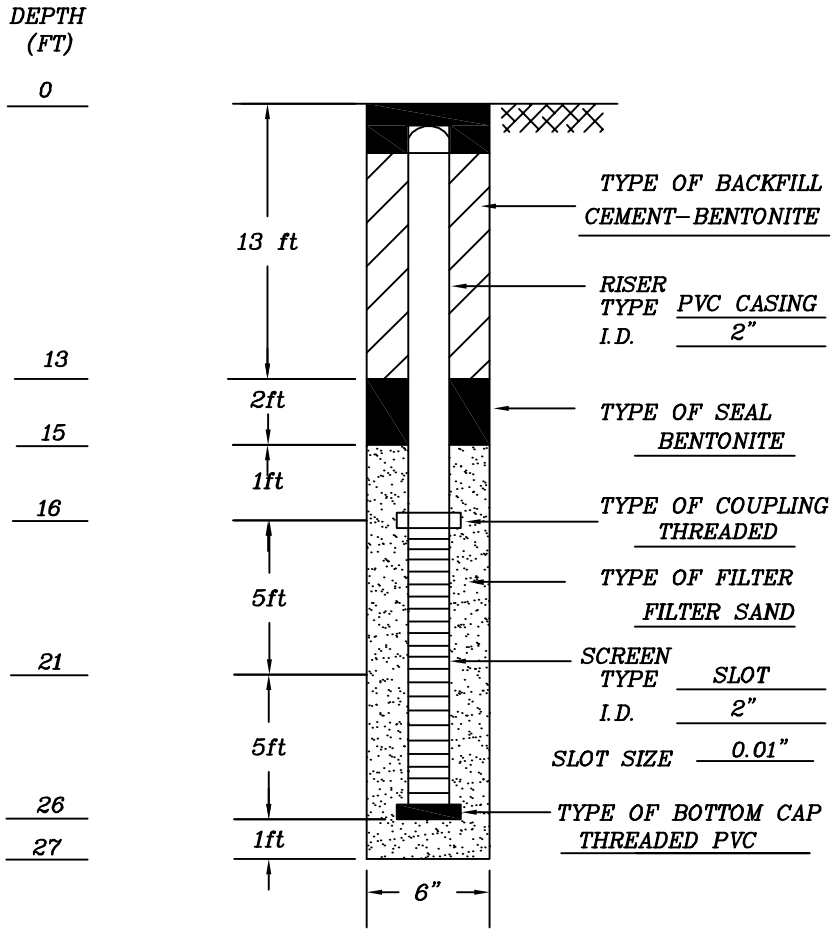
DRILING FLUID: _____

DEVELOPMENT DATE: 10-10-13

METHOD OF DEVELOPMENT: BAILING

WATER LEVEL READING:

DATE	READING
10-11-13	11'
10-17-13	11'
11-11-13	11'



(NOT TO SCALE)

REMARKS:

NOTES:

DRILLED BY; VAN & SON	STARTED: 10-10-13	ATL job No. G13-211
LOGGED BY: PV	COMPLETED: 10-10-13	
CHECKED BY: JITU	APPROVED BY: PST	SHEET 2 OF 4

ASSOCIATED TESTING LABORATORIES, INC.

PIEZOMETER INSTALLATION REPORT

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING WBS No.: M-000285-0001-4		PIEZOMETER NO.: B-19 (PZ-3)
GEOTECHNICAL CONSULTANT ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT PGAL, INC.	CITY OF HOUSTON

COMPLETION DATE: 10-9-13

DRY AUGERED 0 TO 24 FT

WASH BORED _____ TO _____ FT

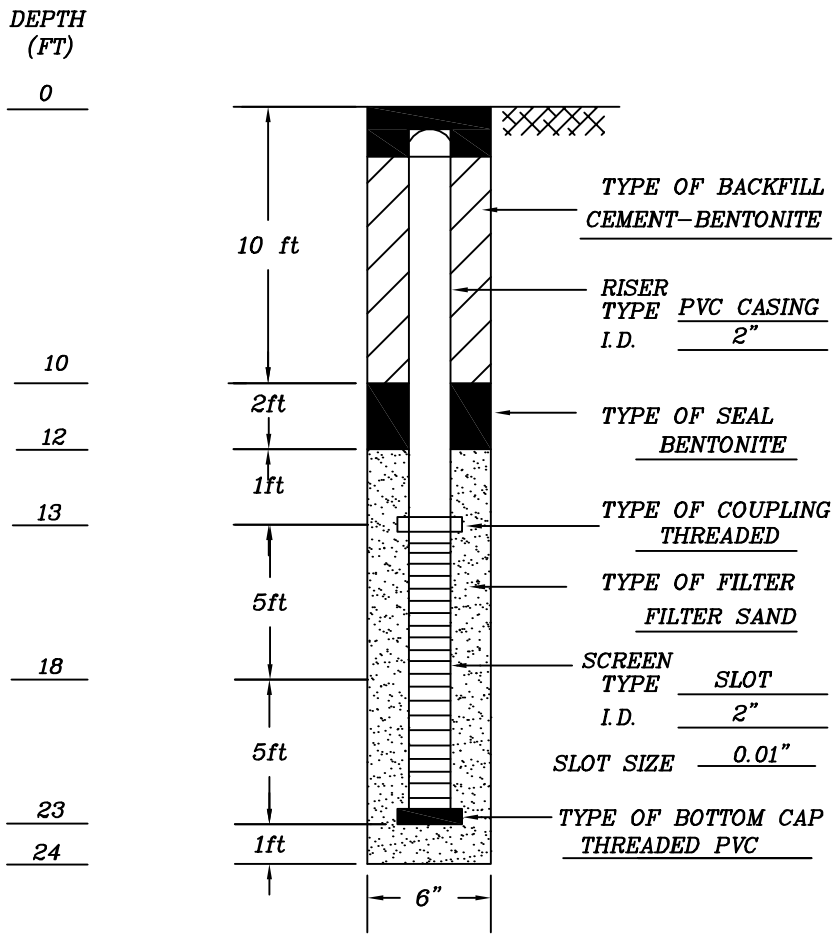
DRILING FLUID: _____

DEVELOPMENT DATE: 10-9-13

METHOD OF DEVELOPMENT: BAILING

WATER LEVEL READING:

DATE	READING
10-10-13	11'
10-17-13	11.5'
11-11-13	11'



(NOT TO SCALE)

REMARKS:

NOTES:

DRILLED BY: VAN & SON	STARTED: 10-9-13	ATL job No. G13-211
LOGGED BY: PV	COMPLETED: 10-9-13	
CHECKED BY: JITU	APPROVED BY: PST	SHEET 3 OF 4

PIEZOMETER INSTALLATION REPORT

PROJECT NAME: GARDEN OAKS AND SHEPHERD PARK (CENTRAL) DRAINAGE AND PAVING	WBS No.: M-000285-0001-4	PIEZOMETER NO.: B-21 (PZ-4)
GEOTECHNICAL CONSULTANT ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT PGAL, INC.	CITY OF HOUSTON

COMPLETION DATE: 10-9-13

DRY AUGERED 0 TO 21 FT

WASH BORED _____ TO _____ FT

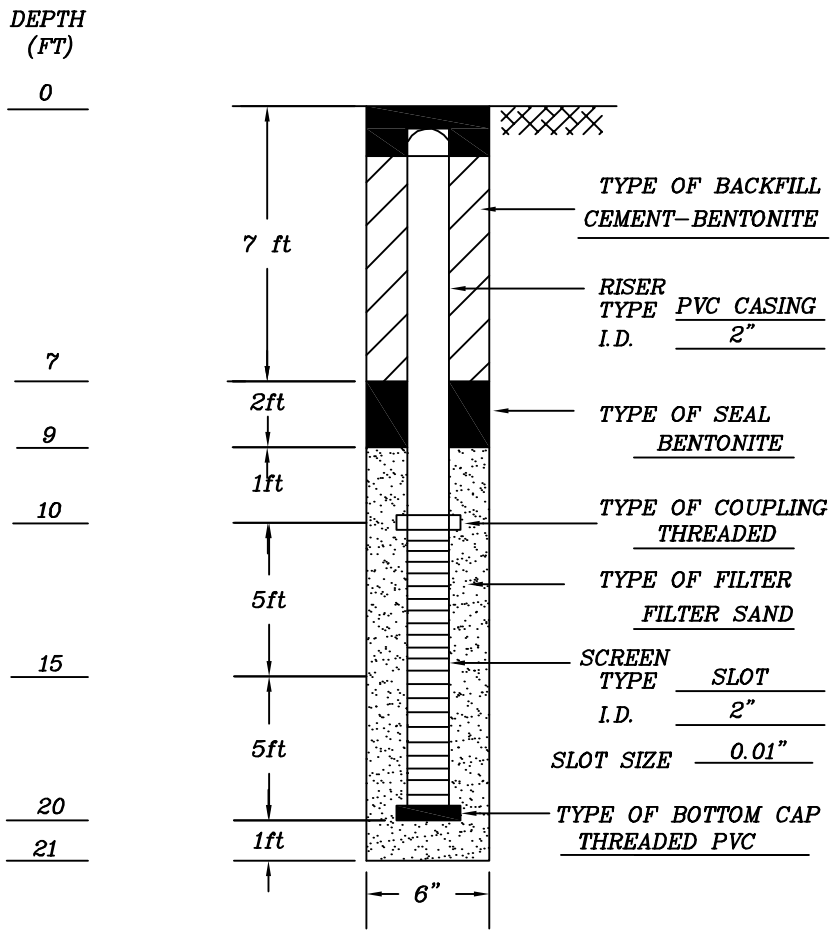
DRILING FLUID: _____

DEVELOPMENT DATE: 10-9-13

METHOD OF DEVELOPMENT: BAILING

WATER LEVEL READING:

DATE	READING
10-10-13	13'
10-17-13	13'
11-11-13	12'



(NOT TO SCALE)

REMARKS:

NOTES:

DRILLED BY: VAN & SON	STARTED: 10-9-13	ATL job No. G13-211
LOGGED BY: PV	COMPLETED: 10-9-13	
CHECKED BY: JITU	APPROVED BY: PST	SHEET 4 OF 4

ASSOCIATED TESTING LABORATORIES, INC.

STATE OF TEXAS WELL REPORT for Tracking #348136

Owner:	**City of Houston Geotechnical Dept**	Owner Well #:	**PZ-1**
Address:	**611 Walker Floor 14 Houston , TX 77002**	Grid #:	**65-13-5**
Well Location:	**Alba Rd at Judiway Houston , TX 77088**	Latitude:	**29° 49' 15" N**
Well County:	**Harris**	Longitude:	**095° 25' 13" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **10/9/2013** Completed: **10/9/2013**
Diameter of Hole:	Diameter: **4 in From Surface To 30 ft**
Drilling Method:	**Mud Rotary**
Borehole Completion:	Other: **(No Data)**
Annular Seal Data:	1st Interval: **From 0 ft to 6 ft with .5 cement (#sacks and material)** 2nd Interval: **From 6 ft to 8 ft with .5 bentonite (#sacks and material)** 3rd Interval: **No Data** Method Used: **tremmie** Cemented By: **No Data** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**
Water Level:	Static level: **27 ft. below land surface on 10/9/2013** Artesian flow: **No Data**
Packers:	**20/40 8-30**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**No Data**
Well Tests:	**No Data**
Water Quality:	Type of Water: **No Data** Depth of Strata: **No Data** Chemical Analysis Made: **No** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No Data**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Driller License Number:	**3286**

Licensed Well Driller Signature:	**Mark Thornton**
Registered Driller Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking **#348136**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft) To (ft) Description
0-2 Sandy Clay
2-4 Sand
4-6 Clay
6-8 Sandy Clay
8-10 Sandy Clay
10-12 Clayey Sand
12-20 Sandy Clay
20-25 Clay
25-30 Silty Clay

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
2 n Sch 40 PVC Riser 0-20
2 n Sch 40 PVC Screen 20-30 .010

STATE OF TEXAS WELL REPORT for Tracking #348137

Owner:	**City of Houston Geotechnical Dept**	Owner Well #:	**pz-2**
Address:	**611 Walker Floor 14 Houston , TX 77002**	Grid #:	**65-13-5**
Well Location:	**Alba Rd at 42nd St Houston , TX 77023**	Latitude:	**29° 49' 31" N**
Well County:	**Harris**	Longitude:	**095° 25' 13" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **10/10/2013** Completed: **10/10/2013**
Diameter of Hole:	Diameter: **4 in From Surface To 27 ft**
Drilling Method:	Other:
Borehole Completion:	Other: **(No Data)**
Annular Seal Data:	1st Interval: **From 0 ft to 13 ft with 1 cement (#sacks and material)** 2nd Interval: **From 13 ft to 15 ft with .5 bentonite (#sacks and material)** 3rd Interval: **No Data** Method Used: **tremmie** Cemented By: **No Data** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**
Water Level:	Static level: **12 ft. below land surface on 10/10/2013** Artesian flow: **No Data**
Packers:	**20/40 15-27**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**No Data**
Well Tests:	**No Data**
Water Quality:	Type of Water: **No Data** Depth of Strata: **No Data** Chemical Analysis Made: **No** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Driller License Number:	**3286**

Licensed Well Driller Signature:	**Mark Thornton**
Registered Driller Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking **#348137**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft)	To (ft)	Description
0	**8**	**Clay**
8	**12**	**Sandy Clay**
12	**18**	**Sand**
18	**25**	**Clay**
25	**27**	**Sandy Clay**

CASING, BLANK PIPE & WELL SCREEN DATA

Dia.	New/Used	Type	Setting From/To
2	**n**	**Sch 40 PVC Riser**	**0-17**
2	**n**	**Sch 40 PVC Screen**	**17-27**

STATE OF TEXAS WELL REPORT for Tracking #348139

Owner:	**City of Houston Geotechnical Dept**	Owner Well #:	**pz-3**
Address:	**611 Walker Floor 14 Houston , TX 77002**	Grid #:	**65-13-6**
Well Location:	**Brinkman St at Chamboard Ln Houston , TX 77018**	Latitude:	**29° 49' 51" N**
Well County:	**Harris**	Longitude:	**095° 24' 58" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **10/9/2013** Completed: **10/9/2013**
Diameter of Hole:	Diameter: **4 in From Surface To 24 ft**
Drilling Method:	Other:
Borehole Completion:	Other: **(No Data)**
Annular Seal Data:	1st Interval: **From 0 ft to 10 ft with 1 cement (#sacks and material)** 2nd Interval: **From 10 ft to 12 ft with .5 bentonite (#sacks and material)** 3rd Interval: **No Data** Method Used: **tremmie** Cemented By: **No Data** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**
Water Level:	Static level: **14 ft. below land surface on 10/9/2013** Artesian flow: **No Data**
Packers:	**20/40 12-24**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**No Data**
Well Tests:	**No Data**
Water Quality:	Type of Water: **No Data** Depth of Strata: **No Data** Chemical Analysis Made: **No** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Driller License Number:	**3286**

Licensed Well Driller Signature:	**Mark Thornton**
Registered Driller Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

STATE OF TEXAS WELL REPORT for Tracking #348140

Owner:	**City of Houston Geotechnical Dept**	Owner Well #:	**pz-4**
Address:	**611 Walker Floor 14 Houston , TX 77002**	Grid #:	**65-13-3**
Well Location:	**Brinkman St near Janisch Houston , TX 77018**	Latitude:	**29° 50' 14" N**
Well County:	**Harris**	Longitude:	**095° 24' 59" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **10/9/2013** Completed: **10/9/2013**
Diameter of Hole:	Diameter: **4 in From Surface To 22 ft**
Drilling Method:	**Mud Rotary**
Borehole Completion:	Other: **(No Data)**
Annular Seal Data:	1st Interval: **From 0 ft to 8 ft with 1 cement (#sacks and material)** 2nd Interval: **From 8 ft to 10 ft with .5 bentonite (#sacks and material)** 3rd Interval: **No Data** Method Used: **tremmie** Cemented By: **No Data** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**
Water Level:	Static level: **14 ft. below land surface on 10/9/2013** Artesian flow: **No Data**
Packers:	**20/40 10-22**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**No Data**
Well Tests:	**No Data**
Water Quality:	Type of Water: **No Data** Depth of Strata: **No Data** Chemical Analysis Made: **No** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Driller License Number:	**3286**

Licensed Well Driller Signature:	**Mark Thornton**
Registered Driller Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking **#348140**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft)	To (ft)	Description
0	**8**	**Sandy Clay**
8	**22**	**Sand**

CASING, BLANK PIPE & WELL SCREEN DATA

Dia.	New/Used	Type	Setting From/To
2	**n**	**Sch 40 PVC**	**0-12**
2	**n**	**Sch 40 PVC**	**12-22**

STATE OF TEXAS PLUGGING REPORT for Tracking #92020

Owner:	**City of Houston Geotech Dept**	Owner Well #:	**pz-1**
Address:	**611 Walker, Floor 14 Houston , TX 77002**	Grid #:	**65-13-5**
Well Location:	**Alba Rd at Judi Way Houston , TX 77088**	Latitude:	**29° 49' 15" N**
Well County:	**Harris**	Longitude:	**095° 25' 13" W**
		GPS Brand Used:	**No Data**
Well Type:	**Monitor**		

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**Mark Thornton**
Driller's License Number of Original Well Driller:	**3286M**
Date Well Drilled:	**10/9/2013**
Well Report Tracking Number:	**348136**
Diameter of Borehole:	**4 inches**
Total Depth of Borehole:	**30 feet**

Date Well Plugged:	**12/10/2013**
Person Actually Performing Plugging Operation:	**Mark Thornton**
License Number of Plugging Operator:	**3286**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **2 inches diameter, From 0 ft to 30 ft** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 30 ft; Sack(s)/type of cement used: 2 cement** 2nd Interval: **No Data** 3rd Interval: **No Data** 4th Interval: **No Data** 5th Interval: **No Data**

Certification Data:	The plug installer certified that the plug installer plugged this well (or the well was plugged under the plug installer's direct supervision) and that each and all of the statements herein are true and correct. The plug installer understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Plug Installer License Number:	**3286**

Licensed Plug Installer Signature:	**Mark Thornton**
Registered Plug Installer Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Plugging Method Comments:	**No Data**

Please include the plugging report's tracking number (Tracking **#92020**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

STATE OF TEXAS PLUGGING REPORT for Tracking #92021

Owner:	**City of Houston Geotech Dept**	Owner Well #:	**pz-2**
Address:	**611 Walker, Floor 14 Houston , TX 77002**	Grid #:	**65-13-5**
Well Location:	**Alba Rd at 42nd St Houston , TX 77088**	Latitude:	**29° 49' 31" N**
Well County:	**Harris**	Longitude:	**095° 25' 13" W**
		GPS Brand Used:	**No Data**
Well Type:	**Monitor**		

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**Mark Thornton**
Driller's License Number of Original Well Driller:	**3286M**
Date Well Drilled:	**10/10/2013**
Well Report Tracking Number:	**348137**
Diameter of Borehole:	**4 inches**
Total Depth of Borehole:	**27 feet**

Date Well Plugged:	**12/10/2013**
Person Actually Performing Plugging Operation:	**Mark Thornton**
License Number of Plugging Operator:	**3286**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **2 inches diameter, From 0 ft to 27 ft** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 27 ft; Sack(s)/type of cement used: 2 cement** 2nd Interval: **No Data** 3rd Interval: **No Data** 4th Interval: **No Data** 5th Interval: **No Data**

Certification Data:	The plug installer certified that the plug installer plugged this well (or the well was plugged under the plug installer's direct supervision) and that each and all of the statements herein are true and correct. The plug installer understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Plug Installer License Number:	**3286**

Licensed Plug Installer Signature:	**Mark Thornton**
Registered Plug Installer Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Plugging Method Comments:	**No Data**

Please include the plugging report's tracking number (Tracking **#92021**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

STATE OF TEXAS PLUGGING REPORT for Tracking #92022

Owner:	**City of Houston Geotech Dept**	Owner Well #:	**pz-3**
Address:	**611 Walker, Floor 14 Houston , TX 77002**	Grid #:	**65-13-6**
Well Location:	**Brinkman at Chamboard Houston , TX 77018**	Latitude:	**29° 49' 51" N**
Well County:	**Harris**	Longitude:	**095° 24' 58" W**
		GPS Brand Used:	**No Data**
Well Type:	**Monitor**		

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**Mark Thornton**
Driller's License Number of Original Well Driller:	**3286M**
Date Well Drilled:	**10/9/2013**
Well Report Tracking Number:	**348139**
Diameter of Borehole:	**4 inches**
Total Depth of Borehole:	**24 feet**

