**CITY OF HOUSTON**
**DEPARTMENT OF PUBLIC WORKS AND ENGINEERING**
**ENGINEERING AND CONSTRUCTION DIVISION**

# FINAL REPORT
# GEOTECHNICAL STUDY
# GESSNER ROAD PAVING AND DRAINAGE IMPROVEMENTS
# FROM NEUENS ROAD TO LONG POINT ROAD
**WBS NO. N-000809-0001-3**
**CITY OF HOUSTON, TEXAS**

**PROJECT NO. 13-825E**

**TO**

**REYNOLDS, SMITH & HILLS, INC.**
**HOUSTON, TEXAS**

**BY**

**GEOTECH ENGINEERING AND TESTING**

**SERVICING**

**TEXAS, LOUISIANA, NEW MEXICO, OKLAHOMA**

***www.geotecheng.com***

**SEPTEMBER 2014**

**TEXAS BOARD OF PROFESSIONAL ENGINEERS**
**REGISTRATION NUMBER F-001183**

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11011 Richmond Avenue, Suite 900
Houston, Texas 77042

Project No. 13-825E
Report No. 1
Project Type 24/33/UU
September 24, 2014

Attention: Mr. Ron Kline, P.E.
Highway Design Leader

**FINAL REPORT**
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Gentlemen:

Submitted here is Geotech Engineering and Testing (GET) geotechnical report on the study of subsurface conditions for the above referenced project. This study was conducted in general accordance with our Proposal No. P13-251, Revision III, dated December 14, 2013. Work authorization for this study was received through a Notice to Proceed (NTP) signed by Mr. Ron Kline, P.E., Highway Design Leader of Reynolds, Smith & Hills, Inc. on May 2, 2014.

This report presents the results of our field exploration and laboratory testing together with design recommendations for construction of the proposed paving and drainage improvements for the subject alignment.

We appreciate the opportunity to be of service. Should you have any questions or need additional assistance, please call.

Very truly yours,

GEOTECH ENGINEERING AND TESTING
TEXAS BOARD OF PROFESSIONAL ENGINEERS
REGISTRATION NUMBER F-001183

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## 1.0 EXECUTIVE SUMMARY

It is planned for paving and drainage improvements for Gessner Road from Neuens Road to Long Point Road in the City of Houston, Texas. We understand that the existing pavement will be removed and replaced with new concrete pavement. In addition, underground utilities (sanitary, storm sewers and waterlines) will be installed along the proposed project alignment. The depth of the utilities will range from about 8.5-ft to 14-ft.

Furnished information indicates that open-trench method or augering method of construction will be used for underground utility installations. We understand that waterlines may be adjusted along the project alignments. This report contains a description of our field and laboratory testing results together with engineering analysis and recommendations for the construction of the proposed facilities along the project alignments.

The soil conditions were explored by conducting nine (9) borings (B-1 through B-6, BE-2, BE-4 and BE-7) for paving and underground utilities. The soil borings were drilled along the project alignment to depths ranging from 22- to 30-ft below the existing grade. The soil stratigraphy for the project alignment is summarized as follows:

1. In general, based on our field exploration and laboratory test data, the soils along the project alignments appear to be variable. The soils stratigraphy along the project alignment is summarized as follows:

| Stratum No. | Range of Depth, ft. | Soil Description* |
|---|---|---|
| | | CONCRETE PAVEMENT (7.5" to 8.5" in thickness) |
| I | 0.6 – 2 | FILL: SILTY SAND, dark gray, brownish yellow, dark brown, with root fibers (SM); Borings B-1 and B-6 only |
| II | 0.6 – 2 | FILL: LEAN CLAY, firm to very stiff, light gray, gray, light brown, brownish yellow, with root fibers, ferrous and calcareous nodules, sands, moist (CL) |
| III | 0.6 – 2 | FILL: SANDY SILT, dark gray, with root fibers, clay pockets (ML); Boring B-3 only |
| IV | 2 – 30 | LEAN CLAY, firm to hard, light gray, light brown, brownish yellow, reddish brown, with root fibers to 6', ferrous and calcareous nodules, sands, moist (CL) |
| V | 4 – 23 | FAT CLAY, stiff to very stiff, light gray, brown, brownish yellow, with root fibers to 6', ferrous and calcareous nodules, moist (CH); in Boring B-1 only |
| VI | 8 – 25 | SILTY SAND, medium dense, light brown, gray, brownish yellow, with clay pockets, moist (SM) |
| VII | 12 – 24 | SANDY SILT, medium dense, light brown, gray, light gray, brownish yellow, with clay pockets (ML); in Borings B-3, B-4 and BE-7 only |

* Classification in general accordance with the Unified Soil Classification System (ASTM D 2487)

2. Depth to groundwater/perched water will be important for design and construction of the proposed project. Water level observations were made during drilling and 24 hours after drilling. Our short-term field exploration along the subject alignment indicated that groundwater was not encountered at the borings.

3. Borings B-3 and B-5 were converted to piezometer P-1 and P-2, respectively, after completion of the borings. The results of piezometer observations indicated that stabilized groundwater was measured at a depth of about 22-ft and 21.5-ft below the existing ground surface in piezometers P-1 and P-2, respectively.

4. We understand that open cut excavation or augering method will be used for the construction of underground utilities (sanitary, storm sewers and waterlines) installations. The bedding and backfill recommendations for the construction of the proposed underground utilities are also presented in this report.

5. Furnished information indicated that the proposed paving for the Gessner Road will consist of concrete pavement. Furthermore, we understand traffic loading will be for major thoroughfare. The concrete pavement was designed on the basis of "1993 AASHTO Guide for Design of Pavement Structures." Based on the assumed traffic conditions, the recommended concrete pavement thickness is as follows:

| Design, ESAL $\times 10^6$ | Concrete Pavement Thickness, inch(es) | Subgrade Lime Stabilization Thickness, inch(es) |
|---|---|---|
| 10.0 | 10.0 | 8.0 |

6. Subgrade preparation in pavement areas should specify compaction of the upper eight-inch to at least 95% of maximum standard Proctor density (ASTM D 698) at a moisture content between optimum and +3% of optimum moisture content. Depending on the major type of soils encountered along the project alignment, lime stabilization of the subgrade soils should most likely be performed. The subgrade soils should be stabilized, using lime based on the City of Houston Specifications, Section 02336. Use 5% lime by dry weight to stabilize the subgrade soils. This results in application rate of 23 pounds of lime, per square yard per eight-inch of compacted thickness. City of Houston Specifications, Section 02336, can be used as procedural guides for placing, mixing and compacting the lime stabilizer and the soils.

7. We understand that underground utility installations along the alignment will include sanitary sewers, storm sewers and water lines. Furnished information indicated that the maximum depth of these utilities with range from about 8.5-ft to 14-ft. The design recommendations for the underground utilities presented in this report.

## 2.0 INTRODUCTION

It is planned for drainage and paving improvements for Gesner Road from Neuens Road to Long Point Road in the City of Houston, Texas. A site vicinity map is presented in Plate 1. We understand that the existing concrete paving will be removed and replaced with concrete paving. In addition, underground utilities will be constructed along the project alignment. The specific project information is as follows:

| Facility | Remarks |
|---|---|
| Storm Sewers | The depth will be about 8.5- to 14-ft along the alignment. Storm sewer depth will be about 8.5-ft at the intersection of Neuens Road and Gessner Road and about 14-ft at the intersection of Long Point Road and Gessner Road. The length of storm sewer will be about 4,240-ft. Storm sewer will consist of 36" of pipes along Neuens Road and 8' x 5' box culvert along Long Point Road. The construction technique will be open excavation. |
| Sanitary/Water | The depth will range from 10- to 12-ft. The length will be about 4,240-ft. The construction technique will be open excavation or augering. The sanitary sewer pipe diameter will be about 12-inches. The waterlines diameter will be ranging from 8- to 12 inches. |
| Paving | The length of alignment for concrete paving will be about 4,240-ft. The traffic loading will be major thoroughfare. |
| Box Culverts | There will be concrete box culverts along part of the storm sewer alignment. |

Furnished information indicates that open-trench or augering method of construction will be used for underground utility (sanitary, storm sewers and waterline) installations. This report contains a description of our field and laboratory testing programs together with engineering analysis and recommendations for the proposed project alignment. The pavement design in this study is in general accordance with ASSHTO 1993 Guide of Design of Pavement Structure (Ref. 1). Furthermore, this report provides recommendation for construction of the underground utilities along the project alignment. Our recommendations on underground utilities, site preparation and soil stabilization are in general accordance with the City of Houston (COH) Department of Public Works & Engineering, Infrastructure and Design Manual, dated July 2012 (Ref. 2).

## 3.0 FIELD EXPLORATION

### 3.1 Pavement Coring

The existing pavement was cored prior to drilling and sampling of the soil borings. The results of pavement coring show that the existing pavement consists of concrete pavement. The existing pavement thicknesses are presented on Plate 2 and on the respective boring logs. The pavement core locations were patched with ready mix grout.

### 3.2 Drilling and Sampling

At the request of the City of Houston, the soil conditions were explored by conducting nine (9) borings B-1 through B-6, BE-2, BE-4 and BE-7 along the project alignment. Borings BE-2, BE-4 and BE-7 were drilled for Environmental Phase II study for this project by GET (GET Project Report No. 13-889E, dated July 21, 2014). These borings which contained geotechnical laboratory test data were also used for this geotechnical study. A summary of the borings coordinates, elevations and station number are presented on Plate 3. Approximate boring locations are presented in Appendix A.