Date Well Plugged:	**12/10/2013**
Person Actually Performing Plugging Operation:	**Mark Thornton**
License Number of Plugging Operator:	**3286**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **2 inches diameter, From 0 ft to 24 ft** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 24 ft; Sack(s)/type of cement used: 2 cement** 2nd Interval: **No Data** 3rd Interval: **No Data** 4th Interval: **No Data** 5th Interval: **No Data**

Certification Data:	The plug installer certified that the plug installer plugged this well (or the well was plugged under the plug installer's direct supervision) and that each and all of the statements herein are true and correct. The plug installer understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service 319 John Alber Houston , TX 77076**
Plug Installer License Number:	**3286**

Licensed Plug Installer Signature:	**Mark Thornton**
Registered Plug Installer Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Plugging Method Comments:	**No Data**

Please include the plugging report's tracking number (Tracking **#92022**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

STATE OF TEXAS PLUGGING REPORT for Tracking #92023

Owner:	**City of Houston Geotech Dept**	Owner Well #:	**pz-4**
Address:	**611 Walker, Floor 14** **Houston , TX 77002**	Grid #:	**65-13-3**
Well Location:	**Brinkman near Janisch** **Houston , TX 77018**	Latitude:	**29° 50' 14" N**
Well County:	**Harris**	Longitude:	**095° 24' 59" W**
		GPS Brand Used:	**No Data**
Well Type:	**Monitor**		

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**Mark Thornton**
Driller's License Number of Original Well Driller:	**3286M**
Date Well Drilled:	**10/9/2013**
Well Report Tracking Number:	**348140**
Diameter of Borehole:	**4 inches**
Total Depth of Borehole:	**22 feet**

Date Well Plugged:	**12/10/2013**
Person Actually Performing Plugging Operation:	**Mark Thornton**
License Number of Plugging Operator:	**3286**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **2 inches diameter, From 0 ft to 22 ft** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 22 ft; Sack(s)/type of cement used: 1.5 cement** 2nd Interval: **No Data** 3rd Interval: **No Data** 4th Interval: **No Data** 5th Interval: **No Data**

Certification Data:	The plug installer certified that the plug installer plugged this well (or the well was plugged under the plug installer's direct supervision) and that each and all of the statements herein are true and correct. The plug installer understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Van and Sons Drilling Service** **319 John Alber** **Houston , TX 77076**
Plug Installer License Number:	**3286**

Licensed Plug Installer Signature:	**Mark Thornton**
Registered Plug Installer Apprentice Signature:	**Elliot Van Antwerp**
Apprentice Registration Number:	**No Data**
Plugging Method Comments:	**No Data**

Please include the plugging report's tracking number (Tracking **#92023**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

APPENDIX 3

BORING LOGS AND KEY TO LOG TERMS AND SYMBOLS

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-1 (PZ-1)

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-9-13

SURFACE ELEVATION: 72.53

LOCATION

Alba Road
Northing: 13865214.2921
Easting: 3103825.23

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description
0		2" Asphalt
	SC	8" Base
	SM	Clayey Sand (SC), compact, medium plasticity, light gray & tan
5	CL	Silty Sand (SM), medium dense, non plastic, light gray & tan
	SM	Sandy Lean Clay (CL), hard, medium plasticity, light gray & tan
	CL	Silty Sand (SM), medium dense, non plastic, light gray & tan
10	SM	Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan
		Silty Sand (SM), medium dense, non plastic, light gray & tan
15		Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan
20	CL	
25		
30		

Pocket Penetrometer (P, tsf)	Blow Count (N, Blows/Foot)	Dry Density (pcf)	Unconfined Comp. Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)
4.0						11	31	16	15	40
	12					5				
4.5						8				
	16					9				
4.0		113	1.8		0	10				
	25					10				22
3.0						14	31	16	15	
3.5						17				
4.0		115	1.91		12	18				
3.5						18				
4.0		111	1.6		0	22				
3.0						20	28	15	13	

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20, 40, 60, 80)

Water Level: Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 27', After Drilling: 23'

Sample Key: SPT, Shelby Tube, Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 28' ; PZ water level: 17' (10-10-2013); PZ water level: 16' (10-17-2013); PZ water level: 15' (11-11-2013); Drilled By: Van & Sons, Logged BY: PV, Checked By: Jitu/pankaj QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-2

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

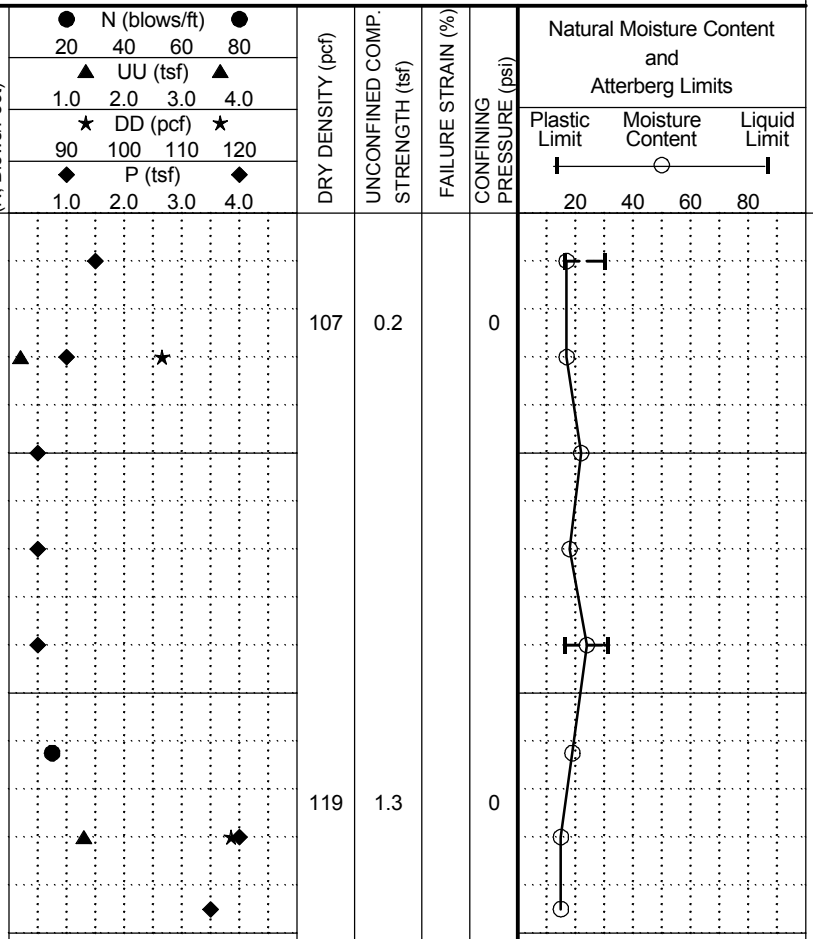
DATE: 10-7-13

SURFACE ELEVATION: 69.96

LOCATION

Wakefield Drive
Northing: 13865401.08039
Easting: 3103617.13882

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		Possible Fill: Sandy Lean Clay (CL), stiff, medium plasticity, light gray & tan	1.5						17	30	16	14	56	
				.. soft below 2'	1.0		107	0.2		0	17					
					0.5						22					
5					0.5						18					
					0.5						24	31	16	15		
10		SM	▽	Silty Sand (SM), medium dense, non plastic, light gray & tan, wet		15					19				20	
		CL	▼	Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	4.0		119	1.3		0	15					
					3.5						15					
15																



Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 10', After Drilling: 14'. Caved in at 14.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-3

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

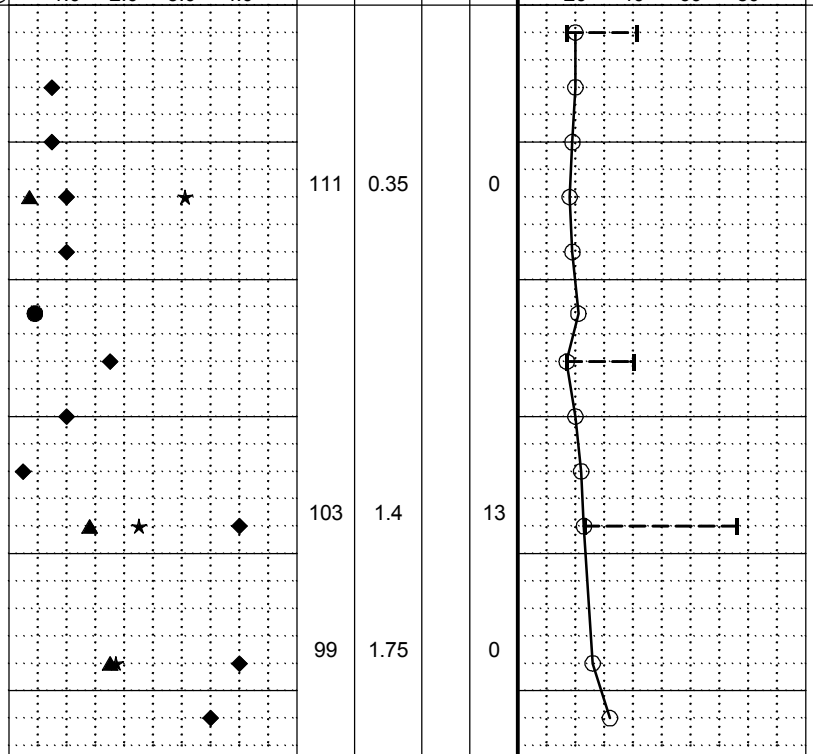
DATE: 10-10-13

SURFACE ELEVATION: 71.31

LOCATION

Alba Road
Northing: 13865859.46
Easting: 3103804.27279

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER (P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		Fill: Sandy Lean Clay (CL), high plasticity, light gray & tan							20	41	17	24		
		.. soft below 2'	0.75						20					
			0.75						19					
5	CL	.. firm below 6'	1.0		111	0.35		0	18					
			1.0						19					
10	SM	Fill: Silty Sand (SM), loose, non plastic, light gray & tan (wet)		9					21					
		Fill: Sandy Lean Clay (CL), stiff, high plasticity, light gray & tan	1.75						17	40	17	23	63	
15	CL	.. firm below 14'	1.0						20					
		.. soft and wet below 16'	0.25						22					
20	CH	Fat Clay With Sand (CH), very stiff, very high plasticity, light gray & tan	4.0		103	1.4		13	23	76	23	53		
		.. with ferrous nodules below 23' (slickensided)	4.0		99	1.75		0	26					
25			3.5						32					



Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 16', After Drilling: N/A. Caved in at 10.5'

Sample Key: ☒ SPT ☐ Shelby Tube ▤ Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 18'; wash boring below 18' & Hole Grouted after Drilling. Drilled By: Van & Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-4

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-7-13

SURFACE ELEVATION: 71.37

LOCATION

Fisher Drive
Northing: 13865888.23863
Easting: 3103370.51983

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0				4" Asphalt												
				4" Lime stabilized shell base												
		CH		Sandy Fat Clay (CH), very stiff, very high plasticity, light gray & tan	2.5						25	79	23	56	66	
					3.5		103	1.0		0	20					
				Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan with sand seams	2.75						16					
5																
		CL			2.5						17					
				.. stiff below 8'	2.0		116	0.85		0	14	29	15	14		
10				Silty Sand (SM), medium dense, non plastic, light gray & tan .. wet at 11'		23					21					
		SM				20					21				19	
						20					21					
15																

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 11', After Drilling: N/A. Caved in at 12'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-5

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

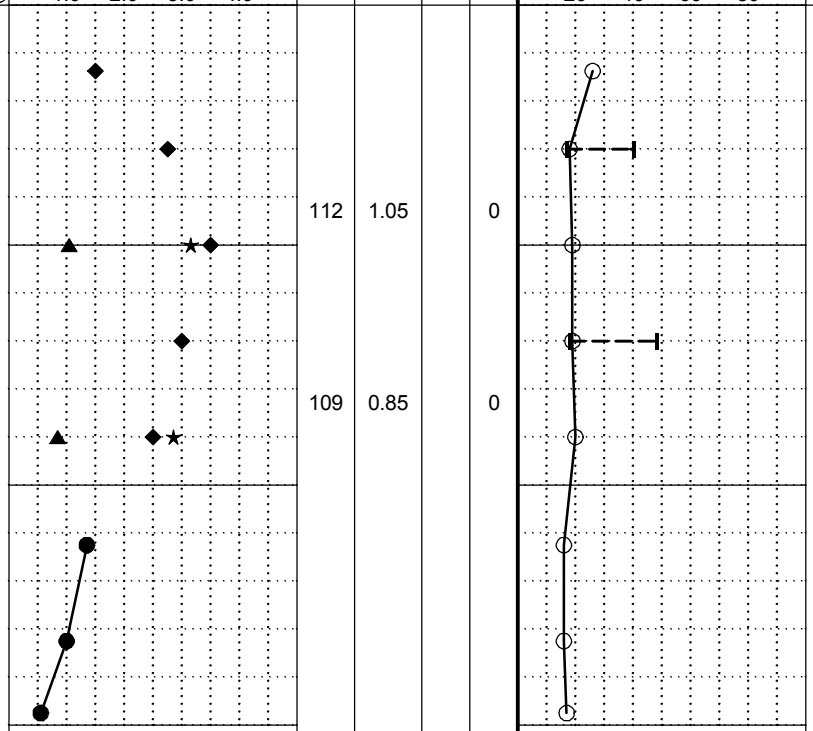
DATE: 10-7-13

SURFACE ELEVATION: 71.66

LOCATION

Fisher Drive
Northing: 13865934.09163
Easting: 3104531.32758

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		5" Asphalt												
		4" Limestone crushed base												
	CL	Sandy Lean Clay (CL), stiff, high plasticity, light gray & tan	1.5						26					
		.. very stiff below 2'	2.75						18	40	17	23	57	
		.. with sand seams below 4'	3.5		112	1.05		0	19					
5		.. with ferrous nodules below 6'	3.0						19	48	18	30		
			2.5		109	0.85		0	20					
10	SM	Silty Sand (SM), medium dense, non plastic, light gray & tan, moist		27					16				37	
				20					16					
15				11					17					



Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: Dry, After Drilling: Dry

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-6

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-10-13

SURFACE ELEVATION: 71.66

LOCATION

W. 41st St.
Northing: 13866401.1279
Easting: 3103835.37894

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	Sandy Lean Clay (CL), stiff, high plasticity, light gray & tan	2.0						14					
		.. hard below 2'	4.5						12	40	17	23	61	
			4.5						15					
5		.. with ferrous nodules below 6'	4.5						16					
		.. very stiff below 8'	4.0						14					
10		.. soft below 10'	0.75						13					
	SM	Silty Sand (SM), medium dense, non plastic, light gray & tan		15					19				16	
15		.. wet at 14'		12					20					
				24					21					
	CH	Fat Clay With Sand (CH), very stiff, high plasticity, light gray & tan (Slickensided)	3.5		103	1.3		0	26					
20			3.25						20	57	20	37		
25		.. hard, reddish brown below 25'	4.5		110	2.25		0	20					

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 14', After Drilling: N/A. Caved in at 12.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 18'; wash boring below 18' & Hole Grouted after Drilling. Drilled By: Van & Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-7

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-8-13

SURFACE ELEVATION: 72.05

LOCATION

W. 41st St.
Northing: 13866405.45662
Easting: 3103478.61734

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		Sandy Lean Clay (CL), stiff, slight plasticity, light gray & tan	1.5						13	24	15	9	55	
				.. with sand seams below 2'	1.5						16					
					3.0						16					
5				.. very stiff below 4'	3.5						16					
				.. with ferrous nodules below 6'	3.0						17					
10				.. stiff below 10'	2.0						16	25	15	10		
				.. firm, with sand seams below 12'	1.5		111	0.4		0	16					
15		SM		Silty Sand (SM), loose, non plastic, light gray & tan (wet)		9					20				15	

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 14', After Drilling: N/A. Caved in at 13.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-8

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

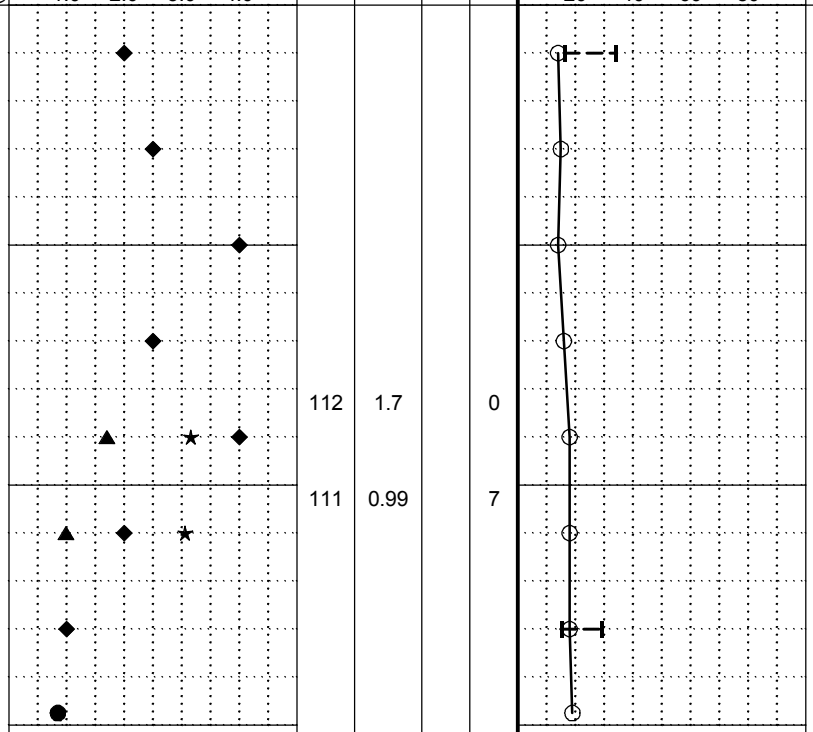
DATE: 10-8-13

SURFACE ELEVATION: 72.09

LOCATION

W. 41st St.
Northing: 13866377.00516
Easting: 3104228.67862

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		Sandy Lean Clay (CL), stiff, medium plasticity, light gray & tan	2.0						14	34	16	18	56	
				.. very stiff, with sand seams below 2'	2.5						15					
					4.0						14					
5				.. with ferrous nodules below 6'	2.5						16					
					4.0		112	1.7		0	18					
10				.. stiff below 10'	2.0		111	0.99		7	18					
				.. firm below 12'	1.0						18	29	15	14		
15		SM	▽	Silty Sand (SM), medium dense, non plastic, light gray & tan (wet)		17					19				22	



Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 14', After Drilling: N/A.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-9

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-7-13

SURFACE ELEVATION: 72.24

LOCATION
W. 41st St.
Northing: 13866355.01932
Easting: 3104686.34834

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		Sandy Lean Clay (CL), stiff, medium plasticity, light gray & tan	2.0						13					
				.. very stiff below 2'	3.5						7	30	16	14	53	
				.. hard below 4'	4.5						12					
5				.. with ferrous nodules below 6'	4.5						12					
					4.5		118	2.05		0	14					
10					4.5						13	33	16	17		
		SM		Silty Sand (SM), medium dense, non plastic, light gray & tan		21					15				35	
15		CL		Sandy Lean Clay (CL), stiff, medium plasticity, light gray & tan	2.0		113	0.75		0	13					

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: Dry, After Drilling: Dry

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-10

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

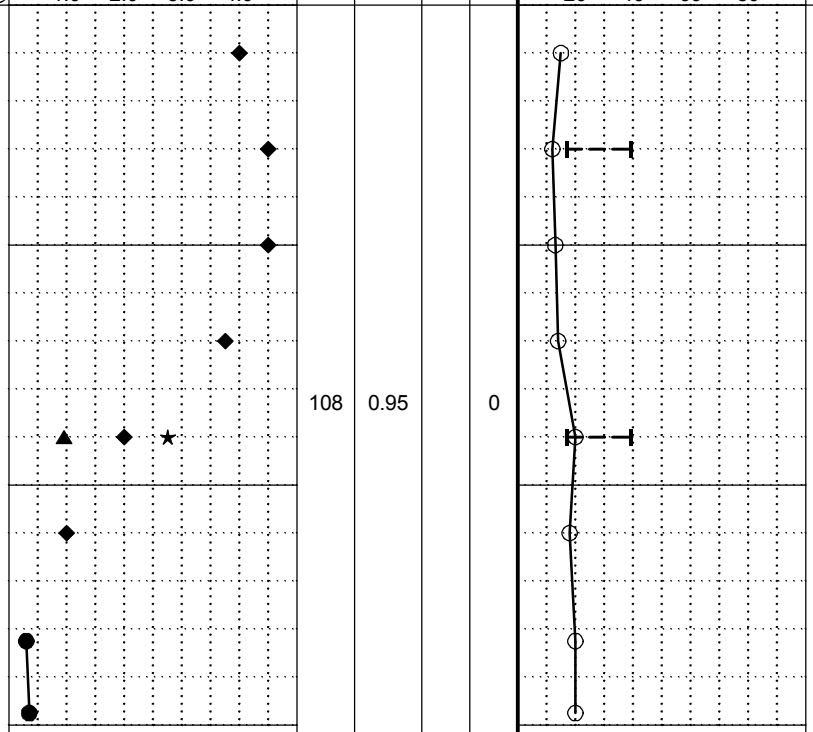
DATE: 10-7-13

SURFACE ELEVATION: 73.04

LOCATION

W. 41st St.
Northing: 13866388.39056
Easting: 3105205.95456

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	4.0						15					
		.. hard below 2'	4.5						12	39	17	22	59	
		.. reddish brown below 4'	4.5						13					
5		.. very stiff, light gray & tan below 6'	3.75						14					
		.. stiff below 8'	2.0		108	0.95		0	20	39	17	22		
10		.. firm below 10'	1.0						18					
	SM	Silty Sand (SM), loose, non plastic, light gray & tan (wet)		6					20				14	
15				7					20					



Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 12.5', After Drilling: N/A. Caved in at 13'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-11 (PZ-2)

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-10-13

SURFACE ELEVATION: 72.60

LOCATION

Alba Road
Northing: 13866958.2133
Easting: 3103818.5043

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		2.5" Asphalt												
		5.5" Concrete												
	CH	Fat Clay With Sand (CH), hard, high plasticity, light gray & tan	4.5						13					
			4.5						14	61	21	40	72	
			4.5						12					
5		Sandy Lean Clay (CL), hard, medium plasticity, light gray & tan												
			4.5						20					
	CL	.. with ferrous nodules below 8'	4.5						20					
10		.. firm, slight plasticity below 10'	1.0		110	0.35		0	19	25	15	10		
		Silty Sand (SM), medium dense, non plastic, light gray & tan .. wet at 12'		18					24					
15	SM			19					24					
				22					22					
		Fat Clay With Sand (CH), stiff, high plasticity, light gray & tan			108	2.00		13	22					
20														
	CH	.. reddish brown below 23' (slickensided)			97	1.05		0	28	65	21	44		
25									20					

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 12', After Drilling: N/A. Caved in at 11.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 14'; wash boring below 14' ; PZ water level: 11' (10-11-2013); PZ water level: 11' (10-17-2013); PZ water level: 11' (11-11-2013); Drilled By: Van & Sons, Logged BY: PV, Checked By: Jitu/pankaj QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-12

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

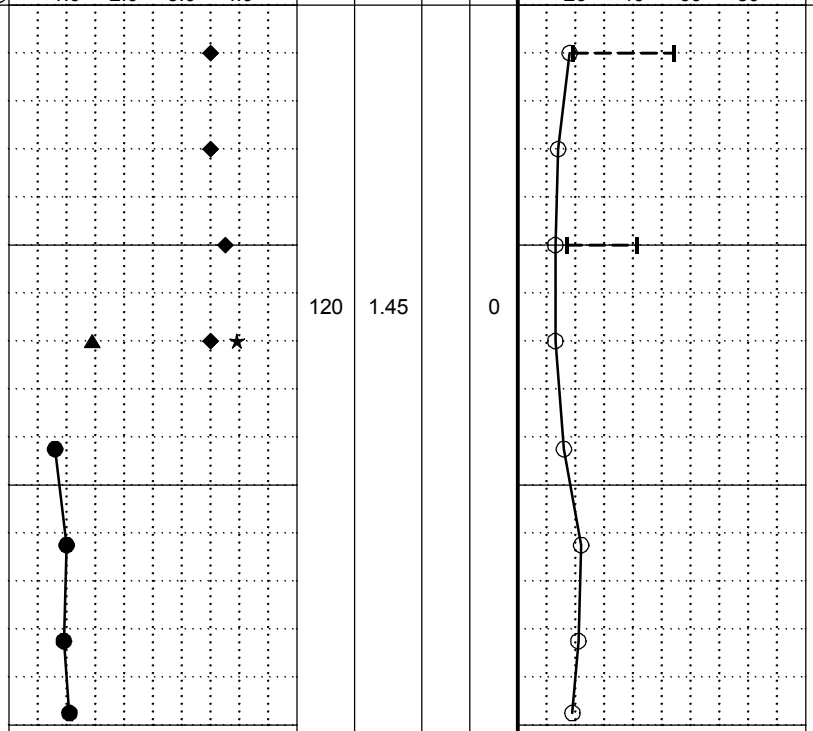
DATE 10-10-13

SURFACE ELEVATION 72.63

LOCATION

W. 42nd St.
Northing: 13866739.908
Easting: 3104412.97134

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CH		Sandy Fat Clay (CH), very stiff, high plasticity, light gray & tan	3.5						18	54	19	35	60	
				.. very stiff below 2'	3.5						14					
		CL		Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	3.75						13	41	17	24		
5					3.5		120	1.45		0	13					
		SM		Silty Sand (SM), medium dense, non plastic, light gray & tan		16					16					
				.. with sandy clay seams 8'-10'												
10			▽	.. wet at 10'		20					22					
						19					21					
15						21					19				28	



Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 10', After Drilling: N/A.

Sample Key: ☒ SPT ▨ Shelby Tube ▤ Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-13

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-10-13

SURFACE ELEVATION: 73.58

LOCATION

La Monte Ln.
Northing: 13867104.60133
Easting: 3104858.18858

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CH		Sandy Fat Clay (CH), stiff, very high plasticity, light gray & tan	2.0						26	80	24	56	62	
					4.0						17					
		CL		Sandy Lean Clay (CL), hard, medium plasticity, light gray & tan	4.5						14					
5				.. with ferrous nodules below 6'	4.5						14					
				.. very stiff below 8'	3.0						16	33	16	17		
10				.. stiff, with sand seams below 10'	2.0		113	0.65			16					
		SM	▽	Silty Sand (SM), medium dense, non plastic, light gray & tan		15					17					
15				.. wet at 14'		18					16				22	

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)

N (blows/ft) 20 40 60 80; UU (tsf) 1.0 2.0 3.0 4.0; DD (pcf) 90 100 110 120; P (tsf) 1.0 2.0 3.0 4.0

Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 14', After Drilling: N/A. Caved in at 14'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-14

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-10-13

SURFACE ELEVATION: 73.33

LOCATION

Alba Road
Northing: 13867549.3146
Easting: 3103914.8926

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER (P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		2" Asphalt												
		6" Concrete												
	CL	Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan	3.0						13					
			3.75						13					
5		.. with ferrous nodules below 2'	4.0						13					
		.. stiff, with sand seams below 6'	2.0						14	28	15	13	51	
		.. firm below 8'	1.0						15					
10	SM	Silty Sand (SM), loose, non plastic, light gray & tan		9					19					
		.. medium dense below 12'		14					19					
15		.. wet below 14'		21					19				15	
				20					21					
20	CH	Fat Clay With Sand (CH), very stiff, high plasticity, light gray & tan	3.5		104	0.89		13	19					
		.. with slickensided layers below 23'	3.5		109	1.45		0	20	53	19	34		
25		.. hard, reddish brown below 25'	4.5						25					

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 14', After Drilling: N/A. Caved in at 12.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 18'; wash boring below 18' & Hole Grouted after Drilling. Drilled By: Van & Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-15

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-10-13

SURFACE ELEVATION: 74.20

LOCATION

Alba Road
Northing: 13868024.0417
Easting: 3103947.6311

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	Material Description	POCKET PENETROMETER (P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	Fill: Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	3.75						11					
		.. hard below 2'	4.5		117	2.25		0	8					
5			4.5						8	38	17	21	52	
	CL	Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	3.0						12					
		.. stiff below 8'	1.5						15					
10	SM	Silty Sand (SM), loose, non plastic, light gray & tan		7					20					
		.. medium dense below 12'		11					19				14	
		.. wet at 13'		14					22					
15	CH	Fat Clay With Sand (CH), very stiff, high plasticity, light gray & tan	3.5		113	2.43		12	16					
		.. hard below 18'	4.5		110	2.1		0	17					
20														
			4.5						17	52	19	33		
25		.. very stiff, with ferrous nodules below 25'	3.5						22					

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 13', After Drilling: N/A. Caved in at 11.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 16'; wash boring below 16' & Hole Grouted after Drilling. Drilled By: Van & Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-16

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-8-13

SURFACE ELEVATION: 75.00

LOCATION

Azalea St.
Northing: 13867907.07271
Easting: 3104581.60657

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		Sandy Lean Clay (CL), stiff, high plasticity, light gray & tan	1.5						20					
					2.0						17	48	18	30	52	
				.. very stiff, with ferrous nodules below 4'	2.5						16					
5																
					3.0						15					
				.. stiff, with sand seams below 8'	2.0						15					
10					2.0		114	0.7		0	16	33	16	17		
		SM	▽	Silty Sand (SM), medium dense, non plastic, light gray & tan .. wet at 12.5'		21					20				23	
15				.. wet below 14'		26					21					

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 12.5', After Drilling: N/A. Caved in at 13'

Sample Key: ☒ SPT ▨ Shelby Tube ▤ Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-17

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

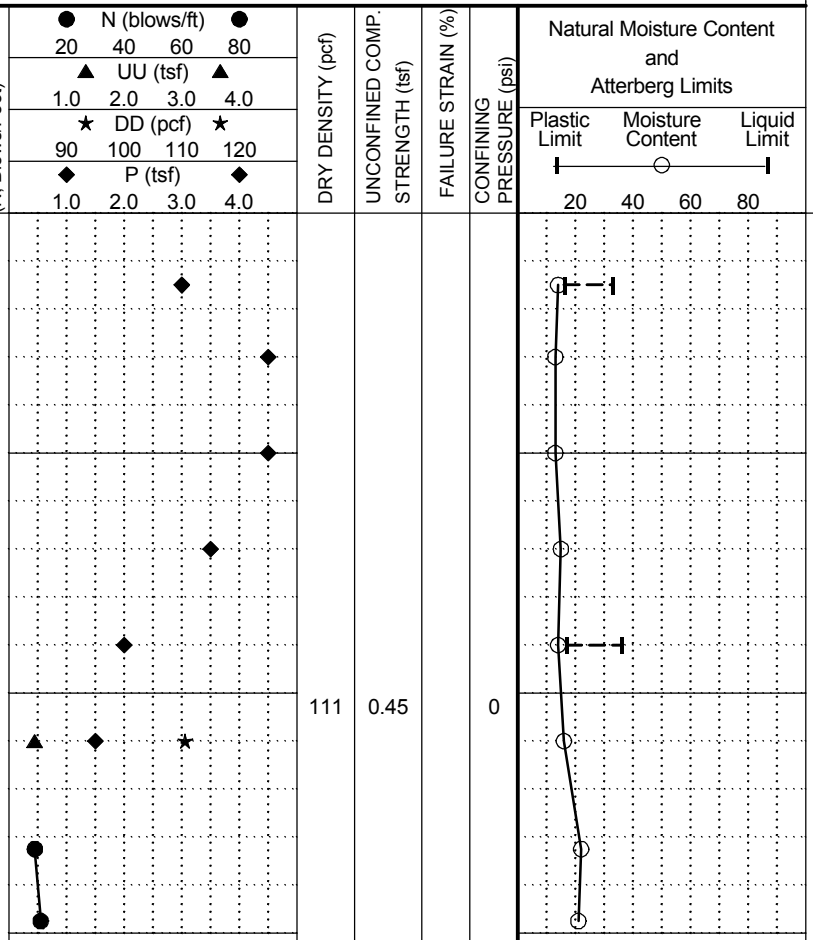
DATE: 10-8-13

SURFACE ELEVATION: 73.93

LOCATION

Sue Barnett St.
Northing: 13868356.6626
Easting: 3104335.17152

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0				4" Asphalt												
				8" Crushed limestone base												
		CL		Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan	3.0						14	33	16	17	51	
				.. hard below 2'	4.5						13					
				.. with ferrous nodules below 4'	4.5						13					
5																
				.. very stiff below 6'	3.5						15					
				.. stiff below 8'	2.0						14	36	17	19		
10					1.5		111	0.45		0	16					
			▽	Silty Sand (SM), loose, non plastic, light gray & tan , wet		9					22				16	
		SM		.. medium dense below 14'		11					21					
15																



Water Level Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 12', After Drilling: N/A. Caved in at 12'

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 15.5' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-18

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-9-13

SURFACE ELEVATION: 75.52

LOCATION

Alba Road
Northing: 13868740.6206
Easting: 3103959.8393

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		5.5" Concrete												
	CL	Sandy Lean Clay (CL), very stiff, slight plasticity, light gray & tan	3.5						8	24	15	9	51	
		.. medium plasticity with ferrous nodules below 2'	4.0		118	1.5		0	15					
5		.. with calcareous nodules below 4'	2.75						15					
			4.0						15	33	16	17		
			3.5		114	1.0		0	17					
10	SM	Silty Sand (SM), medium dense, non plastic, light gray & tan		26					17					
		.. wet at 13'		29					22					
15		.. dense below 14'		32					19					
				35					21					
20				33					21					
25				34					22				17	
30				37					20					

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 13', After Drilling: N/A. Caved in at 12.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 13'; wash boring below 13' & Hole Grouted after Drilling. Drilled By: Van & Sons, Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-19 (PZ-3)

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-9-13

SURFACE ELEVATION: 75.76

LOCATION

Chamboard Ln.
Northing: 13868810.1472
Easting: 3104981.19313

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		3" Asphalt												
		4" Crushed gravel base												
	SC SM	Fill: Clayey Silty Sand (SC-SM), slight plasticity, light gray & tan	3.5						6	20	14	6	46	
			4.0						12					
		Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan	3.0						15					
5	CL	.. with sand seams below 4'												
		.. stiff below 6'	2.0		114	0.5		0	14					
		Silty Sand (SM), medium dense, non plastic, light gray & tan		22					14					
10				25					14					
				30					22				15	
15	SM	.. wet at 14'		27					21					
				25					38					
				13					33					
20		Fat Clay With Sand (CH), very stiff, high plasticity, light gray & tan	4.0		119	1.90		14	15					
	CH	.. hard below 22'	4.5		119	2.2		0	15	50	19	31		

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level: Intial: ▽ After Drilling: ▼ 24 Hrs: ▼
Water Observations: Initial Water Level: 14', After Drilling: N/A. Caved in at 11'

Sample Key: SPT, Shelby Tube, Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 14'; wash boring below 14' ; PZ water level: 11' (10-10-2013); PZ water level: 11.5' (10-17-2013); PZ water level: 11' (11-11-2013); Drilled By: Van & Sons, Logged BY: PV, Checked By: Jitu/pankaj QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-20

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-9-13

SURFACE ELEVATION: 76.05

LOCATION

Brinkman St.
Northing: 13869355.1899
Easting: 3104979.7871

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		6" Asphalt												
	CL	4" Crushed gravel base	2.5						12					
		Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan	3.0						27	59	20	39	60	
5	CH	Sandy Fat Clay (CH), very stiff, high plasticity, light gray & tan	4.5						15					
			4.5						15					
		.. stiff below 8'	2.0		113	0.5		0	17	56	20	36		
10	SM	Silty Sand (SM), medium dense, non plastic, light gray & tan		30					18					
		.. wet at 12'		28					20					
15		.. dense below 14' (wet)		34					20					
		.. wet below 16'		34					20					
20				38					22				25	
				40					22					

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 12', After Drilling: N/A. Caved in at 11'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 12'; wash boring below 12' & Hole Grouted after Drilling. Drilled By: Van & Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-21 (PZ-4)

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-9-13

SURFACE ELEVATION: 77.64

LOCATION

Brinkman St.
Northing: 13871341.58405
Easting: 3104883.65259

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER (P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		4" Asphalt												
		8" Crushed gravel base												
	CL	Fill: Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	3.75						14	24	15	9	51	
			3.5		115	1.0		0	8					
		Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	4.5						10					
5	CL	.. hard, with ferrous nodules below 4'												
			4.5						9	39	17	22		
		Silty Sand (SM), dense, non plastic, light gray & tan		36					4					
10				44					13					
				43					8				34	
15	SM	.. wet at 14'		36					24					
				33					24					
				37					23					
20				41					26					

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 14', After Drilling: N/A. Caved in at 12'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 14'; wash boring below 14' ; PZ water level: 13' (10-10-2013); PZ water level: 13' (10-17-2013); PZ water level: 12' (11-11-2013); Drilled By: Van & Sons, Logged BY: PV, Checked By: Jitu/pankaj QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-22

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

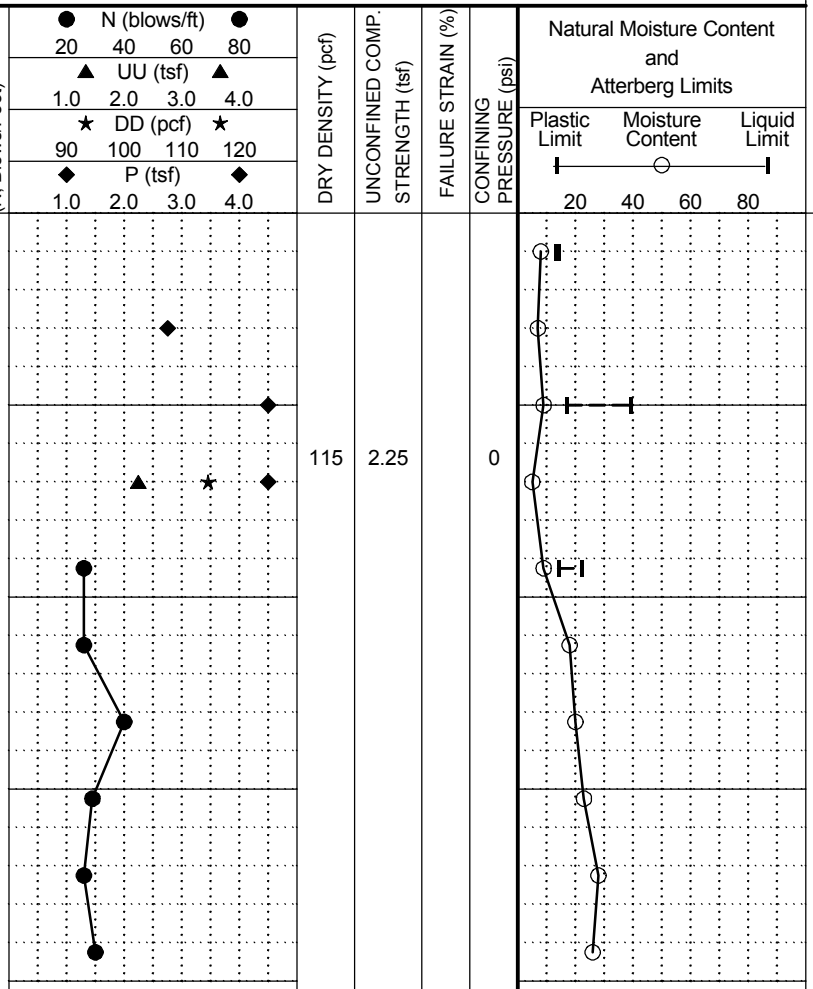
DATE 10-25-13

SURFACE ELEVATION 75.59

LOCATION

On Ditch
Northing: 13871459.4753
Easting: 3105298.6461

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	SM	Silty Sand (SM), slight plasticity, light gray & tan							8	14	13	1	34	
		Sandy Lean Clay (CL), very stiff, high plasticity, light gray & tan	2.75						7				51	(2-4 feet) Crumb=Grade1
		.. hard below 4'	4.5						9	39	17	22	51	(4-6 feet) Crumb=Grade1 Pinhole=ND1
5	CL	.. with ferrous nodules below 6'	4.5		115	2.25		0	5					
	SC SM	Clayey Silty Sand (SC-SM), medium dense, slight plasticity, light gray & tan		26					9	22	14	8	23	(8-10 feet) Crumb=Grade4
10		Silty Sand (SM), medium dense, light gray		26					18				16	
		.. dense, wet below 12'		40					20					
		.. medium dense below 14'		29					23					
15	SM			26					28				15	
				30					26					
20														



Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 12', After Drilling: 12.5'. Caved in at 12.5'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 20' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-23

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE: 10-23-13

SURFACE ELEVATION: 71.74

LOCATION

On Ditch
Northing: 13871488.04
Easting: 3106346.077

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	SC SM	Fill: Clayey Silty Sand (SC-SM), slight plasticity, light gray & tan							14	18	14	4	44	
		.. with gravel below 2'							10					
5	CL	Sandy Lean Clay (CL), hard, high plasticity, light gray & tan	4.5		114	2.05		0	12	39	17	22	53	
		.. with ferrous nodules below 6'	4.5						13					(6-8 feet) Crumb=Grade4 Pinhole=D1
		.. firm below 8'	1.5		106	0.45		0	15	33	16	17	51	(8-10 feet) Crumb=Grade4
10	SM	Silty Sand (SM), non plastic light gray & tan							24					
		.. wet at 12'							23				23	
15									24					
									28				15	
20									27					

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 12', After Drilling: 10'.