Due to presence of existing underground utilities near boring BE-7 location based on Texas 811 information and information provided by HOUSTON GIMS (online source to locate the public utilities in Houston Area- both in use and abandoned), we had to offset Boring (BE-7) about 10-ft east from the project alignment to avoid encountering any underground utilities or obstructions.

Soil samples were obtained continuously from the ground surface to the completion depths of borings at 23- to 30-ft. The cohesive soils were sampled in general accordance with the ASTM D 1587.

Cohesionless soils were generally sampled with a split-spoon sampler driven in general accordance with the Standard Penetration Test (SPT), ASTM D 1586. This test is conducted by recording the number of blows required for a 140-pound weight falling 30-inches to drive the sampler 12-inches into the soil. Driving resistance for the SPT, expressed as blows per foot of sampler resistance (N), is tabulated on the boring logs.

Soil samples were examined and classified in the field, and cohesive soil strengths were estimated using a calibrated hand penetrometer. This data, together with a classification of the soils encountered and strata limits, is presented on the soil stratigraphy profile presented in Appendix A. The logs of borings and key to the log terms and symbols are also presented in Appendix A.

Depth to groundwater is important for design and construction of the proposed facilities. For this reason, borings were drilled dry. Water level observations made during drilling and shortly after drilling are indicated at the bottom portion of each individual boring log. The boreholes were grouted using tremie method after the completion of the field work.

### 3.3 Piezometer Installation

Piezometers P-1 and P-2 were installed to a depth of 23-ft and 22-ft in Borings B-3 and B-5, respectively. The piezometers consisted of two-inch diameter PVC riser pipe connected to a 10-ft and 9-ft long section of 0.01-inch slotted well screens in Piezometers P-1 and P-2, respectively. Each piezometer is capped at the top with a water tight flush mounted cap. After the borings were drilled, the riser pipe and well screen assembly were installed in the borings, filter sand was placed in the bottom of the borings and in the annulus between the borehole wall and the PVC pipe/screen, and subsequently the boreholes were sealed with bentonite grout from the top of the filter sand to the ground surface. The piezometers were developed by using a bailer to purge several volumes of water from the piezometer riser pipe. Water levels were periodically measured to evaluate the stabilized groundwater table. The piezometer installation diagram is shown on Plate 4. A summary of the piezometer readings are presented in the "Piezometer Reading Table" on Plate 5. The piezometers were abandoned, in accordance with the TDLR (Chapter 76 of TAC), the City of Houston Design Manual, Item 11.14-Site Restoration. The piezometer installation and abandonment reports are provided in Appendix B.

## 4.0 LABORATORY TESTS

### 4.1 General

Soil classifications and shear strengths were further evaluated by laboratory tests on representative samples of the major strata. The laboratory tests were performed in general accordance with ASTM Standards. Specifically, ASTM D 2487 is used for classification of soils for engineering purposes. Furthermore, summary of test results are presented in Appendix A.

### 4.2 Classification Tests

As an aid to visual soil classifications, physical properties of the soils were evaluated by classification tests. The tests were conducted in general accordance with ASTM standards. These tests consisted of natural moisture content tests (ASTM D 4643), percent finer than the No. 200 sieve tests (ASTM D 1140) and Atterberg limit determinations (ASTM D 4318, Method A). Similarity of these properties is indicative of uniform strength and compressibility characteristics for soils of essentially the same geological origin. Results of these tests are tabulated on the boring logs at respective sample depths.

### 4.3 Strength Tests

Undrained shear strengths of the cohesive soils, measured in the field, were verified by calibrated hand penetrometer tests, unconfined compressive strength tests (ASTM D 2166) and torvane tests. Natural water content and dry unit weight were determined routinely for each unconfined compressive strength test. These test results are also presented on the boring logs.

### 4.4 Particle Size Analysis Test

This test was conducted in general accordance with ASTM D 422, the Standard Method for Particle-Size Analysis of Soils. This test was performed on selected samples obtained from Borings B-2 and BE-4 at depths of 8-ft to 10-ft and 6-ft to 8-ft, respectively. The analysis results are presented on Plates 6 and 7.

## 4.5 Soil Sample Storage

Soil samples tested or not tested in the laboratory will be stored for a period of fourteen days subsequent to submittal of this report. The samples will be discarded after this period, unless we are instructed otherwise in writing

# 5.0 SITE GEOLOGY

According to the soil survey of Harris County, Texas (prepared by the U.S. Department of Agriculture Soil and Conservation Service (1976), geologically the project areas at the proposed alignment lies on the Gessner-Urban land complex (Gu).

This complex is in broad, nearly level areas and in depressions. It consists of built-up areas and areas w here the population is increasing. The areas range from 15 to 180 acres, but a few are several hundred ac res in size. Slopes are mainly 0 to 1 percent. Water stands on the surface in the depressions for long per iods after rains. There are simple mounds in a few areas. Gessner soils make up 20 to 80 percent of the complex; Urban land, 10 to 75 percent; and other soils, 10 to 20 percent.

The surface layer of the Gessner soils is friable, slightly acid, dark grayish brown loam about 7-inch thick. The layer below that is about 9-inch thick and consists of friable, slightly acid, grayish brown loam. It tongues into the next layers, which is friable, neutral, dark gray loam, about 18-inch thick that is slightly more clayey. The layer below that is about 19-inch thick and consists of friable, moderately alkaline, light brownish gray loam. The next layer, to a depth of 84-inch, is firm, moderately alkaline, light gray sandy clay loam that has distinct mottles of yellowish brown and brownish yellow.

# 6.0 GENERAL SOILS AND DESIGN CONDITIONS

## 6.1 Site Conditions

The project alignments generally consist of concrete paved roadway. In general commercial and residential structures exist in the vicinity of the project alignments. Project site pictures were taken during our site visit and drilling operation. These pictures are presented in Appendix C.

## 6.2 General Soil Stratigraphy

Field and laboratory test data indicate that soil stratigraphy along the project alignment is relatively variable. Details of subsoil conditions at each boring location are presented on the respective boring log, provided in Appendix A. In general, the soils can be grouped into seven (7) major strata with depth limits and characteristics as follows:

| Stratum No. | Range of Depth, ft. | Soil Description* |
|---|---|---|
| | | CONCRETE PAVEMENT (7.5" to 8.5" in thickness) |
| I | 0.6 – 2 | FILL: SILTY SAND, dark gray, brownish yellow, dark brown, with root fibers (SM); Borings B-1 and B-6 only |

| Stratum No. | Range of Depth, ft. | Soil Description* |
|---|---|---|
| II | 0.6 – 2 | FILL: LEAN CLAY, firm to very stiff, light gray, gray, light brown, brownish yellow, with root fibers, ferrous and calcareous nodules, sands, moist (CL); in Borings B-2, B-4 and B-5 only |
| III | 0.6 – 2 | FILL: SANDY SILT, dark gray, with root fibers, clay pockets (ML); Boring B-3 only |
| IV | 2 – 30 | LEAN CLAY, firm to hard, light gray, light brown, brownish yellow, reddish brown, with root fibers to 6', ferrous and calcareous nodules, sands, moist (CL) |
| V | 4 – 23 | FAT CLAY, stiff to very stiff, light gray, brown, brownish yellow, with root fibers to 6', ferrous and calcareous nodules, moist (CH); in Boring B-1 only |
| VI | 8 – 25 | SILTY SAND, medium dense, light brown, gray, brownish yellow, with clay pockets, moist (SM) |
| VII | 12 – 24 | SANDY SILT, medium dense, light brown, gray, light gray, brownish yellow, with clay pockets (ML); in Borings B-3, B-4 and BE-7 only |

* Classification in general accordance with the Unified Soil Classification System (ASTM D 2487)

## 6.3 Soil Properties

Soil strength and index properties and how they relate to the pavement design and underground utility installations along the project alignments are summarized below:

| Stratum No. | Soil Type | PI(s) | SPT | Soil Expansivity | Soil Strength, tsf | Remarks |
|---|---|---|---|---|---|---|
| I | Fill: Silty Sand (SM) | – | – | Non-Expansive | – | Moisture Sensitive |
| II | Fill: Lean Clay (CL) | 11 – 19 | – | Non-Expansive | 0.46 – 1.50 | – |
| III | Fill: Sandy Silt with (ML) | – | – | Non-Expansive | – | Moisture Sensitive |
| IV | Lean Clay (CL) | 10 – 22 | – | Non- to Low Expansive | 0.23 – 0.40 | – |
| V | Fat Clay (CH) | 36 | – | Expansive | 0.23 – 1.51 | – |
| VI | Silty Sand (SM) | – | 11 – 23 | Non-Expansive | – | Moisture Sensitive |
| VII | Sandy Silt (ML) | – | 15 – 19 | Non-Expansive | – | Moisture Sensitive |

Legend: PI = Plasticity Index
SPT = Standard Penetration Test

## 6.4 Water-Level Measurements

The soil borings were first drilled dry to evaluate the presence of perched or free-water conditions. A wet rotary technique was used thereafter to the completion depths of the borings. The levels where free water was first encountered in the open boreholes during drilling and 24 hours after drilling are shown on the boring logs. Our groundwater/perched water measurements in the boreholes and piezometers are as follows:

| Boring No./ Piezometer | Groundwater Depth, ft. at the Time of Drilling | Groundwater Depth, ft. After 24 Hour Later | Piezometer Water Depth, ft. | |
|---|---|---|---|---|
| | | | 1st Reading | 2nd Reading |
| B-1 | Dry | Dry | – | – |
| B-2 | Dry | Dry | – | – |
| B-3/P-1 | Dry | Dry | 22.2 | 22.2 |
| B-4 | Dry | Dry | – | – |
| B-5/P-2 | Dry | Dry | 21.5 | 21.5 |
| B-6 | Dry | Dry | – | – |
| BE-2 | Dry | Dry | – | – |
| BE-4 | Dry | Dry | – | – |
| BE-7 | Dry | Dry | – | – |

Fluctuations in groundwater generally occur as a function of seasonal moisture variation, temperature, groundwater withdrawal and future construction activities that may alter the surface drainage and subdrainage characteristics of this site.