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 20' & Hole Grouted after Drilling. Drilled By: M.G. Drilling, using portable rig. Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd
Houston, Texas-77054

LOG OF BORING B-24

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
WBS No.: M-000285-0001-4

PROJECT NO.: G13-211 BORING TYPE: Auger

DATE 10-25-13

SURFACE ELEVATION 73.02

LOCATION

On Ditch
Northing: 13871468.00322
Easting: 3106585.82573

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	POCKET PENETROMETER(P,tsf)	BLOW COUNT (N, Blows/Foot)	DRY DENSITY (pcf)	UNCONFINED COMP. STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		10" Concrete												
		14" Light gray & tan, Limestone base							7				32	
	CL	Sandy Lean Clay (CL), very stiff, medium plasticity, light gray & tan, with sand pockets	4.0						13					
		.. stiff below 4'	2.0		112	0.55		0	15	28	15	13		(4-6 feet) Crumb=Grade4
5		.. very stiff below 6'	2.75						15					
			3.0						18	31	16	15		(8-10 feet) Crumb=Grade4
10		.. stiff, with sand seams below 10'	2.0						18					CU TEST (2'-4', 6'-8',10'-12') cu=358 psf, phi =14.9 deg, Ccu'= 338 psf, phi' =28.7 deg,
	SM	Silty Sand (SM), medium dense, non plastic, light gray & tan (wet)		15					24				15	
		.. dense below 14'		39					21				48	
15		.. medium dense below 16'		15					22					
				21					19					
20														

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Intial: After Drilling: 24 Hrs:
Water Observations: Initial Water Level: 12', After Drilling: 10.5'. Caved in at 10.5'

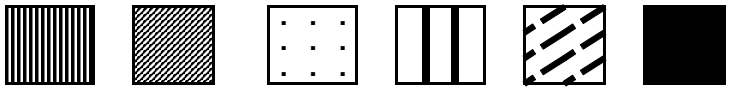
Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
Q_u - Unconfined Comp. Strength (tsf)
DD - Dry Density (pcf)

Notes:
Augered dry to 20' & Hole Grouted after Drilling. Drilled By: Johnson and Sons , Logged BY: PV, Checked By: Jitu/pankaj, QC/QA By: PST

KEY TO LOG TERMS AND SYMBOLS

SOIL TYPE

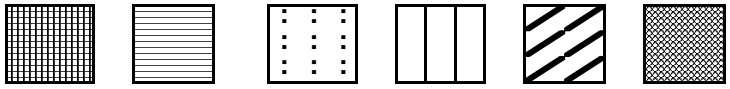


ROCK GRAVEL SAND SILT CLAY PEAT

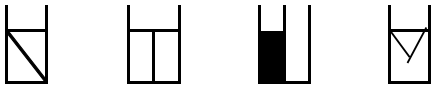
SAMPLER TYPE

NO SAMPLE | AUGER SAMPLE | SHELBY TUBE | SPLIT SPOON

MODIFIER



STONE GRAVELY SANDY SILTY CLAYEY FILL



NO RECOVERY | ROCK CORE | 2" SHELBY TUBE | TXDOT CONE

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D 2487

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS LESS THAN 50% PASSING No. 200 SIEVE	GRAVEL & GRAVELY SOILS LESS THAN 50% PASSING No.4 SIEVE	CLEAN GRAVELS LITTLE OR NO FINES	GW	WELL GRADEED GRAVELS,GRAVELSAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS,GRAVEL SAND MIXTURES WITH LITTLE OR NO FINES
		W/ APPRECIATEBLE FINES	GM	SILTY GRAVELS,GRAVEL SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS,GRAVEL SAND-CLAY MIXTURES
	SANDS MORE THAN 50% PASSING No.4 SIEVE	CLEAN SANDS LITTLE FINES	SW	WELL GRADED SAND,GRAVELY SAND (LITTLE FINES)
			SP	POORLY GRADED SANDS,GRAVELY SAND(L. FINES)
		SANDS WITH APPREA. FINES	SM	SILTY SANDS,SAND-SILT MIXTURES
			SC	CLAYEY SANDS,SAND-CLAY MIXTURES
FINE GRAINED SOILS LESS THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS & VERY FINE SANDS,ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILT W/PI
			CL	INORGANIC CLAY OF LOW TO MEDIUM PI LEAN CLAY, GRAVELY CLAYS,SANDY CLAYS,SILTY CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PI
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS,MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY FAT CLAYS
			OH	ORGANIC CLAYS OF MED TO HIGH PI, ORGANIC SILT
HIGHLY ORGANIC SOIL			FT	PEAT AND OTHER HIGHLY ORGANIC SOILS
UNCLASSIFIED FILL MATERIALS			ARTIFICIALLY DEPOSITED AND OTHER UNCLASSIFIED SOILS FILL MATERIALS	

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMP. STRENGTH IN TSF
VERY SOFT	LESS THAN 0.25
SOFT	0.25 TO 0.5
FIRM	0.5 TO 1.0
STIFF	1.0 TO 2.0
VERY STIFF	2.0 TO 4.0
HARD	GREATER THAN 4.0

CONSISTENCY	UNCORR. POCKET PENTROMETER READ.
VERY SOFT	LESS THAN 0.25
SOFT	0.25 TO 0.5
FIRM	> 0.50 TO 1.50
STIFF	> 1.50 TO 3.00
VERY STIFF	> 3.0 TO 4.50
HARD	4.5+

RELATIVE DENSITY - GRANULAR SOILS

CONSISTENCY	N-VALUE (BLOWS PER FT)
VERY LOOSE	<4
LOOSE	5-10
MEDIUM DENSE	11-30
DENSE	31-50
VERY DENSE	>50 OR 50+

CLASSIFICATION OF GRANULAR SOILS

U.S.STANDARD SIEVE SIZE(S)

	6"	3"	3/4"	4	10	40	200	
BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		
152	76.2	19.1	4.76	2.0	0.42	0.074		0.002

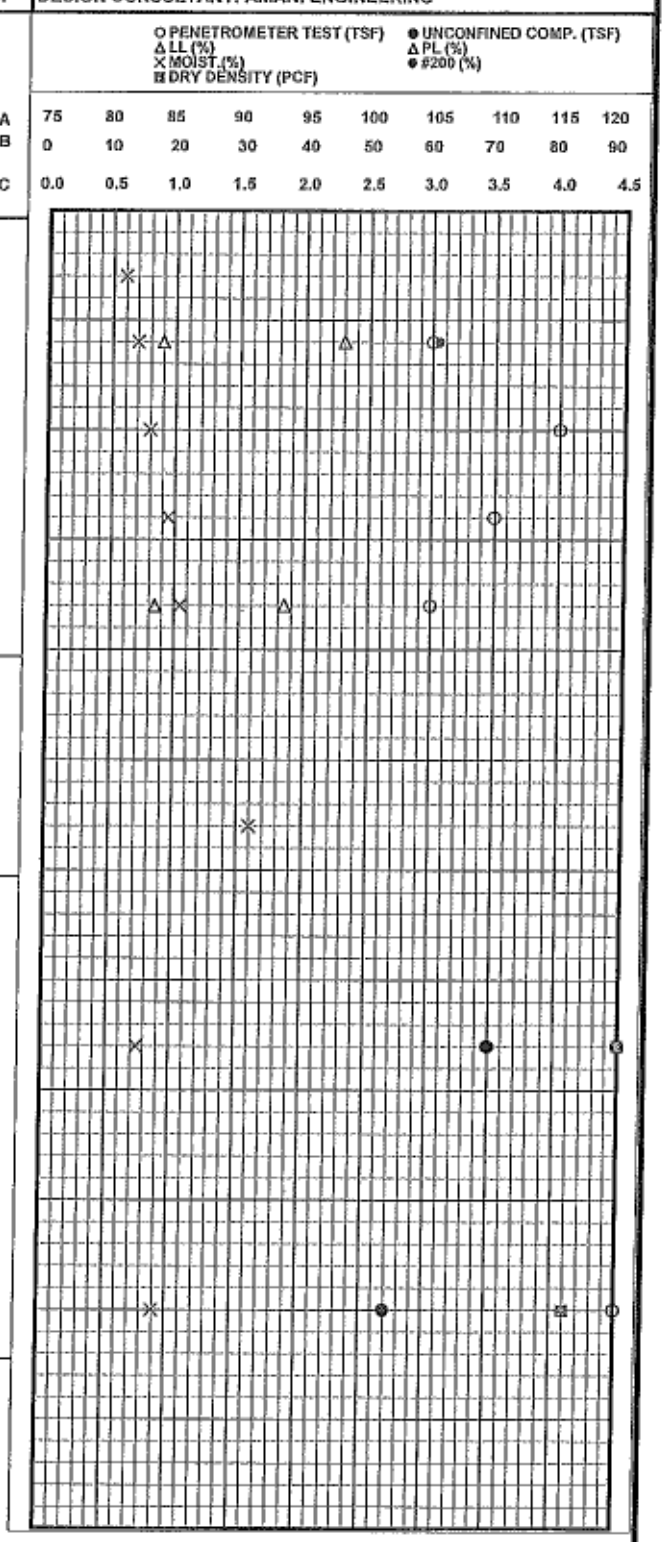
GRAIN SIZE IN MM

APPENDIX 4

BORING LOGS FROM PREVIOUS INVESTIGATIONS BY ATL AND OTHERS

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK	BORING LOG	
TERRACE AREA WBS No.: S-000035-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-15 (PZ-1)
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT: AMANI ENGINEERING	

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
		1			Gray & tan Lean Clay (CL)
2.0					
		2			.. stiff, with sand seams below 2'
4.0					
		3			.. very stiff, light gray & tan, with sand pockets below 4'
6.0					
		4			
8.0					
		5			.. stiff below 8'
10.0					
					Medium dense, light gray & tan Silty Sand (SM) (wet)
		6	22		
15.0					
					Very stiff, tan & light gray Lean Clay (CL)
		7			
20.0					
		8			.. reddish brown, with fat clay layers below 25'
26.0					
					Boring terminated at 26 feet.
30.0					



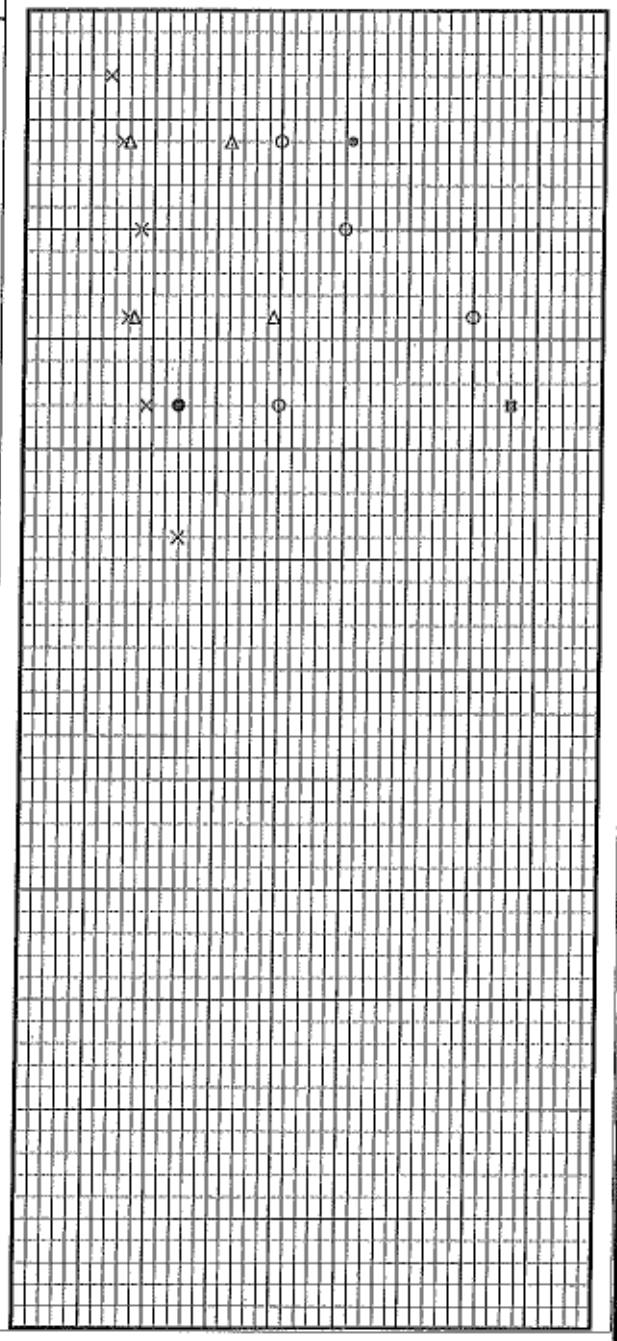
Water First Noticed: 13'	DRILLED & LOGGED BY: F.P.	STARTED: 11-27-2006	STATION OFFSET
Final Water Reading: 12'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: 9' (11-28-06)	PREPARED BY: A. SINGH	COMPLETED: 11-27-2006	NOTE: For Scales Above
PZ WATER LEVEL: 8' (12-05-06)			Scale-A-For Dry Density
PZ WATER LEVEL: 8' (12-28-06)	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
COMPLETION DEPTH: 26'			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK		BORING LOG	
TERRACE AREA	WBS No.: S-000035-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-22
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.		DESIGN CONSULTANT: AMANI ENGINEERING	

O PENETROMETER TEST (TSF) ● UNCONFINED COMP. (TSF)
Δ LL (%) Δ PL (%)
X MOIST.(%) ● #200 (%)
⊠ DRY DENSITY (PCF)

A	75	80	85	90	95	100	105	110	115	120
B	0	10	20	30	40	50	60	70	80	90
C	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
		1			Gray & tan Lean Clay (CL)
2.0					
		2			.. stiff,light gray & tan below 2'
4.0					
		3			.. with ferrous nodules below 4'
6.0					
		4			.. very stiff, tan & light gray below 6'
8.0					
		5			.. stiff below 8'
10.0					
		6	15		Medium dense, light gray & tan Silty Sand (SM) (wet)
13.0					Boring terminated at 13 feet.
15.0					
20.0					
25.0					
30.0					



Water First Noticed: 11'	DRILLED & LOGGED BY: Bryan	STARTED: 11-18-2006	STATION OFFSET
Final Water Reading: 10'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: N/A	PREPARED BY: A. SINGH	COMPLETED: 11-18-2006	NOTE: For Scales Above
HOLE CAVED AT: 11'			Scale-A-For Dry Density
COMPLETION DEPTH: 13'	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
GROUT: YES			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK PLAZA AREA

BORING LOG

WBS No.: S-000035-00N6-4

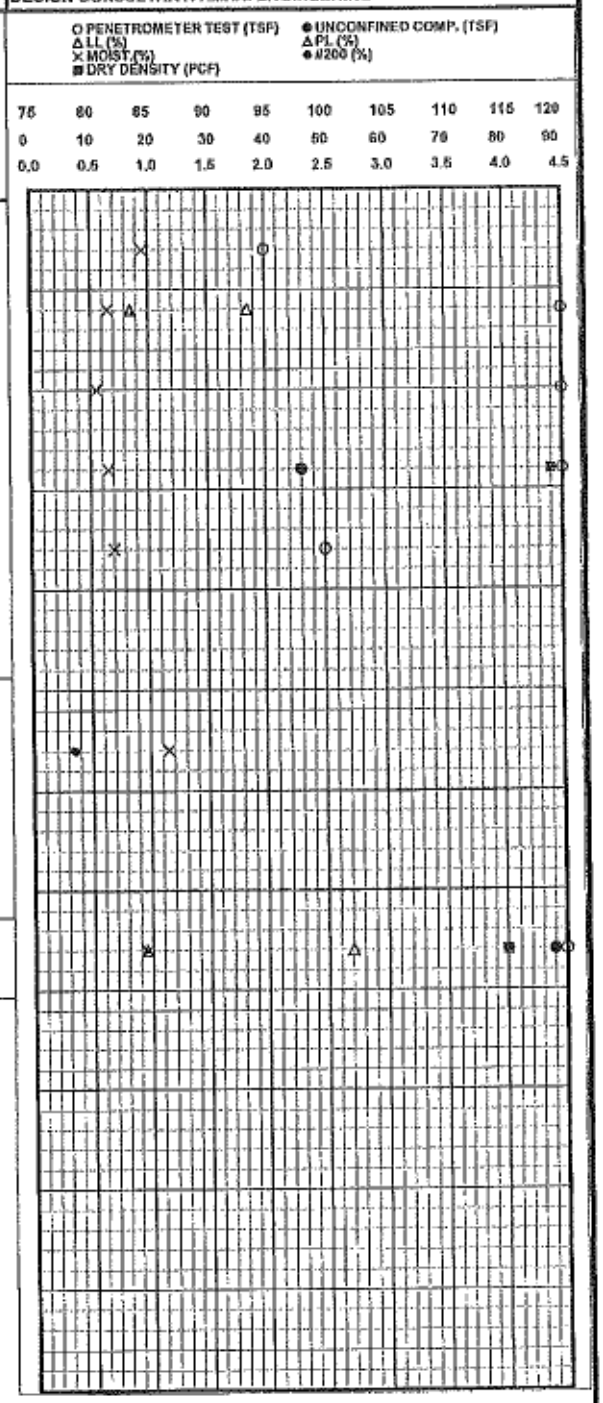
PROJECT NUMBER: G06-408

BORING NUMBER: GB-39 (PZ-4)

GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.