An accurate evaluation of the hydrostatic water table in the relatively impermeable clay and low permeability silts/sands requires long term observation of monitoring wells and/or piezometers. It is not possible to accurately predict the pressure and/or level of groundwater that might occur based upon short-term site exploration. In view of this, Borings B-3 and B-5 were converted to Piezometer P-1 and P-2, respectively. The result of piezometer readings are presented in Plate 5.

We recommend that GET be immediately notified if a noticeable change in groundwater water occurs from that mentioned in our report. We would be pleased to evaluate the effect of any groundwater changes on our design and construction sections of this report.

## 7.0 UNDERGROUND UTILITIES

### 7.1 General

We understand that underground utilities installation along the alignment will include saniraty sewers, storm sewers and water lines. Furnished information indicated that the maximum depth of these utilities with range from about 8.5-ft to 14-ft. Furthermore, Open-trench or Augering method will be used for the underground utility installations. We understand that the proposed underground utilities will be constructed according to the "City of Houston Specifications, Section 02317 – Excavation and Backfill for Utilities, and Section 02447 – Augering Pipe and Conduit".

## 7.2 Open-Trench Method

### 7.2.1 Sewerlines

In general, where dry stable trench conditions exist, bedding and backfill for the sanitary sewerlines should be in accordance with the City of Houston Specifications Drawing No. 02317-03. Bedding for the sanitary sewerlines, where wet stable trench conditions exist (where excavations below groundwater table are required), should be in accordance with the City of Houston Specifications Drawing No. 02317-02.

**The results of our field exploration and laboratory testing indicate that unsatisfactory soils for excavation, such as sandy silt (ML), silty sand (SM) and poorly graded sand with silt (SP-SM) subsoils, exist at various depths in the borings along the project alignment. A summary of the unsatisfactory soils, locations and depths are as follows:**

| Boring(s) | Depth Range, ft. |
|---|---|
| B-1 | 12 to 16 |
| B-2 | 8 to 18 |
| B-3 | 12 to 18 / 20 to 22 |
| B-4 | 8 to 16 |
| B-5 | 10 to 14 |
| B-6 | 1 to 2 / 10 to 16 |
| BE-2 | 10 to 16 |
| BE-4 | 8 to 16 / 20 to 25 |
| BE-7 | 10 to 24 |

If these conditions are encountered during the time of construction, suitable groundwater control measures should be implemented in accordance with the “City of Houston Standard Specifications, Section 01578 – Control of Groundwater and Surface Water”. Furthermore, the contractor may have to over excavate an additional 6-inch and remove unstable or unsuitable materials with approval by geotechnical engineer, and then place an equal depth of cement stabilization sand.

Due to potential variability of the on-site soils, unstable trench conditions may still exist in the areas where we did not conduct our borings. If these conditions are encountered during the time of construction, a stable trench should be provided to allow proper bedding and installation.

Sand backfill used in the cement-stabilized sand and sand backfill sections should be free of clay lumps, organic materials, or other deleterious substances, and should have a PI less than 4 for the cement-stabilized sand and less than 7 for the sand backfill section, and not more than 15% passing the No. 200 sieve. Cement stabilized sand should conform to the “City of Houston Standard Specifications, Section 02321 – Cement Stabilized Sand”.

7.2.2 Water Lines

The bedding and backfill for the proposed water lines should be constructed in accordance with the City of Houston Specifications drawing No. 02317-04 for open-trench construction. Trenches for the proposed water lines must have a width below the top of the pipe of not less than the outside diameter of the pipe plus 24-inches and shall be wide enough to permit making up the joints but shall not be wider than the outside diameter of the pipe plus 36-inches.

In general, 12-inch of bank sand should be placed above the waterlines. Twelve-inch lifts of bank sand should be placed below the waterlines for dry excavation bottom. In case of wet excavation bottom, geotextile fabrics should be placed at the excavation bottom and along the excavation sides to a height of at least 24 inches.

## 7.3 Augering and Augering Pits

7.3.1 Sanitary Sewerlines and Water Lines

We understand that Augering may be used for the underground utility installations along the proposed alignments in City of Houston, Texas. The augering should be conducted in accordance with the City of Houston Standard Specifications 02447 – Augering Pipe and Conduit or 02448 – Pipe and Casing Augering for Sewers. Augering should be started from approved pit locations. Excavation for pits and shoring installation should conform to the aforementioned City of Houston Standard Specifications and 02317 – Excavation and Backfill for Utilities. If the augering zone is within the cohesionless soils or collapsible soils, install casings as required by City of Houston Standard Specifications 02447 – Augering Pipe and Conduit. The augering near existing structures or utility lines should be conducted in accordance with the City of Houston Standard Specification 02233 – Clearing and Grubbing.

Diameter of auger hole should not exceed pipe bell diameter plus 2-inches. The receiving pit distance should conform to the aforementioned City of Houston Standard Specifications. A minimum spacing of 6-inch should be provided between the pipe and walls of bore pit. The maximum allowable width of pit shall be 5-ft unless approved by City Engineers. Width of pit at surface shall not be less than the pit width at the bottom.

## 7.4 Groundwater Control

7.4.1 General

We understand that the invert depths of the proposed utilities will range from about 8.5-ft to 14-ft along the proposed project alignment. Our short-term field exploration along the project alignment indicated that groundwater/perched water was not encountered in the borings. However, piezometer readings indicated stabilized groundwater levels at a depth of about 22-ft and 21.5-ft below the existing ground surface in piezometers P-1 and P-2, respectively. Hence, groundwater dewatering may be required. Fluctuations in groundwater can occur as a function of seasonal moisture variations. Groundwater control recommendations are presented in the following report sections.

7.4.2 Dewatering Technique

The water level readings measured in piezometers P-1 and P-2 indicate that the range of stabilized groundwater level is approximately between 21-ft to 22-ft. Therefore, groundwater dewatering may be required. In the event that groundwater is encountered during construction, it is our opinion that groundwater should be lowered to a depth of at least three-ft below the deepest excavation grade in order to provide dry working conditions and firm bedding. Any minor water inflow in cohesive soil layers can probably be removed using a sump-pump or trench sump-pump. Wellpoint system can be used in the area where silty sand soils are present. **Due to the presence of silty sand/ sandy silt soils near the invert depths of the underground utilities and the hydrostatic pressure, bottom blow up may occur if an effective dewatering system is not in place at the time of construction.** The selection and proper implementation of an effective groundwater control system is the responsibility of the contractor.

Design of a wellpoint system should consider the amount of groundwater to be lowered and the permeability of the affected soils. The selection and proper implementation of an effective groundwater control system is the responsibility of the contractor. The design of dewatering system for groundwater and surface water control should be in accordance with the City of Houston Specifications, Section 01578 − Control of Ground Water and Surface Water.

## 7.5 OSHA Soil Classifications

The subsoils can be classified in accordance with Occupational Safety and Health Administration (OSHA) Standards, dated October 31, 1989 of the Federal Register. OSHA classification system categorizes the soil and rock in four types based on shear strength and stability. The description of four (4) types in classification system is summarized in the Appendix D.

Based on our geotechnical exploration and laboratory test results, details of soil classifications at each boring are summarized in the OSHA Soil Classification, presented in Appendix D. Furthermore, a letter for trench safety recommendation is provided separately.

## 7.6 Excavations

Each side of an excavation or trench which is five-ft or deeper must be protected by sheeting/bracing shoring or sloped. Based on soil strength data and OSHA soil classifications, temporary (less than 24 hours) open-trenched, non-surcharged, and unsupported excavations should be made on slopes of about 1.5(h):1(v). Vertical cuts can be constructed, provided shoring and bracing are used for the excavation wall stability. Benched excavation can also be used with average slopes of about 1(h):1(v) and steps should not be higher than five-ft. In all cases, excavations should conform to OSHA guidelines. Flatter slopes may have to be used if large amounts of sand need to be excavated for deep installations. Specifications should require that no water be allowed to pond in the excavations. The surface slopes should be protected from deterioration and weathering if they are to be left open for more than 24 hours.

Excavations should be performed with equipment capable of providing a relatively clean bearing area. Excavation equipment should not disturb the soil beneath the design excavation bottom and should not leave large amounts of loose soil in the excavation.

## 7.7 Lateral Earth Pressures

In the event that open excavations are not used, the proposed underground utilities can be installed using trench sheeting. The sheeting can be constructed in the form of cantilever sheeting or with bracing. Lateral earth pressures for each method used are summarized on Plates 8 and 9. The trenching and shoring operations should follow OSHA Standards. We recommend a geotechnical engineer monitor all phases of trench excavation and bracing to assure trench safety.

## 7.8 Backfilling for Auger Pits and Auger Holes

Sand backfill used in the cement-stabilized sand and sand backfill sections should be free of clay lumps, organic materials, or other deleterious substances, and should have a PI less than 4 for the cement-stabilized sand and less than 7 for the sand backfill section, and not more than 15% passing the No. 200 sieve.

Cement stabilized sand should conform to the "City of Houston Specifications, Section 02321 – Cement Stabilized Sand". Backfill should be placed in accordance with "City of Houston Standard Specifications, Section 02317 – Excavation and Backfill for Utilities". City of Houston Standard Specification Drawing No. 02447-01 should be followed when backfilling the auger pits. The annular space between the pipe and the auger hole should be backfilled to a minimum of 12-inches on both sides beyond the auger pit as indicated in the City of Houston Standard Specification Drawing No. 02447-01.

# 8.0 BOX CULVERT

## 8.1 General

We understand that four box culverts of varying sizes ranging from 5' x 5' to 8' x 5' will be installed along the proposed project alignment. Excavation and groundwater control for construction of the box culverts should be in accordance with our recommendations provided in construction consideration section of this report. The proposed box culverts may be designed in accordance with the parameters presented on Plate 10.

## 8.2 Allowable Bearing Pressure

We understand that the box culverts may be supported on a seal slab foundation at a depth of varying from 3-ft to 5-ft. The allowable bearing pressures for the seal slab foundation at this depths are as follows:

| Foundation Type | Depth, ft.[1] | Allowable Net Bearing Pressure, psf | |
|---|---|---|---|
| | | Dead Load[2] | Total Load (Dead + Live) |
| Seal Slab | 3.0 to 5.0 | 2,000 | 2,500 |

1. Below existing grade
2. Dead load + sustained live load

Footings proportioned in accordance with the above bearing capacity values will have a safety factor of 2.5 and 2.0 with respect to shearing failure for dead and total loading, respectively.

## 8.3 Bedding and Backfilling

The proposed concrete box culverts should be placed on a well prepared, properly compacted working surface. Cast-in-place culverts can be supported on the natural soils provided subgrade is protected from construction disturbances and surface water is not allowed to pond within the excavation. We recommend the exposed subgrade be uniformly proofrolled to at least 95 percent of Standard Proctor (ASTM D 698) maximum dry density at a moisture content between optimum and +3% of optimum. The excavation, trenching, foundation, embedment, and backfilling for the proposed inlet and outlet structures shall be in accordance with City of Houston (COH) Department of Public Works & Engineering, dated July 2012 (Ref. 2).

Sand used in the cement-stabilized sand backfill sections should be free of clay lumps, organic materials, or other deleterious substances, and should have a PI less than 4 for the cement-stabilized sand, and not more than 15% passing the No. 200 sieve. Cement stabilized sand should conform to City of Houston (COH) Department of Public Works & Engineering, dated July 2012 (Ref. 2)

## 8.4 Buoyancy

The proposed box culverts may experience uplift loads from the groundwater during flood conditions. The box culverts should perform satisfactorily if a design factor of safety against uplift loads of 2.0 is used. In general, the hydrostatic pressure will be resisted by the dead weight of the structure, weight of the overburden soils above the top of the box culverts and the friction or adhesion between the walls and natural soils or fill. A submerged unit weight of 60 pounds per cubic foot (pcf) and 85 pcf can be used for soils and concrete, respectively, to compute the resistance to uplift loads. An adhesion value of 200 psf can be used between the backfill and the box culverts to resist the uplift loads. A factor of safety of 2.0 is included in the adhesion value.

# 9.0 PAVEMENT RECOMMENDATIONS

## 9.1 General

It is planned for paving and drainage improvements at Gessner Road from Neuens Road to Long Point Road in the City of Houston, Texas. We understand that the existing concrete pavement will be removed and replaced with new concrete paving. The new pavement design is in accordance with the "1993 ASSHTO Guide for Design of Pavement Structures" (Ref. 1). Furthermore, our recommendations on site preparation and soil stabilization are in general accordance with the City of Houston (COH) Department of Public Works & Engineering, Infrastructure and Design Manual, dated July 2012 (Ref. 2).

## 9.2 Traffic Information

We understand that the pavement will be designed based on major thoroughfare traffic. A design ESAL of $10 \times 10^6$ was assumed for the proposed major thoroughfare. The results of the pavement design analyses are provided in the following sections.

## 9.3 Subgrade Stabilization

The type of subgrade stabilization for the concrete pavement areas will depend on the final grade elevation. Subgrade preparation in pavement areas should specify compaction of the upper eight-inch to at least 95% of maximum standard Proctor density (ASTM D 698) at a moisture content between optimum and +3% of optimum moisture content. Depending on the type of soils encountered along the project alignment, lime stabilization of the subgrade soils should most likely be performed. The subgrade soils should be stabilized, using lime based on the City of Houston Specifications, Section 02336. Use 5% lime by dry weight to stabilize the subgrade soils. This results in application rates of 23 pounds of lime, per square yard per eight-inch of compacted thickness. City of Houston Specifications, Section 02336, can be used as procedural guides for placing, mixing and compacting the lime stabilizer and the soils.

**Our recommendations on subgrade stabilization are preliminary. The actual depth and type of stabilization should be determined in the field at the time of construction just after site stripping and proofrolling. Furthermore, the type and amount of the stabilizer may vary depending on the final grade elevation and the soil type encountered.**

## 9.4 Recommended Subgrade Design Values

Results of the soils test indicated that subgrade soils consist of silty sand fill (SM), sandy silt fill (ML) and lean clay fill (CL) soils based on Unified Soils Classification System (ASTM D 2487). For these soils, the recommended design parameters for CBR and $M_R$ values are 5 and 7,500 psi, respectively.

## 9.5 Concrete Pavement

The following design parameters (based on 1993 AASHTO Guide for Design of Pavement Structures, Ref. 1) were used in the concrete pavement design for the proposed project alignment.

| AASHTO Design Parameter | Pavement Design Value |
|---|---|
| ESAL × $10^6$ for 20-year design life | 10.0 |
| Reliability, R | 95% |
| Overall Standard Deviation, $S_0$ | 0.35 |
| Load Transfer Coefficient, J | 3.2 |
| Loss of Support, LS | 1.0 |
| Drainage Coefficient, $C_d$ | 1.2 |
| Design Serviceability Loss, Δ psi | 2.0 |
| Concrete Modules of Rupture (28 days) in psi, $S_c$’ | 600 |
| Concrete Compressive Strength at 28 days in psi, $f_c$’ | 3,500 |
| Effective Modulus of Subgrade Reaction k, in pci | 130 |

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

| Design, ESAL × $10^6$ | Concrete Pavement Thickness, inch(es) | Subgrade Stabilization Thickness, inch(es) |
|---|---|---|
| 10.0 | 10.0 | 8.0 |

Detailed design computations are presented in Appendix E. Our design recommendations also consider excellent drainage is provided near the pavement structures, assuming the pavement are exposed to moisture levels approaching saturation from 1 to 5 percent of the time. Concrete should meet the requirements of the City of Houston design paving specifications as well as AASHTO "Guide Specifications for Highway Construction and the Structural Specifications for Transportation Materials." The construction of rigid pavement should be in accordance with the City of Houston Standard Specification Drawing No. 02751-01.

Subgrade preparation in pavement areas should specify compaction of the upper eight-inch to at least 95% of maximum standard Proctor density (ASTM D 698) at a moisture content between optimum and +3% of optimum moisture content. Depending on the major type of soils encountered along the project alignment, lime stabilization of the subgrade soils should most likely be performed. The subgrade soils should be stabilized, using lime based on the City of Houston Specifications, Section 02336. Use 5% lime by dry weight to stabilize the subgrade soils. This results in application rate of 23 pounds of lime, per square yard per eight-inch of compacted thickness. City of Houston Specifications, Section 02336, can be used as procedural guides for placing, mixing and compacting the lime stabilizer and the soils.

The steel reinforcement was designed using No. 4 and No. 5 bars as described below:

- The reinforcing steel was designed on the basis of Grade 60 steel. The longitudinal steel reinforcement should be No. 4 bars at 12.5-inch spacing. The transverse steel reinforcement should be No. 4 bars at the spacing of 36-inch for a pavement width of 25-ft. We recommend a lap length of 22-inches for the No. 4 bars. The end bar spacing should be 3.5 inches.

- The reinforcing steel was designed on the basis of Grade 60 steel. The longitudinal steel reinforcement should be No. 5 bars at 18.25-inch spacing. The transverse steel reinforcement should be No. 5 bars at the spacing of 36-inch for a pavement width of 25-ft. We recommend a lap length of 27-inches for the No. 5 bars. The end bar spacing should be 4-inches.