DESIGN CONSULTANT: AMANI ENGINEERING

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
		1			Stiff, gray & tan Sandy Clay (CL)
2.0					
		2			.. very stiff, light gray & tan below 2'
4.0					
		3			.. with ferrous nodules below 4'
6.0					
		4			
8.0					
		5			.. stiff, with sand seams below 8'
10.0					
		6	14		Medium dense, gray & tan Poorly graded Sand with Silt (SP-SM) (wet)
15.0					
		7			Hard, light gray & tan Clay (CH) with calcareous nodules
20.0					
					Boring terminated at 20 feet.
25.0					
30.0					



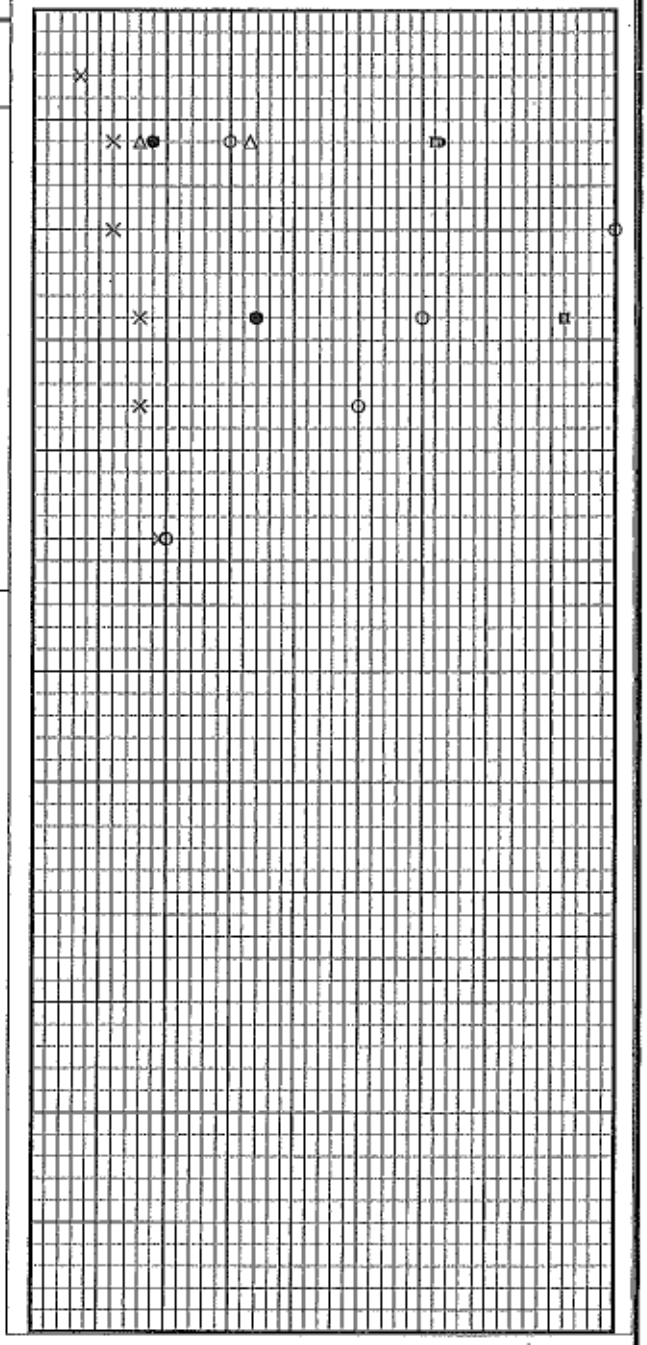
Water First Noticed: 12'6"	DRILLED & LOGGED BY: F.P.	STARTED: 11-1-2006	STATION OFFSET
Final Water Reading: No			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: 9' (11-2-06)	PREPARED BY: A. SINGH	COMPLETED: 11-1-2006	NOTE: For Scales Above
PZ WATER LEVEL: 9' (11-9-06)			Scale-A-For Dry Density
PZ WATER LEVEL: 10' (12-1-06)	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
COMPLETION DEPTH: 20'			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK	BORING LOG	
TERRACE AREA WBS No.: S-000035-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-40
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT: AMANI ENGINEERING	

○ PENETROMETER TEST (TSF) ● UNCONFINED COMP. (TSF)
△ LL (%) △ PL (%)
✕ MOIST.(%) ● #200 (%)
▣ DRY DENSITY (PCF)

A	75	80	85	90	95	100	105	110	115	120
B	0	10	20	30	40	50	60	70	80	90
C	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
2.0		1			Light gray & tan Silty Sand (SM)
4.0		2			Firm, light gray & tan Lean Clay (CL)
6.0		3			.. very stiff below 4'
8.0		4			.. stiff, with sand pockets below 6'
10.0		5			
13.0		6			.. firm below 11' (very moist)
					Boring terminated at 13 feet.
15.0					
20.0					
25.0					
30.0					



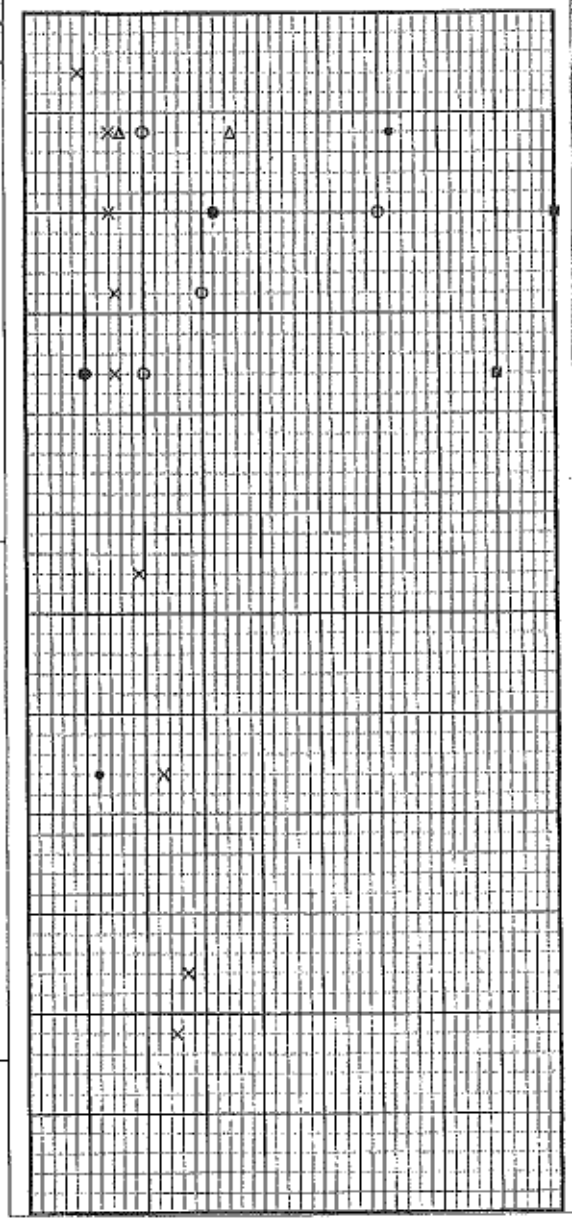
Water First Noticed: No	DRILLED & LOGGED BY: Bryan	STARTED: 11-17-2006	STATION OFFSET
Final Water Reading: No			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: N/A	PREPARED BY: A. SINGH	COMPLETED: 11-17-2006	NOTE: For Scales Above
HOLE CAVED AT: 11'			Scale-A-For Dry Density
COMPLETION DEPTH: 13'	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
GROUT: YES			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK	BORING LOG	
TERRACE AREA WBS No.: S-000036-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-15
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT: AMANI ENGINEERING	

O PENETROMETER TEST (TSF) ● UNCONFINED COMP. (TSF)
Δ LL (%) Δ PL (%)
× MOIST.(%) ● #200 (%)
■ DRY DENSITY (PCF)

A	75	80	85	90	95	100	105	110	115	120
B	0	10	20	30	40	50	60	70	80	90
C	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
					4" Asphalt & 6" Lime Stabilized soil
		1			Gray & tan Lean Clay (CL)
2.0					
		2			.. firm below 2'
4.0					
		3			.. stiff, light gray & tan below 4'
6.0					
		4			.. firm, with sand seams below 6'
8.0					
		5			
10.0					
		6	21		Medium dense, light gray & tan Silty Sand (SM)
15.0					
		7	30		.. wet below 18'
20.0					
		8	33		.. very dense below 23'
25.0					
		9	18		.. medium dense below 25'
26.0					Boring terminated at 26 feet.
30.0					



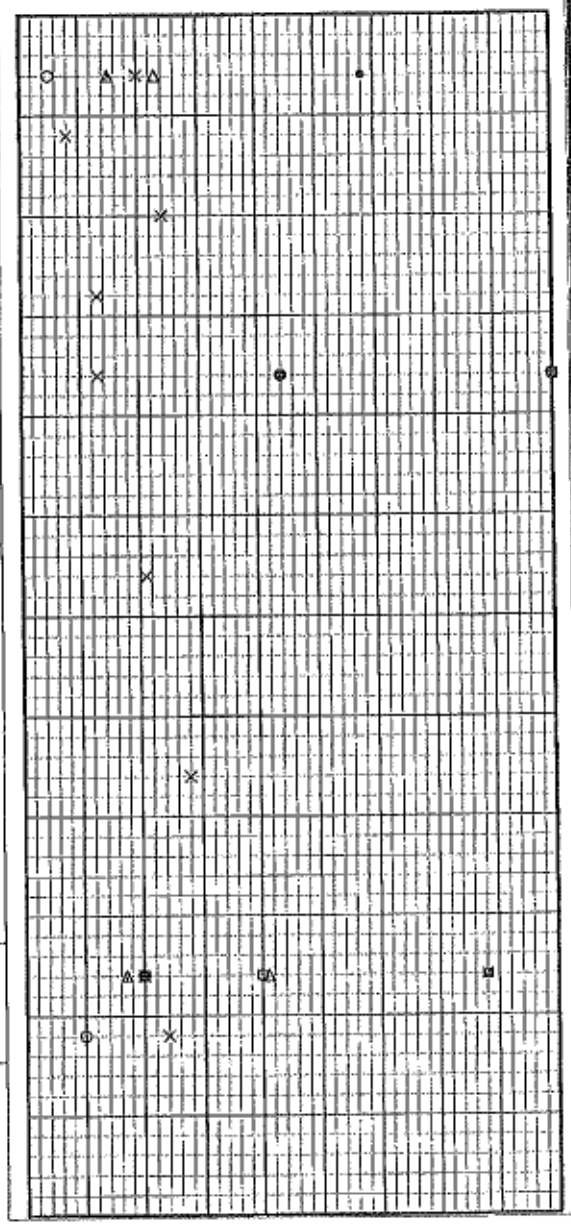
Water First Noticed: 18'	DRILLED & LOGGED BY: F.P.	STARTED: 11-17-2006	STATION OFFSET
Final Water Reading: 16'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: N/A	PREPARED BY: A. SINGH	COMPLETED: 11-17-2006	NOTE: For Scales Above
HOLE CAVED AT: No			Scale-A-For Dry Density
COMPLETION DEPTH: 26'	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
GROUT: YES			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK	BORING LOG	
TERRACE AREA WBS No.: S-000035-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-46 (PZ-3)
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT: AMANI ENGINEERING	

○ PENETROMETER TEST (TSF) ● UNCONFINED COMP. (TSF)
△ LL (%) △ PL (%)
X MOIST.(%) ● #200 (%)
■ DRY DENSITY (PCF)

A	75	80	85	90	95	100	105	110	115	120
B	0	10	20	30	40	50	60	70	80	90
C	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5

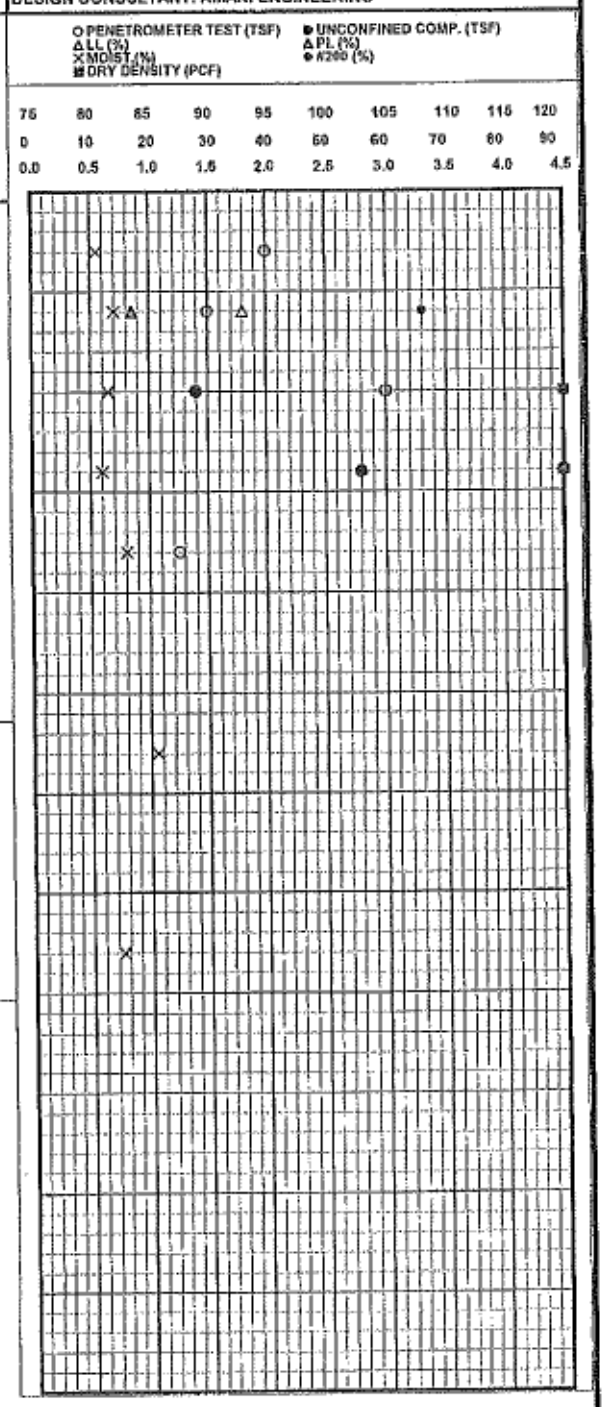
DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
					3" Asphalt & 3" Gravel
2.0		1			Very soft, gray & tan Lean Clay (CL)
4.0		2	16		Medium dense, light gray & tan Silty Sand (SM)
6.0		3	22		
8.0		4	21		
10.0		5			Very stiff, tan & light gray Lean Clay (CL)
15.0		6	43		Very dense, light gray & tan Silty Sand (SM) (wet)
20.0		7	17		.. reddish brown & light gray, with lean clay layers below 18'
25.0		8			Stiff, reddish brown & light gray Lean Clay (CL)
26.0		9			.. soft, light gray & tan, with sand seams below 25'
					Boring terminated at 26 feet.
30.0					



Water First Noticed: 13'	DRILLED & LOGGED BY: F.P.	STARTED: 11-27-2006	STATION OFFSET
Final Water Reading: 12'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: 12' (11-28-06)	PREPARED BY: A. SINGH	COMPLETED: 11-27-2006	NOTE: For Scales Above
PZ WATER LEVEL: 12' (12-05-06)			Scale-A-For Dry Density
PZ WATER LEVEL: 10' (12-28-06)	CHECKED BY: Jitu / Panka	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
COMPLETION DEPTH: 26'			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK	BORING LOG	
TERRACE AREA WBS No.: S-000035-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-47
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.	DESIGN CONSULTANT: AMANI ENGINEERING	

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
		1			Stiff gray & tan Lean Clay (CL)
2.0					
		2			.. firm below 2'
4.0					
		3			.. stiff, light gray & tan, with ferrous nodules below 4'
6.0					
		4			.. very stiff below 6'
8.0					
		5			.. firm, with sand seams below 8'
10.0					
		6	7		Loose, light gray & tan Silty Sand (SM) (wet)
15.0					
		7	28		.. medium dense, with lean clay layers below 18'
20.0					
					Boring terminated at 20 feet.
25.0					
30.0					



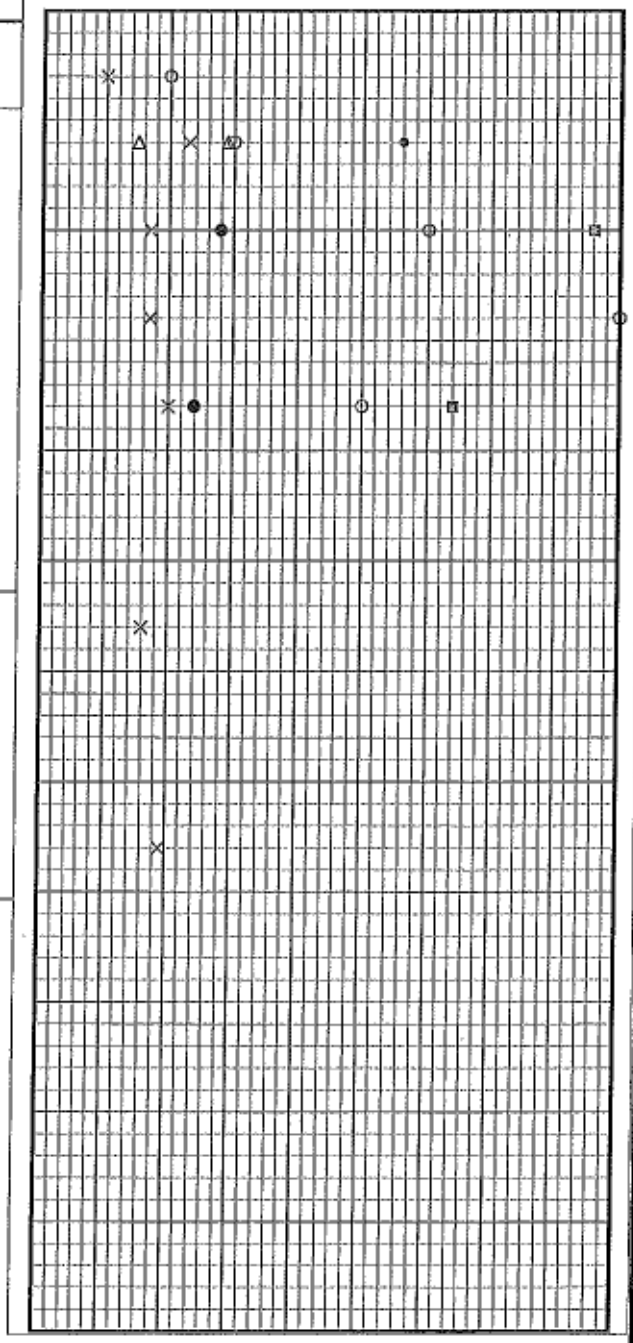
Water First Noticed: 13'	DRILLED & LOGGED BY: F.P.	STARTED: 11-15-2006	STATION OFFSET
Final Water Reading: 11'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: N/A	PREPARED BY: A. SINGH	COMPLETED: 11-15-2006	NOTE: For Scales Above
HOLE CAVED AT: No			Scale-A-For Dry Density
COMPLETION DEPTH: 20'	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PI. and #200
GROUT: YES			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK		BORING LOG	
TERRACE AREA	WBS No.: S-000035-00N5-4	PROJECT NUMBER: G06-420	BORING NUMBER: GB-71
GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.		DESIGN CONSULTANT: AMANI ENGINEERING	

○ PENETROMETER TEST (TSF) ● UNCONFINED COMP. (TSF)
△ LL (%) △ PL (%)
× MOIST.(%) ● #200 (%)
⊠ DRY DENSITY (PCF)

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
2.0		1			Firm, gray & tan Lean Clay (CL) with shells (2' fill)
4.0		2			Firm, gray & tan Lean Clay (CL) with sand pockets
6.0		3			.. stiff, with sand seams below 4'
8.0		4			.. Very stiff, with ferrous nodules below 6'
10.0		5			.. stiff below 8'
15.0		6	27		Medium dense, light gray & tan Silty Sand (SM) (wet)
20.0		7	24		
					Boring terminated at 20 feet.
25.0					
30.0					

A	75	80	85	90	95	100	105	110	115	
B	0	10	20	30	40	50	60	70	80	90
C	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5



Water First Noticed: 13'	DRILLED & LOGGED BY: F.P.	STARTED: 11-14-2006	STATION OFFSET
Final Water Reading: 12'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: N/A	PREPARED BY: A. SINGH	COMPLETED: 11-14-2006	NOTE: For Scales Above
HOLE CAVED AT: No			Scale-A-For Dry Density
COMPLETION DEPTH: 20'	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
GROUT: YES			Scale-C-For Penetrometer and Unconfined Comp.

PROJECT NAME: WATER LINE REPLACEMENT IN SHEPHERD PARK

TERRACE AREA WBS No.: S-000035-00N5-4

GEOTECHNICAL CONSULTANT: ASSOCIATED TESTING LABORATORIES, INC.

BORING LOG

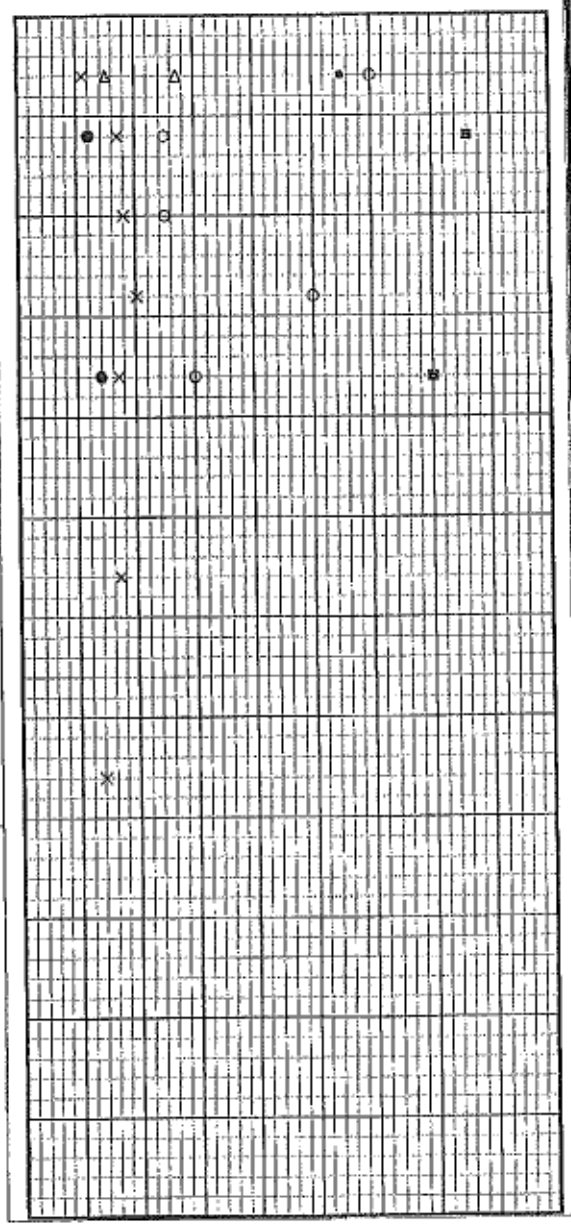
PROJECT NUMBER: G06-420

BORING NUMBER: GB-75

DESIGN CONSULTANT: AMANI ENGINEERING

○ PENETROMETER TEST (TSF) ● UNCONFINED COMP. (TSF)
△ LL (%) △ PL (%)
× MOIST.(%) ● #200 (%)
■ DRY DENSITY (PCF)

DEPTH, FEET	SAMPLE TYPE	SAMPLE NUMBER	SPT	LEGEND	MATERIAL DESCRIPTION
2.0		1			Stiff, gray & tan Lean Clay (CL) with calcareous nodules (2' fill)
4.0		2			Firm, light gray & tan Lean Clay (CL)
6.0		3			
8.0		4			.. stiff, with sand seams below 6'
10.0		5			.. firm, with ferrous nodules below 8'
15.0		6	36		Dense, light gray & tan Silty Sand (SM) (wet)
20.0		7	26		.. medium dense, with lean clay layers below 18'
25.0					Boring terminated at 20 feet.
30.0					



Water First Noticed: 13.5'	DRILLED & LOGGED BY: F.P.	STARTED: 11-14-2006	STATION OFFSET
Final Water Reading: 12'			GROUND LEVEL(MSL): Existing
PZ WATER LEVEL: N/A	PREPARED BY: A. SINGH	COMPLETED: 11-14-2006	NOTE: For Scales Above
HOLE CAVED AT: No			Scale-A-For Dry Density
COMPLETION DEPTH: 20'	CHECKED BY: Jitu / Pankaj	APPROVED BY: JAY	Scale-B-For Moist.,LL,PL and #200
GROUT: YES			Scale-C-For Penetrometer and Unconfined Comp.