## 10.0 CONSTRUCTION CONSIDERATIONS

### 10.1 Site Preparation

**The project alignment has the potential for construction problems related to the near surface layer of silty sand fill, sandy silt fill and lean clay fill soils as encountered in the borings. The permeable silty sand fill/sandy silt fill soils are underlain by relatively impermeable soils. Thus, due to poor site drainage, wet season or site geohydrology, water ponds on the clays soils and creates a "perched water table condition". The surficial silty sand fill/ sandy silt fill soils could become extremely soft when wet, and must be stabilized, aerated, or replaced in order to minimize rutting and pumping. Therefore, these soils should be improved. The depth of the improvement is generally to the bottom of the surficial granular layer. We recommend that the contractor inspect the site prior to providing a bid of the earthwork. If soft, wet and compressible surficial soils are encountered (by proofrolling or using a metal probe), the contractor should increase the subgrade improvement in his/her earthwork bid. Our recommendations on subgrade improvements are presented in the earthwork section of this report.** Site preparation should be conducted in accordance with the "City of Houston Standard Specifications, Section 02221 – Removing Existing Pavements and Structures and Section 02233 – Clearing and Grubbing". In general, subgrade preparation should be as follows:

1. The requirement for removal of any existing paving, and subsoil materials will depend on final grades and other alignment information. In general, remove all vegetation, tree roots, organic topsoil, existing foundations, paved areas and any undesirable materials from the construction area. Any tree trunks under the pavement should be removed to a root size of less than 0.5-inches. We recommend that the stripping depth be evaluated at the time of construction by a soil technician.

2. The subgrade areas should then be proofrolled with a loaded dump truck or similar pneumatic-tired equipment with loads ranging from 25- to 50-tons. The proofrolling serves to compact surficial soils and to detect any soft or loose zones. The proofrolling should be conducted in accordance with TxDOT Standard Specification Item 216. Any soils deflecting excessively under moving loads should be undercut to firm soils and recompacted. Any subgrade stabilization should be conducted after site proofrolling is completed and approved by the geotechnical engineer. The proofrolling operations should be observed by an experienced geotechnician.

3. Off-site borrow for fill should consist of lean clays with a liquid limit not exceeding 40 and a PI between 7 and 20. These soils should be placed in loose lifts not exceeding eight-inches and compacted to at least 95% of maximum standard Proctor density (ASTM D 698) at moisture contents between optimum and +3% of optimum. Bank sands should not be used as select structural fill. On-site soils, free of organics, (with the exception of sands and silts) are also suitable for use as structural fill.

4. In cut areas, the soil should be excavated to grade and the surficial soil proofrolled and scarified to a minimum depth of six-inches and recompacted to the previously mentioned density and moisture content.

5. Positive site drainage should be developed at the beginning of the project to limit construction difficulties with wet surface soils.

## 10.2 Suitability of On-Site Soils for Use as Fill

### 10.2.1 General

Fill requirements should be in accordance with the 'City of Houston Standard Specifications, Section 02316 –Excavation and Backfill for Structures, Section 02317 – Excavation and Backfill for Utilities and Section 02320 – Utility Backfill Materials". The on-site soils can be used as fill materials as described in the following report sections.

### 10.2.2 Select Backfill

This is the type of fill that can be used for the structures or utilities. These soils should consist of lean clays with plasticity indices between 8 and 20 and amount of passing No. 200 sieve greater than 50 percent.

### 10.2.3 Random Backfill

This type of fill does not meet the Atterberg limit requirements for select structural fill. This fill should consist of lean clays or fat clays. They can be used for the structures or utilities after treatment.

### 10.2.4 General Fill

This type of fill consists of silts, sands and clays. However, the silts and sands are moisture sensitive and are difficult to compact in a wet condition (they may pump). Furthermore, these soils can erode easily. Their use is not recommended as backfill materials. They can be used for site grading and in unimproved areas.

### 10.2.5 On-Site Fill Soil Classification

Based on Borings B-1 through B-6, BE-2, BE-4 and BE-6, the on-site soils can be used as fill materials as described below:

| | | Use as Fill | | | |
|---|---|---|---|---|---|
| Stratum No.[1] | Soil Type | Select Backfill | Random Backfill | General Fill | Notes |
| I | Fill: Silty Sand (SM) | – | – | ✓ | 2, 3 |
| II | Fill: Lean Clay (CL) | – | ✓ | ✓ | 2 |
| III | Fill: Sandy Silt (ML) | – | – | ✓ | 2, 3 |
| IV | Lean Clay (CL) | ✓ | ✓ | ✓ | 2, 4 |
| V | Fat Clay (CH) | – | ✓ | ✓ | 2, 5 |
| VI | Silty Sand (SM) | – | – | ✓ | 2, 3 |
| VII | Sandy Silt (ML) | – | – | ✓ | 2, 3 |

Notes:
1. See soil stratigraphy and design conditions sections of this report for strata description.
2. All fill soils should be free of organics, roots, etc.
3. The on-site cohesionless soils are moisture sensitive and erode easily. These soils will pump when they get wet. Compaction difficulties will occur in these soils in a wet condition.
4. Some of these soils should be lime modified with 5% by dry weight and can be used as select structural fill.
5. These soils should be lime modified with 5% by dry weight and can be used as select structural fill.

## 10.3 Earthwork

### 10.3.1 General

**Difficult access and workability problems can occur in the surficial soils due to poor site drainage, wet season, or site geohydrology.** Based on the laboratory test results, the near surface soils at the project site consist of silty sand fill (SM), sandy silt fill (ML) and lean clay fill (CL) soils. Considering the soils stratigraphy, the construction of this project should be conducted during the dry season to avoid major earthwork problems. Our recommendations for earthwork activity for areas with cohesive and cohessionless soils are provided separately.

### 10.3.2 Earthwork for Cohesive Soils

Difficult access and workability problems can occur in the near surface lean clay fill (CL) soils due to poor site drainage, wet season, or site geohydrology. Should this condition develop, drying of the soils for support of pavement may be improved by the addition of 5% lime by dry weight. The application rate corresponding to this additive amount would be 23 pounds of lime per square yard for eight-inch of compacted thickness.

City of Houston Standard Specifications 02336 shall be used as procedural guides for placing, mixing, and compacting lime stabilizer and the soils.

**Our recommendations on subgrade stabilization are preliminary. The actual depth and type of stabilization should be determined in the field at the time of construction just after site stripping and proofrolling. Furthermore, the type and amount of the stabilizer may vary depending on the final grade elevation and the soil type encountered.**

Provided the site work is performed during dry weather and/or project schedules permit aeration of wet soils, the subgrade will be suitable for pavement support.

### 10.3.3 Earthwork for Cohesionless Soils

**Difficult access and workability problems will most likely occur in the near surface silty sand fill (SM) and sandy silt fill (ML) soils due to poor site drainage, wet season, or site geohydrology.** Considering the soils stratigraphy, the construction of this project should be conducted during the dry season to avoid major earthwork problems. In the event the subgrade soils become wet and experience pumping problems, they can be (a) opened up to dry up, (b) removed and replaced with dry cohesive soils or (c) chemically modified or stabilized. These alternatives are discussed in the following report sections.

10.3.3.1 Improving Drainage

The project site drainage in the pumping soils can be accomplished by placing several shallow ditches (about 18-inches ±) in the surficial cohesionless soils. These ditches should be directed to a low area, such as a hole or another ditch in the lowest elevation area of the site. This will allow the surficial soils to drain the water and make the drying process faster. The hole/low area should not be under the building areas. The excess water can be pumped out of the hole and moved off-site.

10.3.3.2 Subgrade Drying

The on-site wet soils can be opened up so that it would dry up. However, opening up the surficial cohesionless soils for drying purposes may not be practical, due to cyclic rainfall in the Gulf-Coast area.

10.3.3.3 Removal and Replacement

The surficial cohesionless soils can be removed and replaced with select structural fill. The actual depth of removal and replacement should be evaluated in the field, but it should reach level of dry and stable subgrade. This procedure will include removal of the surficial cohesionless soils, proofrolling and compacting the subgrade soils to a minimum of 95 percent standard Proctor density (ASTM D 698). The site can then be backfilled with select structural fill, compacted to a minimum of 95 percent of standard Proctor density. The proofrolling should be in accordance with the site preparation section of this report. All of the fill soils should be placed and tested in accordance with the site preparation section of this report.

10.3.3.4 Modification/Stabilization

We recommend that the on-site cohesionless soils be modified (to dry up), using 5 to 10 percent fly ash by dry weight. City of Houston Standard Specifications 02337, shall be used as a procedural guide for placing, mixing and compacting the fly-ash stabilizer. The estimated amount of fly ash per depth of modification are as follows:

| Modification Depth, in. | Fly Ash Weight Range, lbs. per Square Yard |
|---|---|
| 6 | 23 − 45 |
| 12 | 46 − 90 |
| 18 | 69 − 135 |
| 24 | 92 − 180 |

We recommend that five percent fly ash be used if the surficial soils are relatively moist at the time of application. Higher levels (10 percent) of fly ash should be used if wet and soggy subgrade soils are encountered.

The subgrade soils should be removed to a depth of 24-inch (or more) below existing grade. These soils should be stockpiled. The soils below a depth of 24-inch should be modified to a depth of 12-inch. These soils should be compacted to a minimum of 95 percent of standard proctor density (ASTM D 698). The stockpiled soils should then be modified and replaced in six-inch lifts and compacted to 95 percent of maximum dry density as determined by ASTM D 698 at moisture contents within ±2 percent of optimum.

Due to poor drainage and the depth of the cohesionless soils, the depth of stabilization may be as deep as depth of cohesionless soils. A test section can be implemented for this purpose. The subgrade soils should be modified in six-inch lifts and compacted within four hours of mixing and placement. All of the subgrade soils should be compacted to a minimum of 95 percent of the standard proctor density at the moisture content with optimum. The degree of compaction for the lifts, below a depth of 24-inch can be relaxed to 90 percent of maximum dry density to ease the construction procedures.