AYLES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

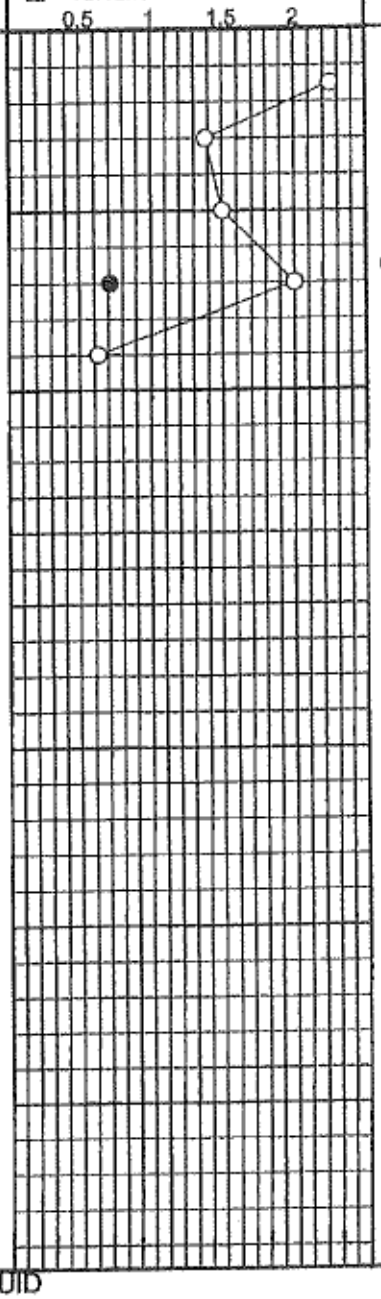
PROJECT: Water Line Replacement in Garden Oaks Phs. II BORING B-27

DATE 5/4/10 TYPE 4" Dry Auger LOCATION See Boring Location Plan

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
			Survey Coordinates (ft): *Easting: 3103201.39* *Northing: 13867115.90* *Elevation: 73.06*							
0			Tan Silty Sand (SM), with roots							
			Stiff to hard, tan and light gray Sandy Lean Clay (CL), with silt pockets, sand fissures and seams 1'-4', and ferrous nodules		15					
			-tan 2'-4'		15					
5					15					
			-with vertical sand seams 6'-8'		17	110	63	40	13	27
			-tan, with sand layers 8'-10'		19					
10			Medium dense, tan and light gray Silty Sand (SM) -wet at 11'	13	21		33			
			Termination depth = 13 feet.							
15										
20										
25										
30										

SHEAR STRENGTH, TSF

△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane



BORING DRILLED TO 13 FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT 11 FEET WHILE DRILLING
WATER LEVEL AT 10 FEET AFTER DRILLING
DRILLED BY J.H. CHECKED BY ACO LOGGED BY AEC

PROJECT NO. G119-10 PLATE A-29

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: Water Line Replacement in Garden Oaks Phs. II BORING B-33

DATE 5/19/10 TYPE 4" Dry Auger / Wet Rotary LOCATION See Boring Location Plan

DESCRIPTION

Survey Coordinates (ft):
Easting: 3103804.89
Northing: 13867868.27
Elevation: 75.18

SHEAR STRENGTH, TSF: △ Confined Compression; ● Unconfined Compression; ○ Pocket Penetrometer; □ Torvane

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0			Fill: gray Clayey Sand (SC), with roots		10		48	20	14	6
			Firm to hard, dark gray Sandy Lean Clay (CL), with clayey sand layers 2'-4'	12	13		57			
			-light gray and tan 4'-10'		16					
5					18	109				
					16					
10										
			Dense, light gray Silty Sand (SM) -wet at 13'	34	17		22			
15										
			Dense, light gray Clayey Sand (SC), wet	48	18					
20										
			Very dense, light gray and tan Silty Sand (SM), wet	53	22		15			
25			Termination depth = 25 feet.							
30										

BORING DRILLED TO 13 FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT 13 FEET WHILE DRILLING
WATER LEVEL AT 11.6 FEET AFTER 15 MIN.
DRILLED BY V&S CHECKED BY ACO LOGGED BY AEC

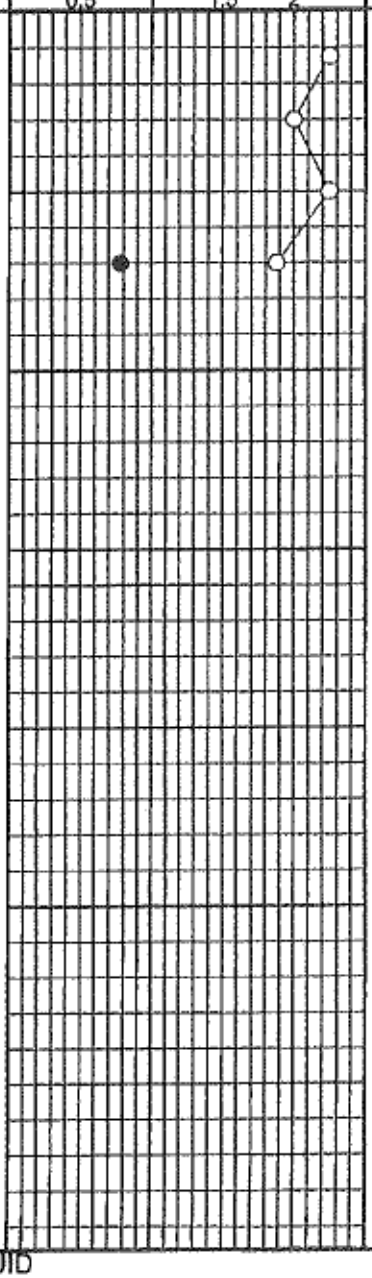
AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: Water Line Replacement in Garden Oaks Phs. II BORING B-35

DATE 5/3/10 TYPE 4" Dry Auger LOCATION See Boring Location Plan

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0			Gray Silty Sand (SM), with shell, gravel and roots		14					
			Stiff to hard, tan and light gray Sandy Lean Clay (CL), with sand pockets and roots 6"-2' -with vertical sand seams 2'-4' -with roots 4'-6', and sand pockets 4'-8'		14					
5					14		54	40	14	26
					16	114				
			Tan and light gray Clayey Sand (SC)		16					
10			Medium dense, tan and light gray Silty Sand (SM)	12	19		23			
			Termination depth = 12 feet.							
15										
20										
25										
30										

SHEAR STRENGTH, TSF



△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane

Survey Coordinates (ft):
Easting: 3104360.42
Northing: 13867481.86
Elevation: 74.86

BORING DRILLED TO 12 FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT N/A FEET WHILE DRILLING
WATER LEVEL AT N/A FEET AFTER N/A
DRILLED BY J.H. CHECKED BY ACO LOGGED BY AEC

PROJECT NO. G119-10 PLATE A-37

AYLES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: Water Line Replacement in Garden Oaks Phs. II BORING B-37

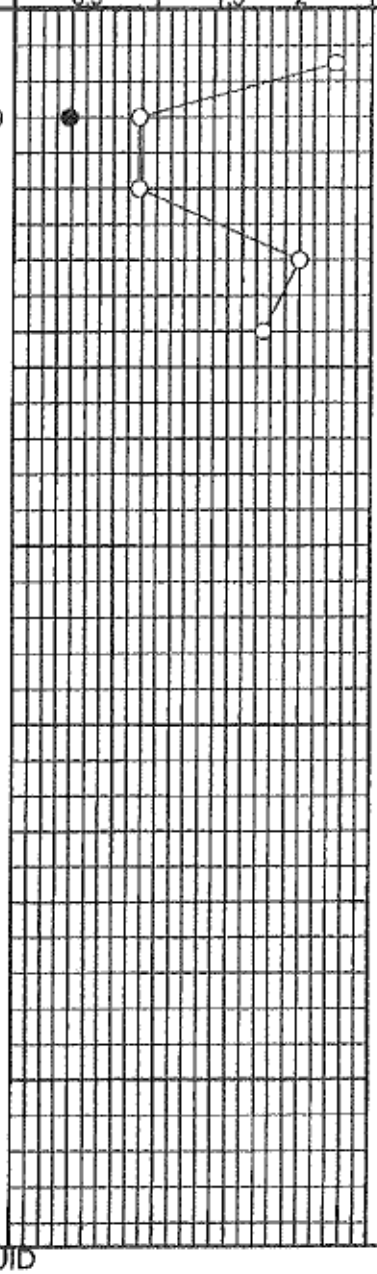
DATE 5/4/10 TYPE 4" Dry Auger LOCATION See Boring Location Plan

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0			Gray Silty Sand (SM), with roots							
			Firm to hard, tan Sandy Lean Clay (CL), with silt and sand pockets and sand fissures 1'-2', and ferrous nodules		8					
			-tan and gray 2'-4', with vertical sand seams 2'-6'		17	109				
5			-tan, light gray and reddish brown, with wet sand fissures 4'-6'		15		55	34	12	22
			-light gray and tan 6'-10', with sand pockets 6'-8'		14					
			-with vertical sand seams 8'-10'		19					
10			Medium dense, tan and light gray Clayey Sand (SC) -wet at 11'	14	18		22			
			Termination depth = 13 feet.							
15										
20										
25										
30										

SHEAR STRENGTH, TSF

△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane

0.5 1 1.5 2



BORING DRILLED TO 13 FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT 11 FEET WHILE DRILLING
WATER LEVEL AT 9.5 FEET AFTER DRILLING
DRILLED BY J.H. CHECKED BY ACO LOGGED BY AEC

PROJECT NO. G119-10

PLATE A-39

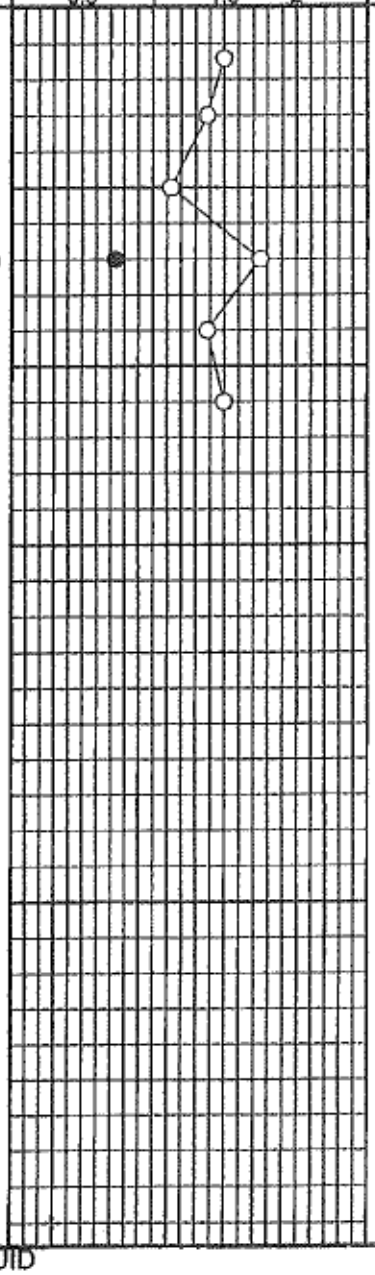
AVILES ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

PROJECT: Water Line Replacement in Garden Oaks Phs. II BORING B-45

DATE 5/10/10 TYPE 4" Dry Auger LOCATION See Boring Location Plan

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
			Survey Coordinates (ft): *Easting: 3105144.88* *Northing: 13866364.43* *Elevation: 70.99*							
0			Pavement: 3.5" asphalt + 6.5" concrete							
			Fill: very stiff, tan and gray Sandy Lean Clay (CL), with sand seams and pockets, and ferrous nodules		13					
					18		62	36	11	25
5			Stiff to very stiff, tan and light gray Sandy Lean Clay (CL), with sand seams 2'-4', sand pockets 2'-6', and ferrous nodules -with sand fissures 4'-6' -with vertical sand seams and fat clay pockets 6'-8' -with sand fissures and sand pockets 8'-10'		16					
					18	110				
					22					
10			Very stiff, reddish brown and light gray Fat Clay (CH), with sand fissures and pockets, and ferrous nodules		26		87	52	17	35
			Termination depth = 12 feet.							
15										
20										
25										
30										

SHEAR STRENGTH, TSF



△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane

BORING DRILLED TO 12 FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT N/A FEET WHILE DRILLING ▽
WATER LEVEL AT N/A FEET AFTER N/A ▽
DRILLED BY J.H. CHECKED BY ACO LOGGED BY AEC

PROJECT NO. G119-10

PLATE A-47

APPENDIX 5

RESULTS OF CRUMB, PINHOLE AND TRIAXIAL CONSOLIDATED UNDRAINED TESTS

ASSOCIATED TESTING & LABORATORIES, INC

CRUMB TEST FOR DETERMINATION OF DISPERSIBILITY OF SOILS
ASTM D 6572, METHOD A

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving

PROJECT NO : G 13 - 211

DATE : 10/30/2013

LOCATION: B-22, B-23, B-24

CLIENT: PGAL, Inc

SPECIMEN DATA:

[ ] *DISTURBED* [√] *UNDISTURBED*

SPECIMEN TYPE: [√] *NATURAL IRREGULARLY SHAPED CRUMB*

[ ] *REMOLDED CRUMB CUBE*

MOISTURE CONTENT: [√] *NATURAL MOISTURE* [ ] *AIR DRIED*

[ ] *DISTILLED WATER ADDED TO REMOLD SPECIMEN*

WATER USED : [√] *DISTILLED WATER*

[ ] *DISTILLED AND DEMINERALIZED WATER*

INITIAL WATER TEMPERATURE : 22.5
FINAL WATER TEMPERATURE : 23.0

TIME AT BEGINNING OF TEST : 8:30 [√] *AM* [ ] *PM*

TESTED BY : J.G **DATE TESTED :** 10/30/2013
CHECKED BY : PST **DATE :**

TEST CONDITION

BORING NO.	DEPTH (FT)	2-MINUTE		1 HOUR		6 HOUR		DATE
		GRADE *	C	GRADE*	C	GRADE*	C	
B-22	2'-4'	1	22.5	1	23.0	1	23.0	10/30/2013
B-22	4'-6'	1	22.5	1	23.0	1	23.0	10/30/2013
B-22	8'-10'	3	22.5	4	23.0	4	23.0	10/30/2013
B-23	6'-8'	3	22.5	4	23.0	4	23.0	10/30/2013
B-23	8'-10'	3	22.5	4	23.0	4	23.0	10/30/2013
B-24	4'-6'	3	22.5	4	23.0	4	23.0	10/30/2013
B-24	8'-10'	3	22.5	4	23.0	4	23.0	10/30/2013

* *GRADE 1 - NON DISPERSIVE* *GRADE 3 - DISPERSIVE*
GRADE 2 - INTERMEDIATE *GRADE 4 - HIGHLY DISPERSIVE*

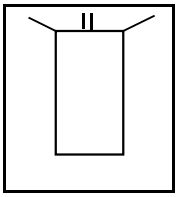
Associated Testing Laboratories, Inc
3143 Yellowstone Blvd
Houston,Texas 77054

ASSOCIATED TESTING LABORATORIES, INC
PINHOLE DISPERSION TEST DATA
ASTM D 4647, Method A

Project No. : G13-211
Boring No. : B-22
Sample Depth, Garde 4'-6'

Date Test: 11/1/2013
Operator: J.G

Water Content: 9



Specimen after test
Final Hole Diameter

1 mm

Effluent: Distilled Water
Compaction Characteristics: N/A

Flow Started on : 1 trial

Classification : ND 1

Clock Time	Head in.	Head mm	Flow ml	Flow sec	Flow Rate, ml/sec	Turbidity from side: Very Dark	Distinctly Dark	Very Slightly Dark	Barely Visible	Completely Clear	From Top: Completely Clear	Remarks (reference to number of particles falling)
9:00	2"	50	10	18	0.56					✓	✓	No
9:02			10	18	0.56					✓	✓	No
9:03			10	18	0.56					✓	✓	No
9:04			10	18	0.56					✓	✓	No
9:05	2"	50	10	18	0.56					✓	✓	No
9:06			10	18	0.56					✓	✓	No
9:08			10	17	0.59					✓	✓	No
9:09			10	17	0.59					✓	✓	No
9:10	7"	180	10	15	0.67					✓	✓	No
9:11			10	15	0.67					✓	✓	No
9:13			25	38	0.66					✓	✓	No
9:14			25	38	0.66					✓	✓	No
9:15	15"	380	10	10	1.00					✓	✓	No
9:16			10	10	1.00					✓	✓	No
9:17			25	25	1.00					✓	✓	No
9:18			25	25	1.00					✓	✓	No
9:20	40"	1040	25	12	2.08					✓	✓	No
9:21			25	12	2.08					✓	✓	No
9:23			25	12	2.08					✓	✓	No
9:24			25	12	2.08					✓	✓	No

PERFORMANCE BY : J.G

REVIEWED BY : PST

Comments: Non Dispersive Soil

Associated Testing Laboratories, Inc
3143 Yellowstone Blvd
Houston,Texas 77054

ASSOCIATED TESTING LABORATORIES, INC

PINHOLE DISPERSION TEST
ASTM D4647 Method A

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
PROJECT NO: G13-211
LOCATION: B-22
DATE OF TEST: *11/1/2013*

CLIENT: PGAL, Inc

BORING NO:	**B-22**
DEPTH:	**4'-6'**
TYPE OF MATERIAL:	**Sandy Lean Clay (CL)**
CLASSIFICATION:	**ND 1**

SPECIMEN DATA

SPECIMEN	*WATER CONTENT (%)*	*UNIT WEIGHT (PCF)*	*LIQUID LIMIT*	*PLASTIC LIMIT*	*PLASTICITY INDEX*	*-200 SIEVE(%)*
Undistured Soil Sample	9	114	39	17	22	51

TEST CONDITIONS

HYDRAULIC HEAD (Inch)	RATE OF FLOW (ML/SEC)	TURBIDITY		TIME OF TEST (MIN)	NEEDLE PUNCH HOLE (MM)	FINAL HOLE	EFFLUENT
		SIDE	TOP				
40"	2.08	Clear	Clear	25 mins	1 mm	1 mm	distilled water

ESTABLISHED 1959

PERFORMANCE BY : *J.G* *REVIEWED BY :* *PST*

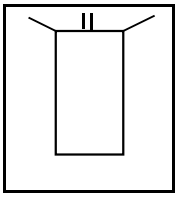
Associated Testing Laboratories, Inc
3143 Yellowstone Blvd
Houston,Texas 77054

ASSOCIATED TESTING LABORATORIES, INC
PINHOLE DISPERSION TEST DATA
ASTM D 4647, Method A

Project No. : G13-211
Boring No. : B-23
Sample Depth, Garde 6'-8'