The subcontractor who will be doing the subgrade modification or stabilization should be experienced with stabilization procedures and methods. Furthermore, all of the earthwork at this project should be monitored by our geotechnician to assured compliance with the project specifications.

Once the subgrade is constructed, the soils at the top of subgrade should be slicked and the subgrade needs to be crowned such that the all surface water would drain away. No low areas should be left within the subgrade areas, since these areas would hold water and destroy the subgrade structure.

## 10.5 Construction Surveillance

Construction surveillance and quality control tests should be planned to verify materials and placement in accordance with the specifications. The recommendations presented in this report were based on a discrete number of soil test borings. Soil type and properties may vary across the site. As a part of quality control, if this condition is noted during the construction, we can then evaluate and revise the design and construction to minimize construction delays. We recommend the following quality control procedures be followed by a qualified engineer or technician during the construction of the project:

- Observe the site stripping and proofrolling.
- Verify the compaction of subgrade soils.
- Verify the type, depth and amount stabilizer.
- Evaluate the quality of fill and monitor the fill compaction for all lifts.
- Observe all phases of trench safety.
- Observe all excavation operations.
- Monitor concrete placement, conduct slump tests and make concrete cylinders.

It is the responsibility of the client to notify GET of when each phase of the construction is taking place so that proper quality control and procedures are implemented.

## 11.0 RECOMMENDED ADDITIONAL STUDIES

This report has been based on assumed conditions/characteristics of the proposed project area where specific information was not available. It is recommended that the architect, civil engineer and structural engineer along with any other design professionals involved in this project carefully review these assumptions to ensure they are consistent with the actual planned development. When discrepancies exist, they should be brought to our attention to ensure they do not affect the conclusions and recommendations provided herein. We recommend that GET be retained to review the plans and specifications to ensure that the geotechnical related conclusions and recommendations provided herein have been correctly interpreted as intended.

## 12.0 STANDARD OF CARE

The recommendations described herein were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical engineering profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty or guarantee, expressed or implied, is made other than the work was performed in a proper and workmanlike manner.

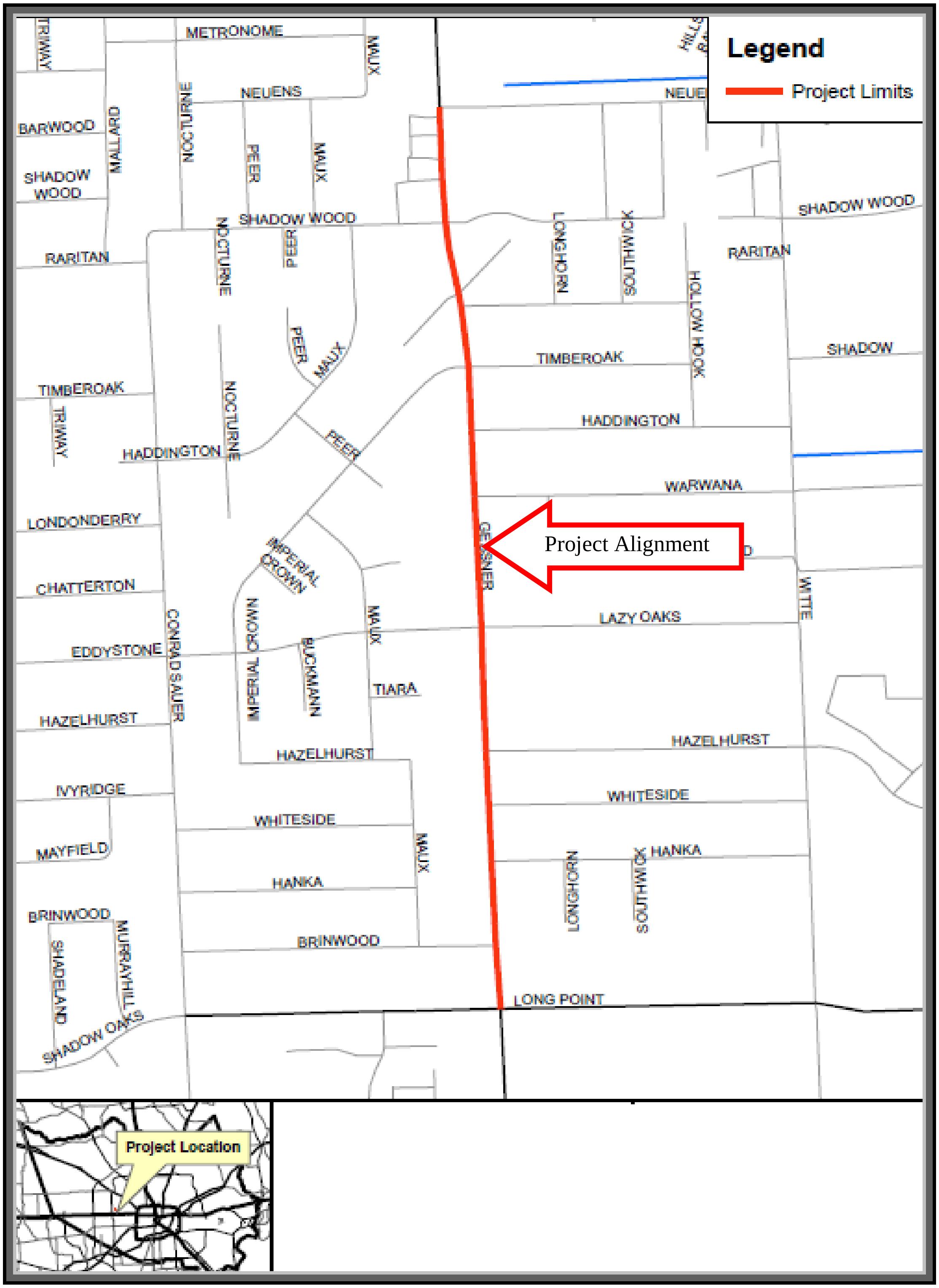
## 13.0 REPORT DISTRIBUTION

This report was prepared for the sole and exclusive use by our client (Reynolds, Smith and Hills, Inc.) and owner (City of Houston), based on specific and limited objectives. All reports, boring logs, field data, laboratory test results, maps and other documents prepared by GET as instruments of service shall remain the property of GET. GET assumes no responsibility or obligation for the unauthorized use of this report by other parties and for purposes beyond the stated project objectives and work limitations.

## 14.0 REFERENCES

1. AASHTO Specifications, “Guide for Design of Pavement Structures”, American Association of State Highway and Transportation Officials, 1993.

2. “City of Houston Standard Construction Specifications”, Department of Pubic Works and Engineering, City of Houston, July 2012.




## SITE VICINITY MAP

PROJECT: Geotechnical Study, Proposed Gessner Road Paving and Drainage Improvements from Neuens Road to Long Point Road, WBS No. N-000809-0001-3, City of Houston, Texas

| SCALE: 1 INCH = 770 FEET | DATE: SEPTEMBER 2014 | PROJECT NO.: 13-825E |
|---|---|---|

NORTH

## EXISTING PAVEMENT THICKNESS

| Boring Locations | Concrete Pavement Thickness, inches |
|---|---|
| B-1 | 8.5 |
| B-2 | 7.5 |
| B-3 | 8.0 |
| B-4 | 8.0 |
| B-5 | 7.5 |
| B-6 | 7.5 |
| BE-2 | 7.5 |
| BE-4 | 7.5 |
| BE-7 | 7.5 |

# SUMMARY OF THE BORING LOCATIONS

| Gessner Road Paving and Drainage Improvements | | | | | |
|---|---|---|---|---|---|
| Boring locations and depths | | | | | |
| Boring No. | Street Name | Start | End | Storm Sewer Depth (ft) | Boring Depth (ft.) |
| B-1 | Gessner Road | Brinwood Dr. | Hanka Dr. | 14.00 | 23 |
| B-2 | Gessner Road | Hanka Dr. | Hazelhurst Dr. | 12.50 | 22 |
| B-3 | Gessner Road | Hazelhurst Dr. | Lazy Oaks St. | 11.50 | 23 |
| B-4 | Gessner Road | Lazy Oaks St. | Warwana Rd. | 11.00 | 22 |
| B-5 | Gessner Road | Timberwood Dr. | Neuens Rd. | 8.50 | 22 |
| B-6 | Gessner Road | Timberwood Dr. | Neuens Rd. | 8.50 | 22 |
| BE-2 | Gessner Road | Timberoak Dr. | Timberwood Dr. | 9.50 | 27 |
| BE-4 | Gessner Road | Warwana Rd. | Timberoak Dr. | 10.50 | 27 |
| BE-7 | Gessner Road | Long Point Rd. | Brinwood Dr. | 14.25 | 30 |
| | | | | Total Footage: | 218 |