Date Test: 11/1/2013
Operator: J.G

Water Content: 13



Specimen after test
Final Hole Diameter

2.2 mm

Effluent: Distilled Water
Compaction Characteristics: N/A

Flow Started on : 1 trial

Classification : D 1

Clock Time	Head in.	Head mm	Flow ml	Flow sec	Flow Rate, ml/sec	Turbidity from side: Dark	Turbidity from side: Distinctly Dark	Turbidity from side: Very Slightly Dark	Turbidity from side: Barely Visible	Turbidity from side: Completely Clear	From Top: Very Dark	Remarks (reference to number of particles falling)
9:00	2"	50	10	10	1.00	✓					✓	Yes
9:01			10	10	1.00	✓					✓	Yes
9:02			25	20	1.25	✓					✓	Yes
9:04			25	20	1.25	✓					✓	Yes

PERFORMANCE BY : J.G

REVIEWED BY : PST

Comments: Dispersive Soil

Associated Testing Laboratories, Inc
3143 Yellowstone Blvd
Houston,Texas 77054

ASSOCIATED TESTING LABORATORIES, INC

PINHOLE DISPERSION TEST
ASTM D4647 Method A

PROJECT: Garden Oaks and Shepherd Park (Central) Drainage and Paving
PROJECT NO: G13-211
LOCATION: B-23
DATE OF TEST: *11/1/2013*

CLIENT: PGAL, Inc

BORING NO:	**B-23**
DEPTH:	**6'-8'**
TYPE OF MATERIAL:	**Sandy Lean Clay (CL)**
CLASSIFICATION:	**D 1**

SPECIMEN DATA

SPECIMEN	*WATER CONTENT (%)*	*UNIT WEIGHT (PCF)*	*LIQUID LIMIT*	*PLASTIC LIMIT*	*PLASTICITY INDEX*	*-200 SIEVE(%)*
Undistured Soil Sample	13	113	38	17	21	52

TEST CONDITIONS

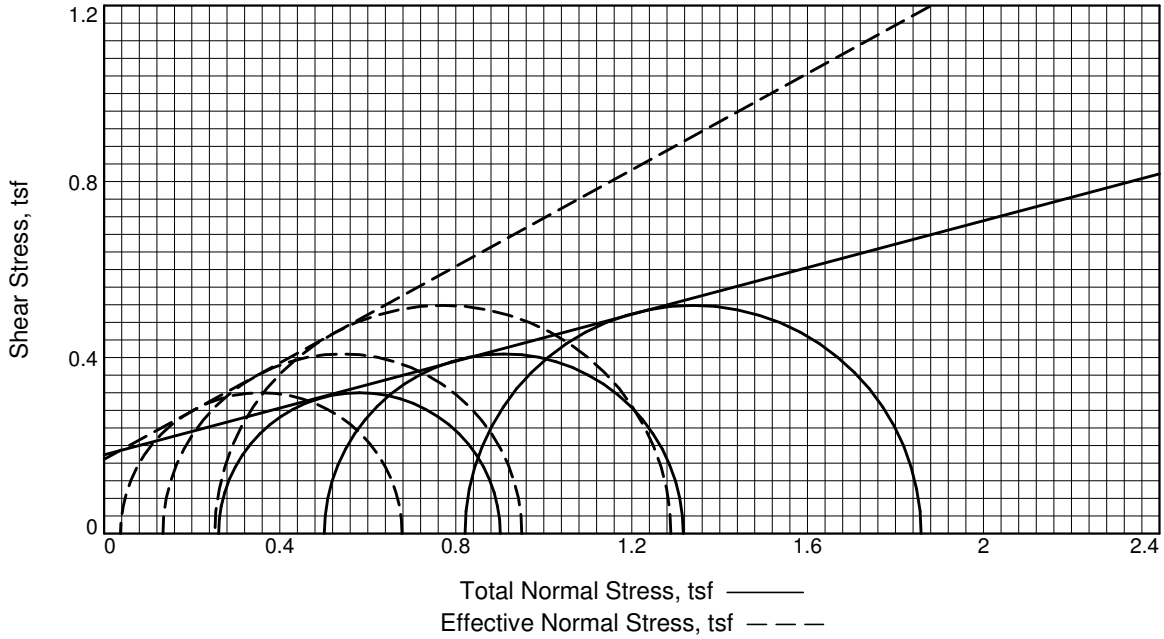
HYDRAULIC HEAD (Inch)	RATE OF FLOW (ML/SEC)	TURBIDITY		TIME OF TEST (MIN)	NEEDLE PUNCH HOLE (MM)	FINAL HOLE	EFFLUENT
		SIDE	TOP				
2"	1.25	dark	very dark	5 mins	1.0 mm	2.2 mm	distilled water

ESTABLISHED 1959

PERFORMANCE BY : *J.G* *REVIEWED BY :* *PST*

Associated Testing Laboratories, Inc
3143 Yellowstone Blvd
Houston,Texas 77054

TRIAXIAL SHEAR TEST REPORT



Type of Test: CU with Pore Pressures **Sample Type:** Undistured

No.	Fluid Press. psi		Fail. Stress, tsf		Ult. Stress, tsf		Principal Stresses at Failure tsf	
	Cell	Back	Deviator	Excess Pore Pressure	Deviator	Excess Pore Pressure	$\bar{\sigma}_1$	$\bar{\sigma}_3$
1	53.62	50.00	0.640	0.223	0.640	0.223	0.678	0.037
2	56.96	50.00	0.816	0.367	0.816	0.367	0.950	0.134
3	61.40	50.00	1.037	0.569	1.037	0.569	1.289	0.252

No.	Consolidated Sample Parameters						
	% Water Content	Dry Dens. pcf	Satur-ation	Void Ratio	Diameter in.	Height in.	% Strain at Peak
1	13.0	124.7	100.0%	0.3514	2.71	5.92	0.3
2	14.7	120.7	100.0%	0.3964	2.79	5.80	2.5
3	17.6	114.2	100.0%	0.4756	2.77	5.87	1.2

Mohr-Coulomb Strength Parameters	Total	Effective
Strength intercept, c=	0.179 tsf	0.169 tsf
Friction angle, ϕ =	14.9 deg	28.7 deg
Tangent, ϕ =	0.27	0.55

Material Description

Sandy Lean Clay (CL)

Client: PGAL,Inc

Project: Garden Oaks and Shepherd Park (Central) Drainage and Paving City of Houston, TX

Location: B-24

Sample Number: 1 **Depth:** 2-4, 6-8, 10-12

Date Sampled: 11/04/2013

File: G13-21$_3$

Remarks:

Sample bulked at failured

TRIAXIAL SHEAR TEST REPORT

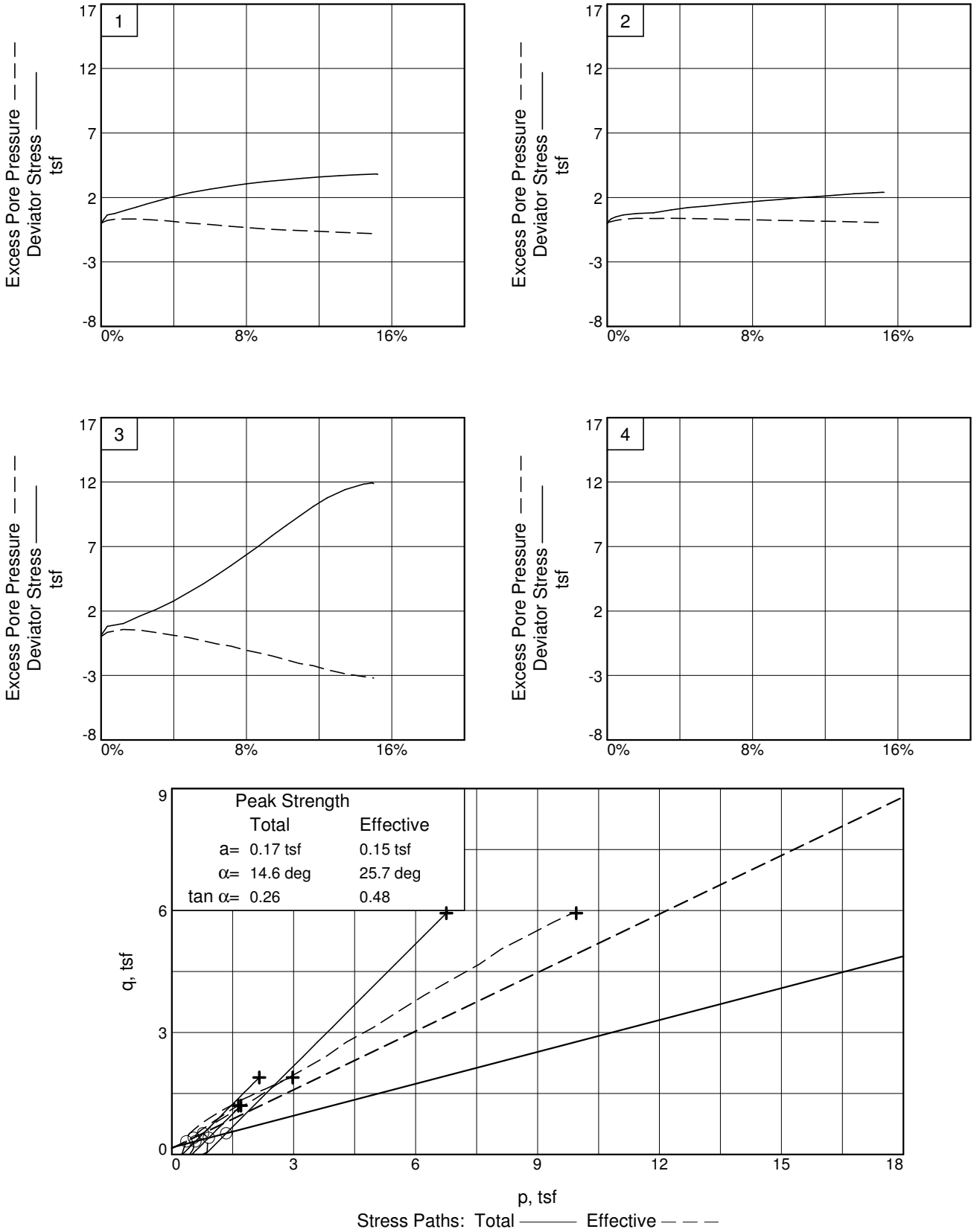
Associated Testing Laboratories, Inc.

Houston, TX

Proj. No.: G13-211

Figure a

Tested By: J.G **Checked By:** PST



Client: PGAL,Inc

Project: Garden Oaks and Shepherd Park (Central) Drainage and Paving

Location: B-24 **Depth:** 2-4, 6-8, 10-12 **Sample Number:** 1

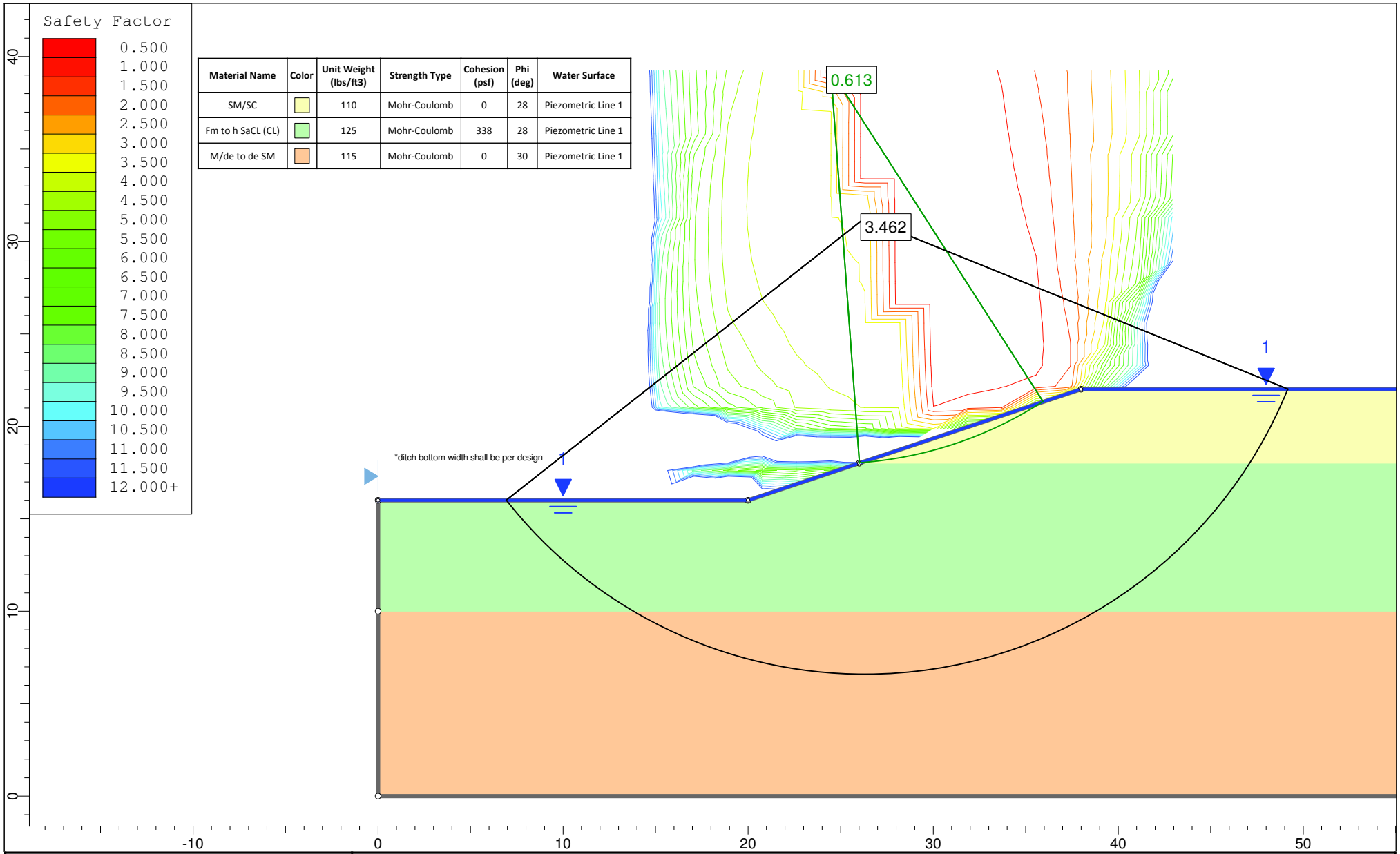
Project No.: G13-211 **Figure** b

Associated Testing Laboratories, Inc.

Tested By: J.G **Checked By:** PST

APPENDIX 6

RESULTS OF SLOPE STABILITY ANALYSES



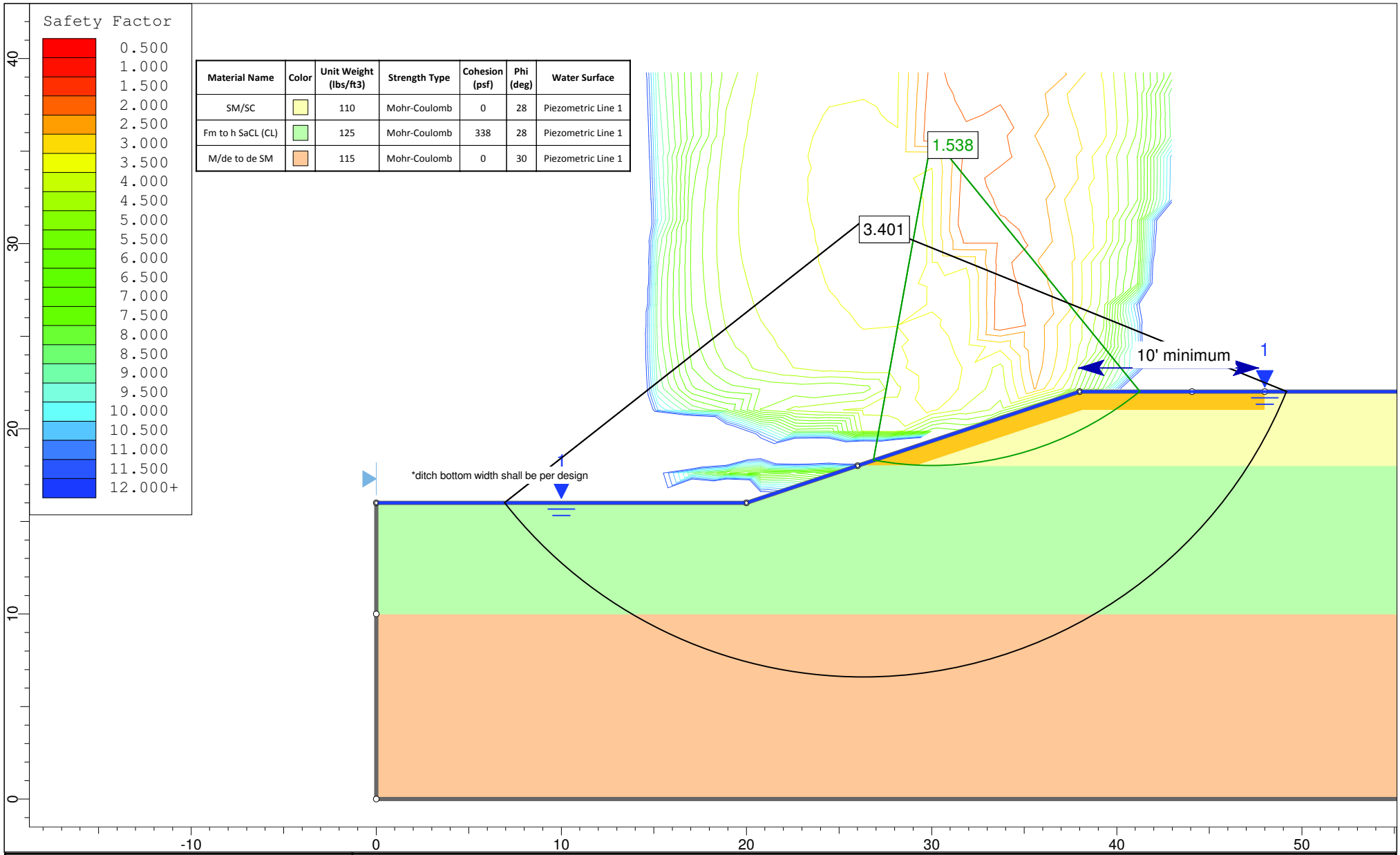
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
SM/SC		110	Mohr-Coulomb	0	28	Piezometric Line 1
Fm to h SaCL (CL)		125	Mohr-Coulomb	338	28	Piezometric Line 1
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1

rocscience

SLIDEINTERPRET 6.025

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Rapid Drawdown Condition, 3H:1V slope		
Drawn By PST	*Scale* 1:86	*Company* ATL	
Date 12-09-13		*File Name* G13-211_DitchImprov_3H1V_RD.slim	