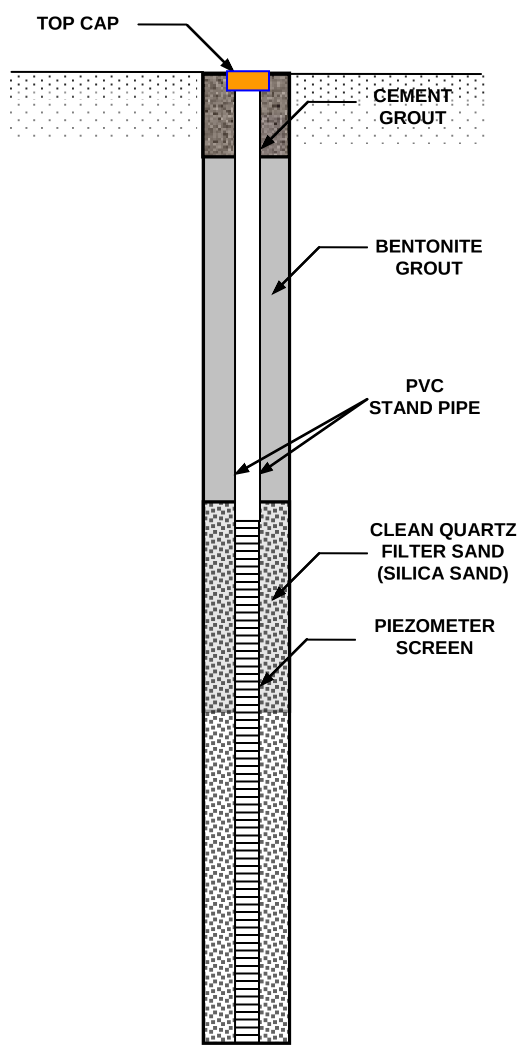
## SUMMARY OF BORING COORDINATES AND ELEVATION

| Boring No. | Alignment | Northing | Easting | Elevation | Station No. | Offset |
|---|---|---|---|---|---|---|
| B-1 | Gessner Road | 13854567 | 3064531.7 | 86.22’ | 40+92.33 | -35.07’ |
| B-2 | Gessner Road | 13855085 | 3064507.5 | 86.92’ | 46+11.29 | -34.37’ |
| B-3 | Gessner Road | 13855573 | 3064484.4 | 87.42’ | 50+98.90 | -35.28’ |
| B-4 | Gessner Road | 13856324 | 3064451.3 | 86.99’ | 58+51.43 | -34.30’ |
| B-5 | Gessner Road | 13857812 | 3064352.8 | 87.98’ | 73+46.89 | +11.50’ |
| B-6 | Gessner Road | 13858043 | 3064341.9 | 88.25’ | 75+77.78 | +11.07’ |
| BE-2 | Gessner Road | 13857165 | 3064409.7 | 88.24’ | 66+95.57 | -34.35’ |
| BE-4 | Gessner Road | 13856613 | 3064438.8 | 87.42’ | 61+39.95 | -33.59’ |
| BE-7 | Gessner Road | 13854008 | 3064798.8 | 87.02’ | 35+21.55 | +204.54’ |

**PIEZOMETER INSTALLATION DATA**

| Piezometer No. | Boring No. | Top of Riser-Height, ft | Piezometer Tip | | Depth to Filter Sand, ft. | | Bentonite Grout, ft. | | Cement Grout, ft. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Depth, ft. | Screen Length, ft. | Top | Bottom | Top | Bottom | Top | Bottom |
| P-1 | B-3 | 0.00 | 23.00 | 10.00 | 11.00 | 23.00 | 2.00 | 11.00 | 0.00 | 2.00 |
| P-2 | B-5 | 0.00 | 22.00 | 9.00 | 10.00 | 22.00 | 2.00 | 10.00 | 0.00 | 2.00 |

Notes: (1) Depth is referenced from the existing ground surface.



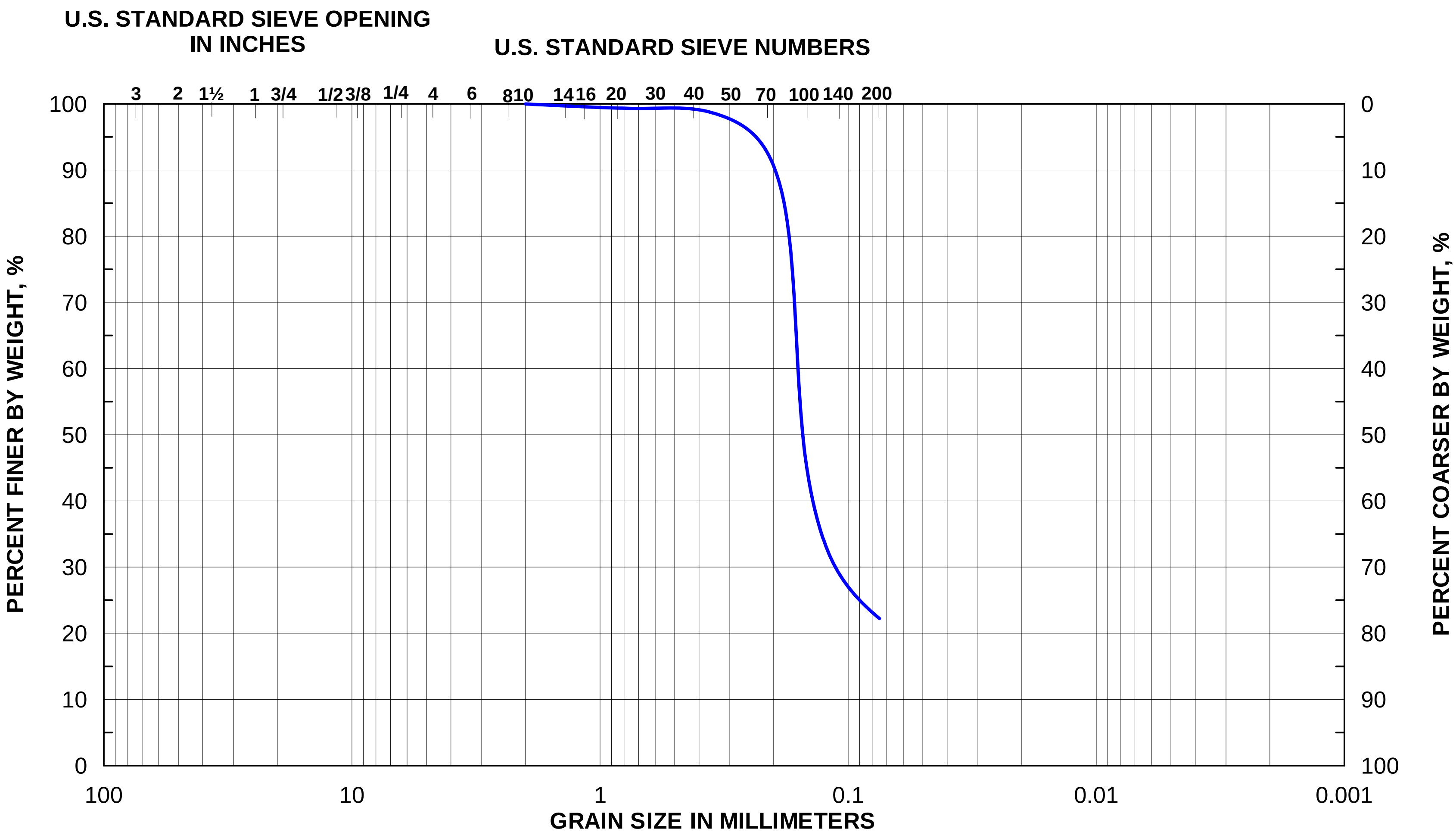

Piezometers P-1 and P-2

Note: Drawing is not to scale.

# PIEZOMETER READING TABLE

| Piezometer No./Depth | Groundwater Depth During Drilling from Ground Surface, ft. | Piezometer Level, ft. | | | | | |
|---|---|---|---|---|---|---|---|
| | | June 20, 2014 (Readings after 15 Days) | | | July 02, 2014 (Readings after 30 Days) | | |
| | | Before Bailing | After Bailing | | | | |
| | | | Time (Min.) | Depth | | Time (Min.) | Depth |
| P-1 (23') Boring B-3 | Dry | 22' 2" | 1 | 22' 2" | 22' 2" | 1 | 22' 2" |
| | | | 2 | 22' 2" | | 2 | 22' 2" |
| | | | 5 | 22' 2" | | 5 | 22' 2" |
| | | | 10 | 22' 2" | | 10 | 22' 2" |
| | | | 20 | 22' 2" | | 20 | 22' 2" |
| | | | 30 | 22' 2" | | 30 | 22' 2" |
| | | | 60 | 22' 2" | | 60 | 22' 2" |
| P-2 (22') Boring B-5 | Dry | 21' 6" | 1 | 21' 6" | 21' 6" | 1 | 21' 6" |
| | | | 2 | 21' 6" | | 2 | 21' 6" |
| | | | 5 | 21' 6" | | 5 | 21' 6" |
| | | | 10 | 21' 6" | | 10 | 21' 6" |
| | | | 20 | 21' 6" | | 20 | 21' 6" |
| | | | 30 | 21' 6" | | 30 | 21' 6" |
| | | | 60 | 21' 6" | | 60 | 21' 6" |

Note: Borings B-3 and B-5 were converted to Piezometers P-1 and P-2, respectively. The piezometer depths are shown in parenthesis.