FIGURE 6-1



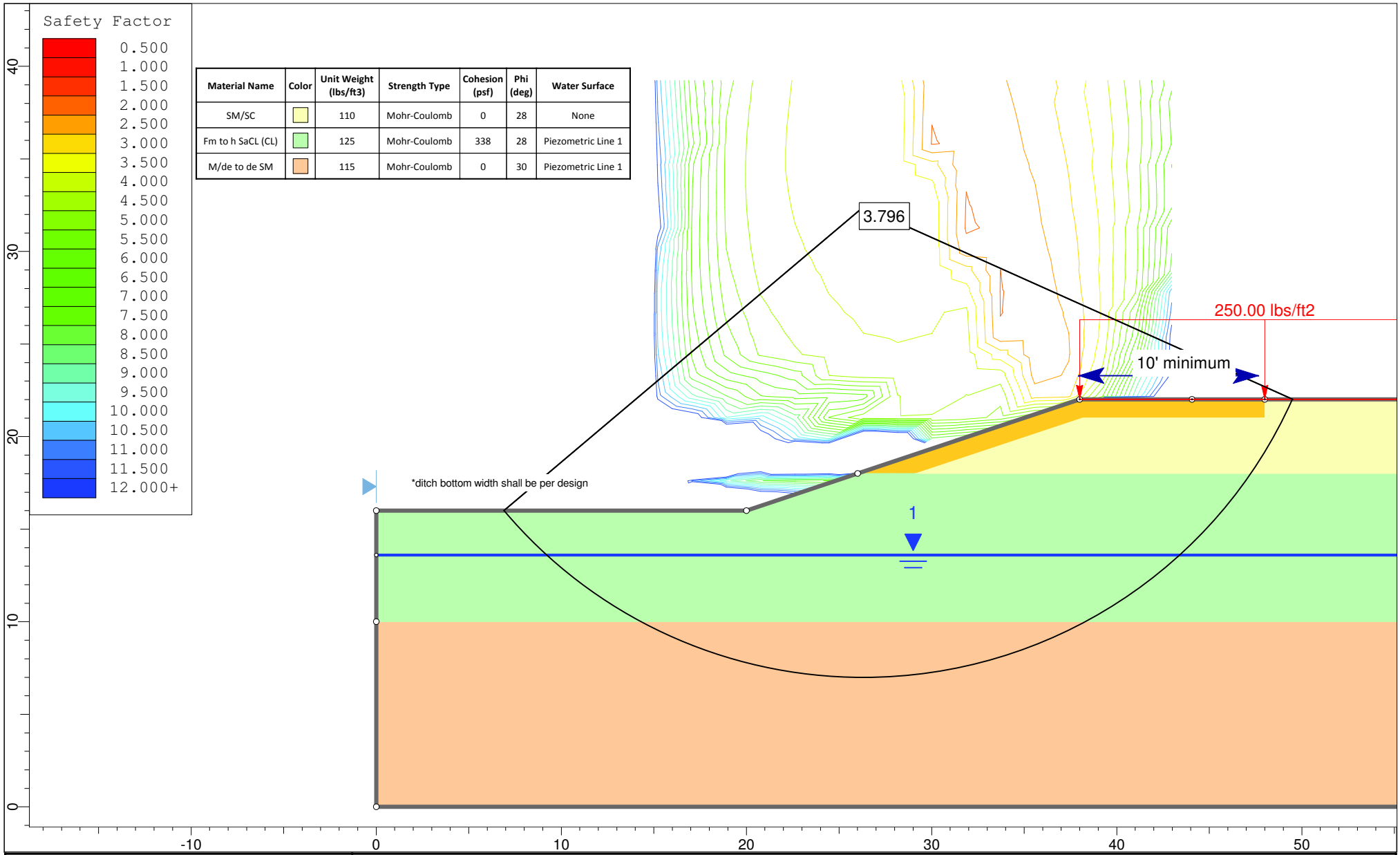
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
SM/SC		110	Mohr-Coulomb	0	28	Piezometric Line 1
Fm to h SaCL (CL)		125	Mohr-Coulomb	338	28	Piezometric Line 1
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1

rocscience

SLIDEINTERPRET 6.025

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Rapid Drawdown Condition, 3H:1V slope		
Drawn By PST	*Scale* 1:86	*Company* ATL	
Date 12-09-13		*File Name* G13-211_DitchImprov_3H1V_RD_w1'CL liner.slim	

FIGURE 6-2



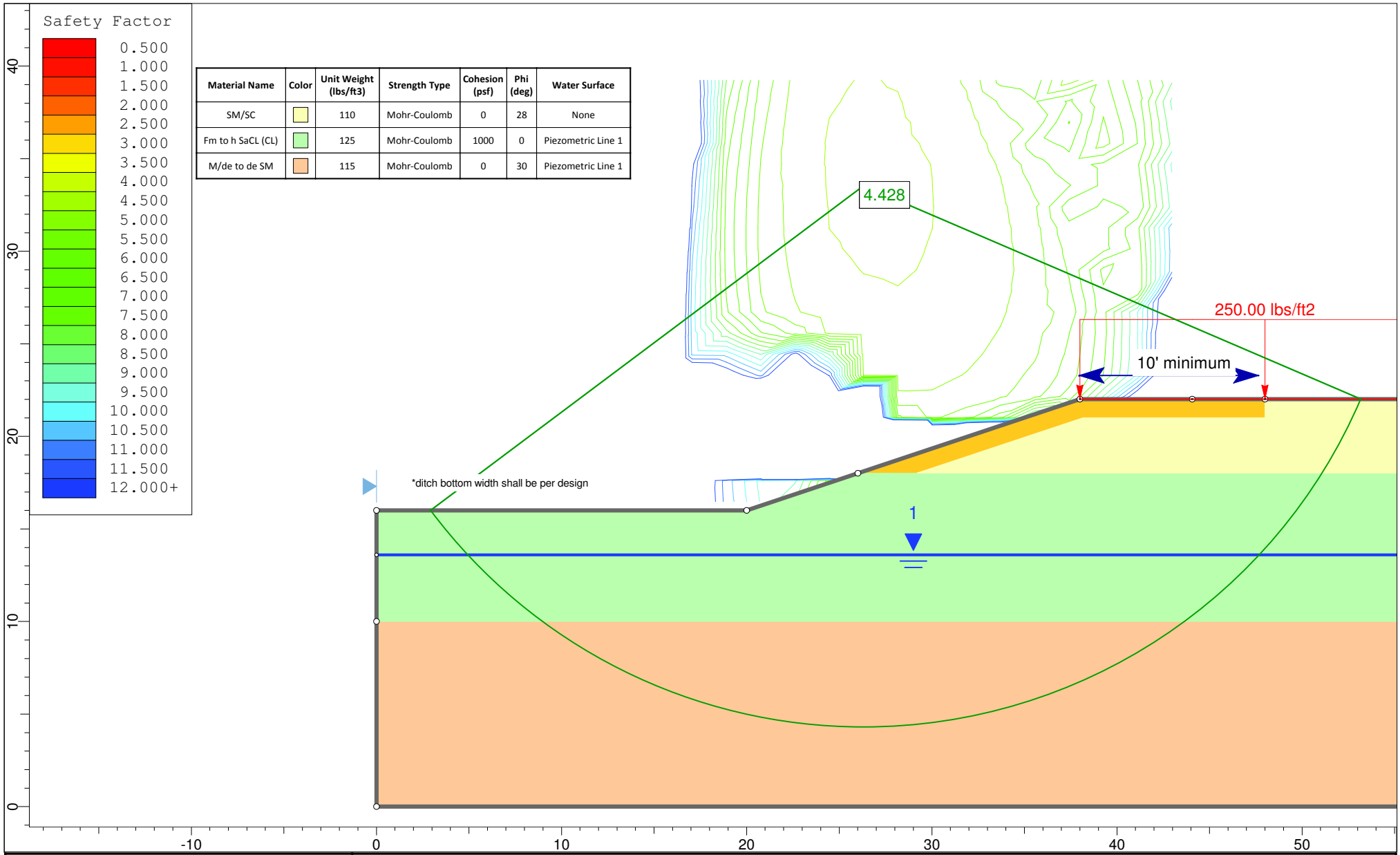
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
SM/SC		110	Mohr-Coulomb	0	28	None
Fm to h SaCL (CL)		125	Mohr-Coulomb	338	28	Piezometric Line 1
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1

rocscience

SLIDEINTERPRET 6.025

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Long Term Loading Condition, 3H:1V slope		
Drawn By PST	*Scale* 1:86	*Company* ATL	
Date 12-09-13		*File Name* G13-211_DitchImprov_3H1V_LT_w1'CL liner.slim	

FIGURE 6-3



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
SM/SC		110	Mohr-Coulomb	0	28	None
Fm to h SaCL (CL)		125	Mohr-Coulomb	1000	0	Piezometric Line 1
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1

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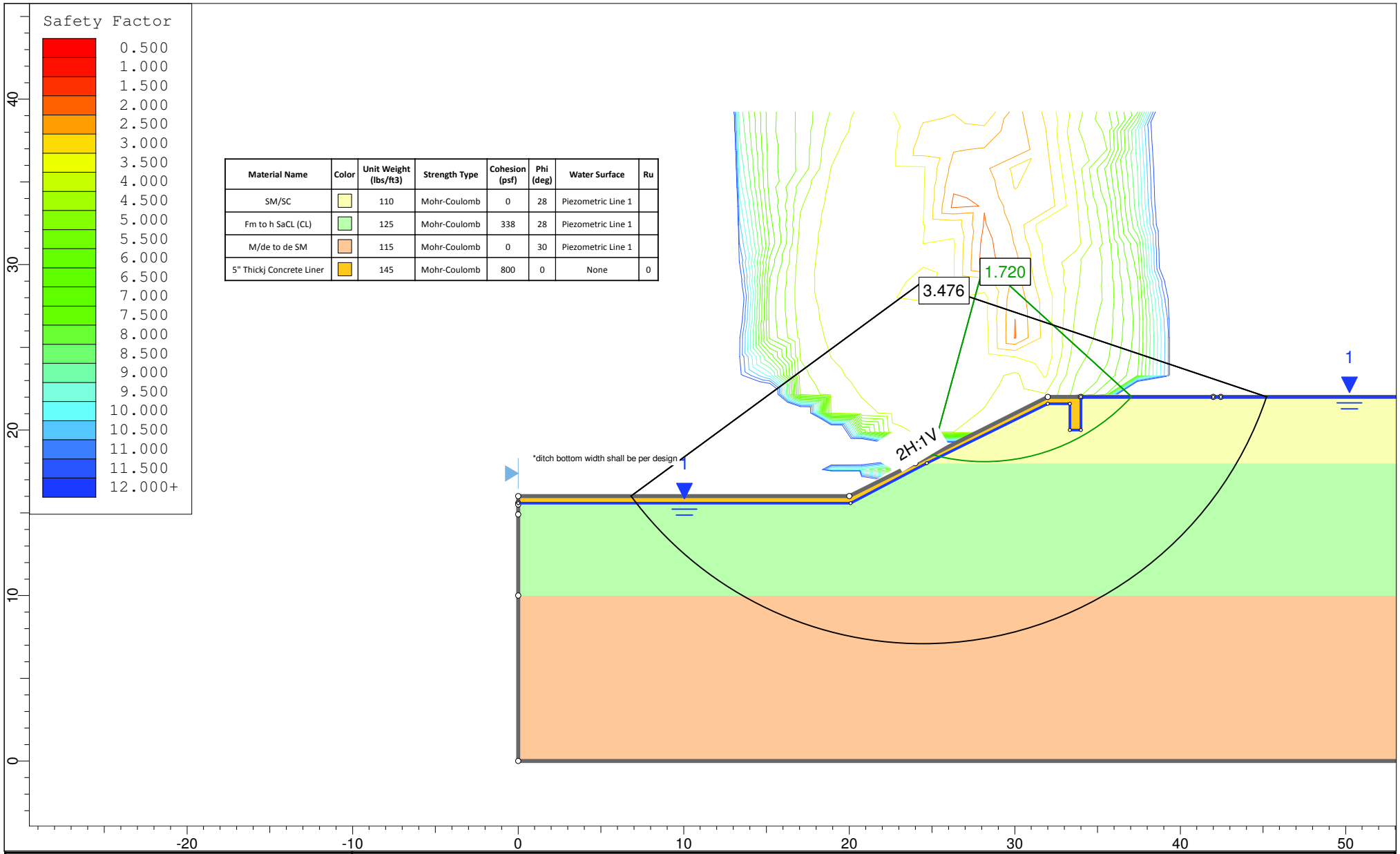
SLIDEINTERPRET 6.025

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Short Term Loading Condition, 3H:1V slope		
Drawn By PST	*Scale* 1:86	*Company* ATL	
Date 12-09-13		*File Name* G13-211_DitchImprov_3H1V_ST_w1'CL liner.slim	

FIGURE 6-4

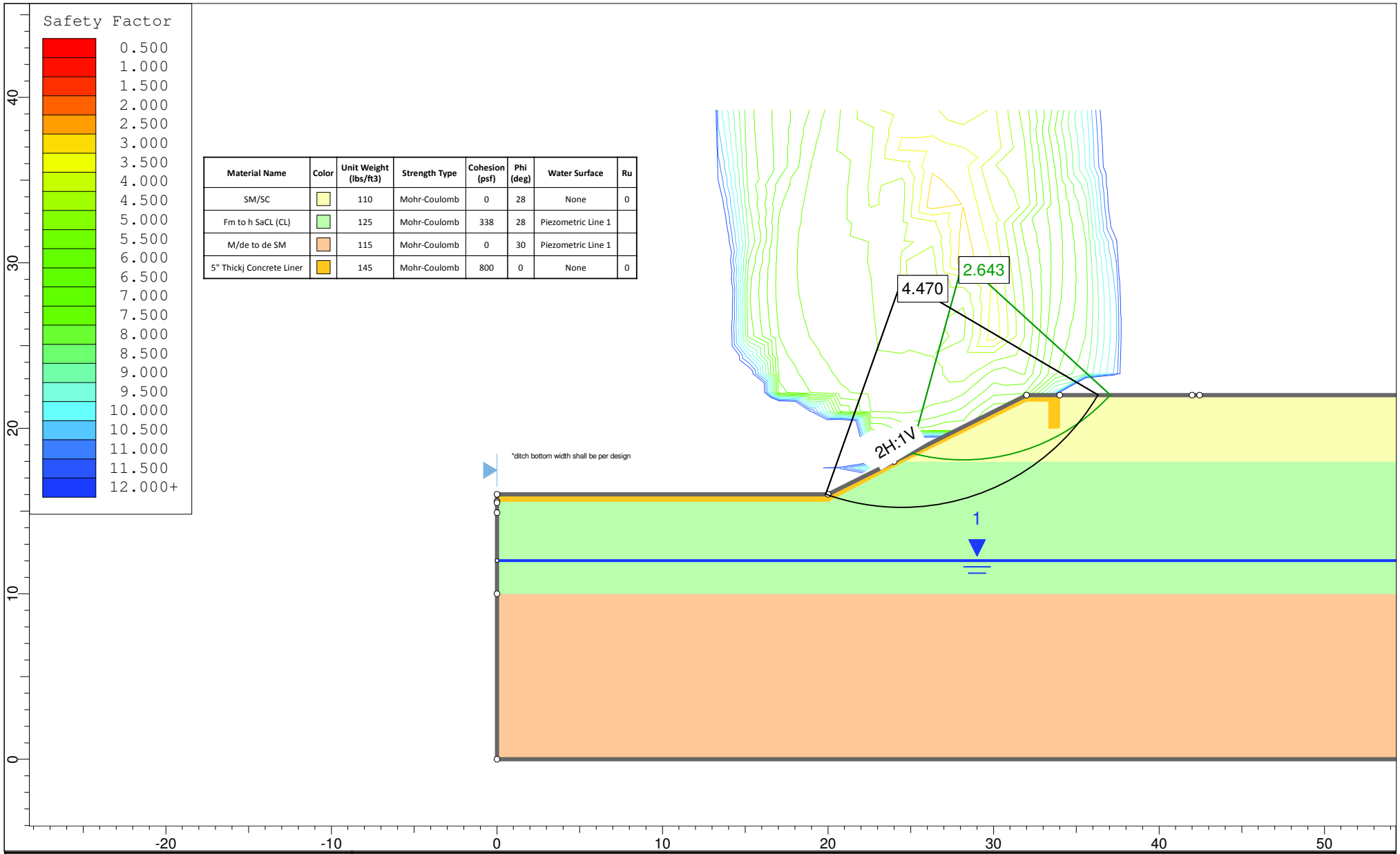


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
SM/SC		110	Mohr-Coulomb	0	28	Piezometric Line 1	
Fm to h SaCL (CL)		125	Mohr-Coulomb	338	28	Piezometric Line 1	
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1	
5" Thickj Concrete Liner		145	Mohr-Coulomb	800	0	None	0

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Rapid Drawdown Condition, 2H:1V slope w/Concrete Liner		
Drawn By	PST	Scale 1:96	Company ATL
Date	12-09-13		File Name G13-211_DitchImprov_2H1V wConcLiner_RD.slim

SLIDEINTERPRET 6.025

FIGURE 6-5



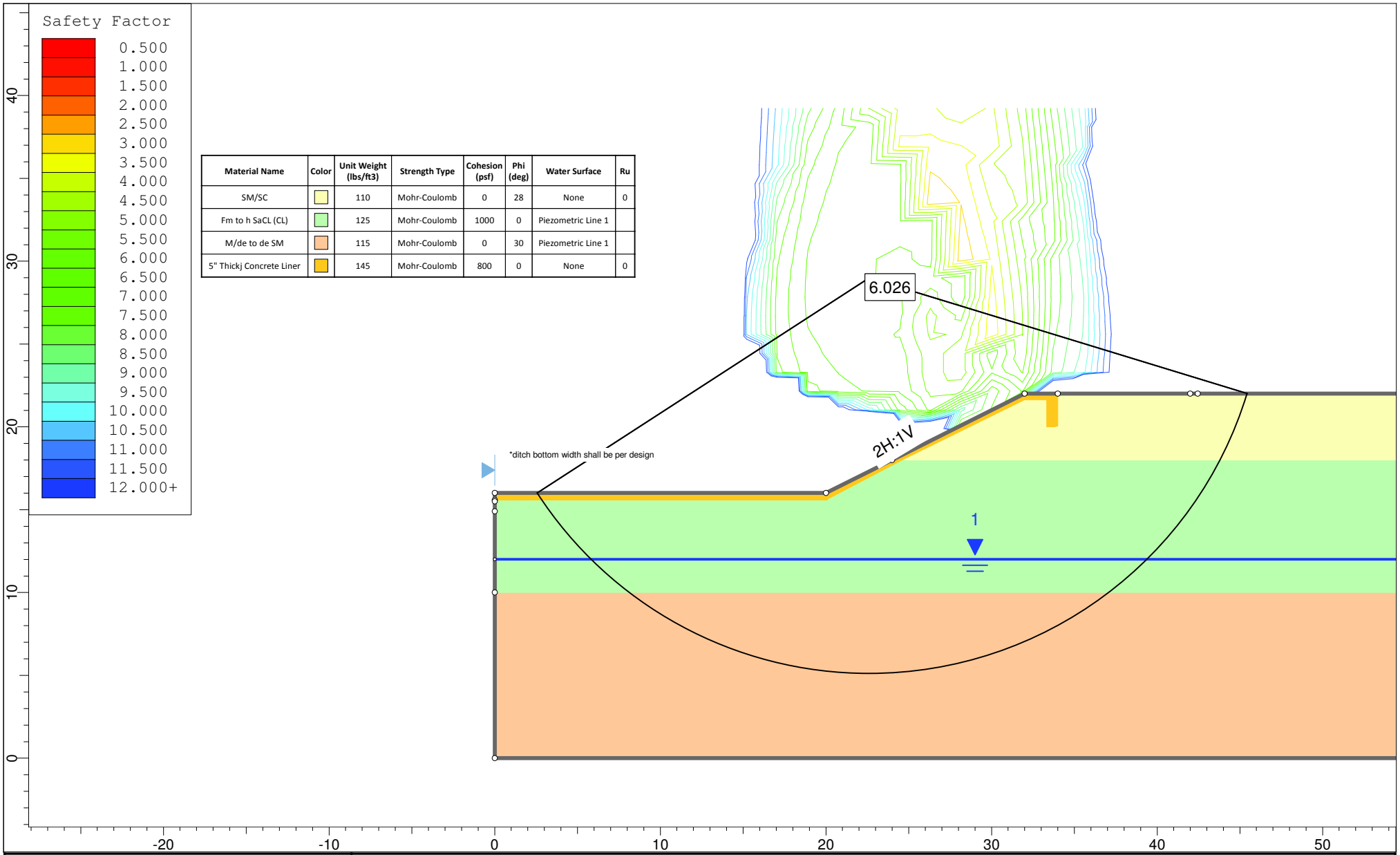
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
SM/SC		110	Mohr-Coulomb	0	28	None	0
Fm to h SaCL (CL)		125	Mohr-Coulomb	338	28	Piezometric Line 1	
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1	
5" Thickj Concrete Liner		145	Mohr-Coulomb	800	0	None	0

rocscience

SLIDEINTERPRET 6.025

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Long Term Loading Condition, 2H:1V slope w/Concrete Liner		
Drawn By PST	*Scale* 1:96	*Company* ATL	
Date 12-09-13		*File Name* G13-211_DitchImprov_2H1V wConcLiner_LT.slim	

FIGURE 6-6



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
SM/SC		110	Mohr-Coulomb	0	28	None	0
Fm to h SaCL (CL)		125	Mohr-Coulomb	1000	0	Piezometric Line 1	
M/de to de SM		115	Mohr-Coulomb	0	30	Piezometric Line 1	
5" Thickj Concrete Liner		145	Mohr-Coulomb	800	0	None	0

SLIDEINTERPRET 6.025

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	Boring B-21 to B-24; Short Term Loading Condition, 2H:1V slope w/Concrete Liner		
Drawn By PST	*Scale* 1:96	*Company* ATL	
Date 12-09-13		*File Name* G13-211_DitchImprov_2H1V wConcLiner_ST.slim	

FIGURE 6-7