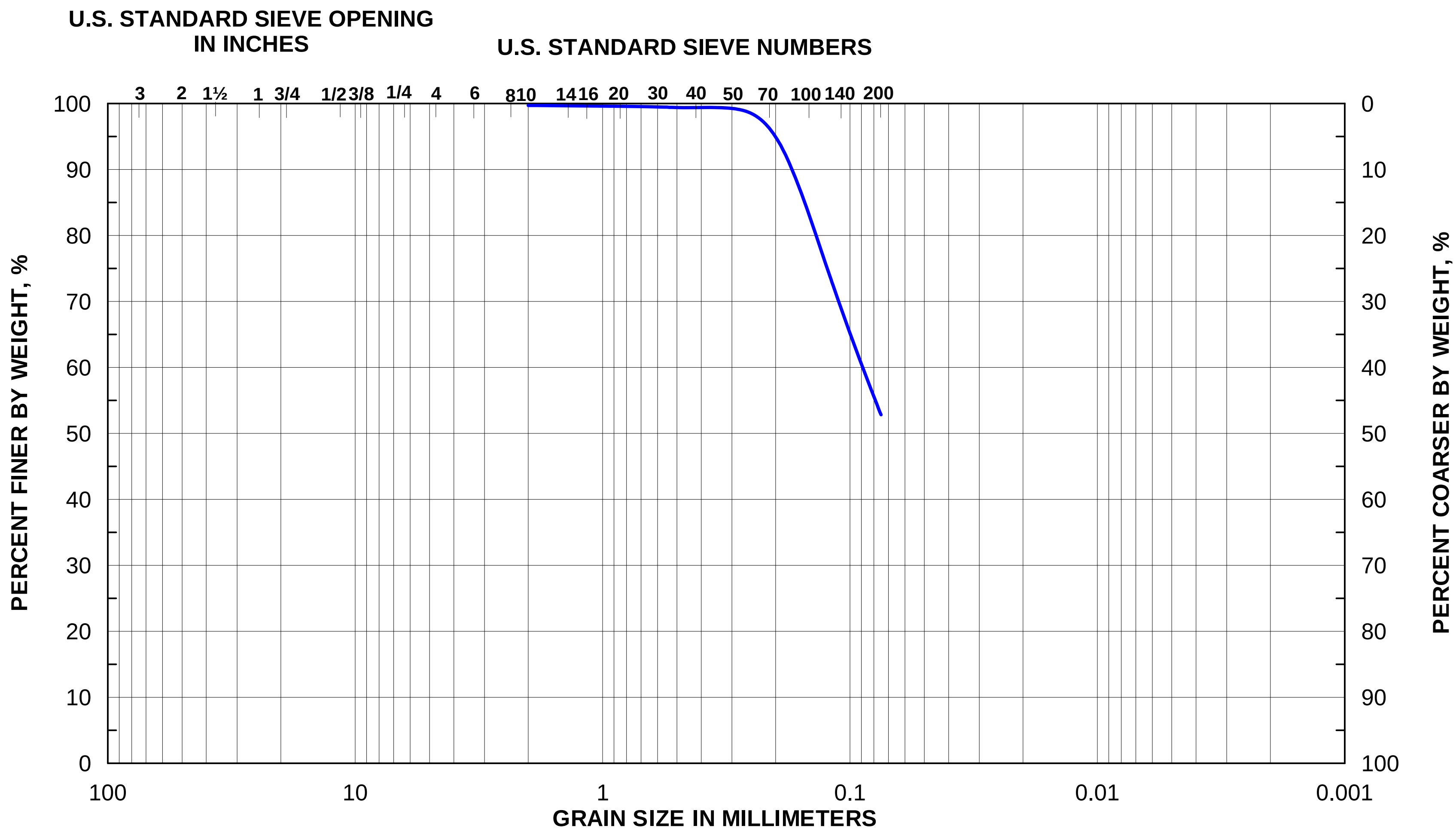

| GRAVEL | | SAND | | | SILT | CLAY |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | | |

**USCS Soil Classification: Silty Sand (SM)**

**Percent Passing - #200: 22%**

**PARTICLE SIZE DISTRIBUTION CURVES FOR B - 2 (8' TO 10')**

Project No. 13-825E




| GRAVEL | | SAND | | | SILT | CLAY |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | | |

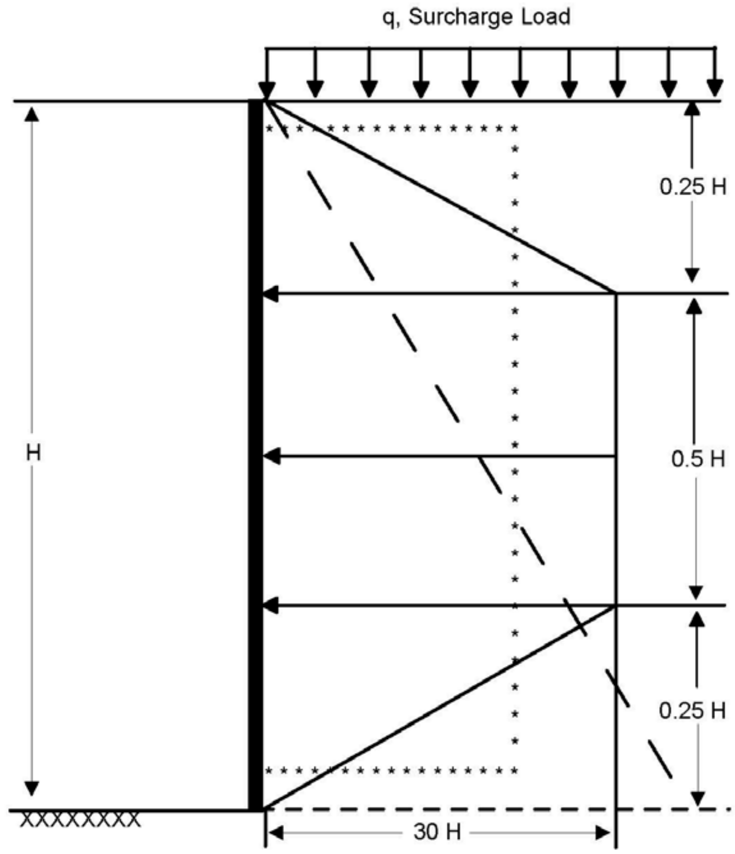
**USCS Soil Classification: Lean Clay with Sand (CL)**

**Percent Passing - #200: 53%**

**PARTICLE SIZE DISTRIBUTION CURVES FOR BE - 4 (6' TO 8')**

Project No. 13-825E

# LATERAL EARTH PRESSURE DIAGRAM




Legend:

——————————— Braced Excavation (stiff clays)
* * * * * * * * * * * * * * Braced Excavation (sands)
- - - - - - - - - - - - - - - Cantilevered sheeting

Active Pressure:

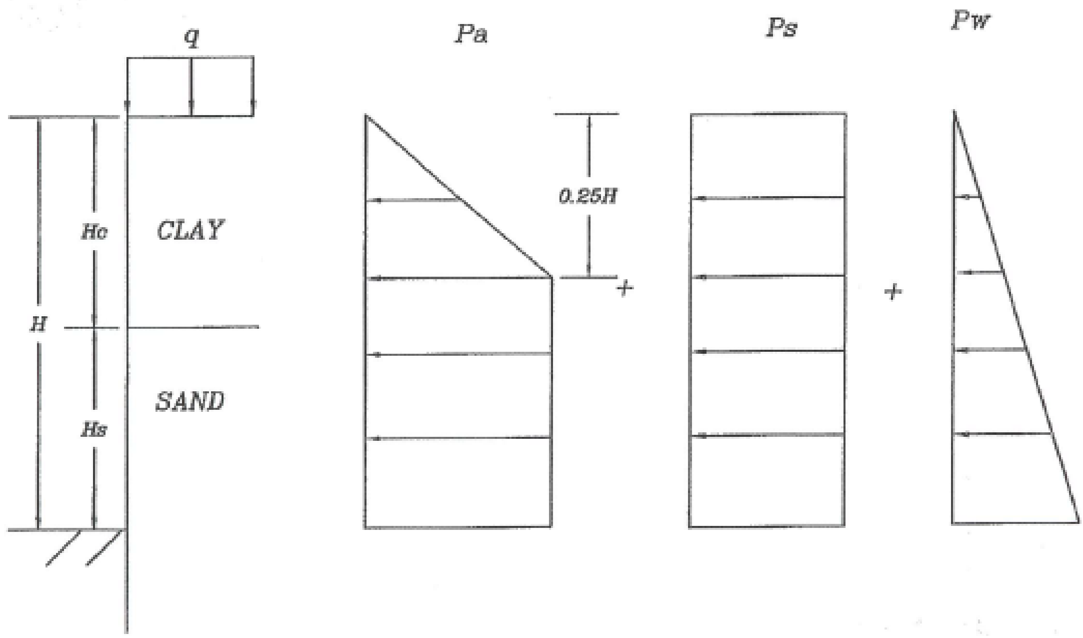
(a) Braced Excavation (stiff clays) = 0.5q + 30H + 62.4H
(b) Braced Excavation (sands) = 0.4q + 18H + 62.4H
(c) Cantilevered sheeting = 0.7q + 42H + 62.4H

where: q = surcharge load, psf: A value of 250 psf can be assumed.
H = wall height, ft.

Notes:

1. The above Active Pressure Equations account for the groundwater at the surface.
2. The final lateral pressures should be reviewed prior to construction.
3. Trench excavation and construction should be observed by a geotechnical engineer.
4. The means and methods for a safe excavation is the responsibility of the contractor.
5. In case of layered soils, active pressure should be calculated based on the dominant or more critical soil conditions.

# LATERAL EARTH PRESSURE DIAGRAM




$P = Pa + Ps + Pw$

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

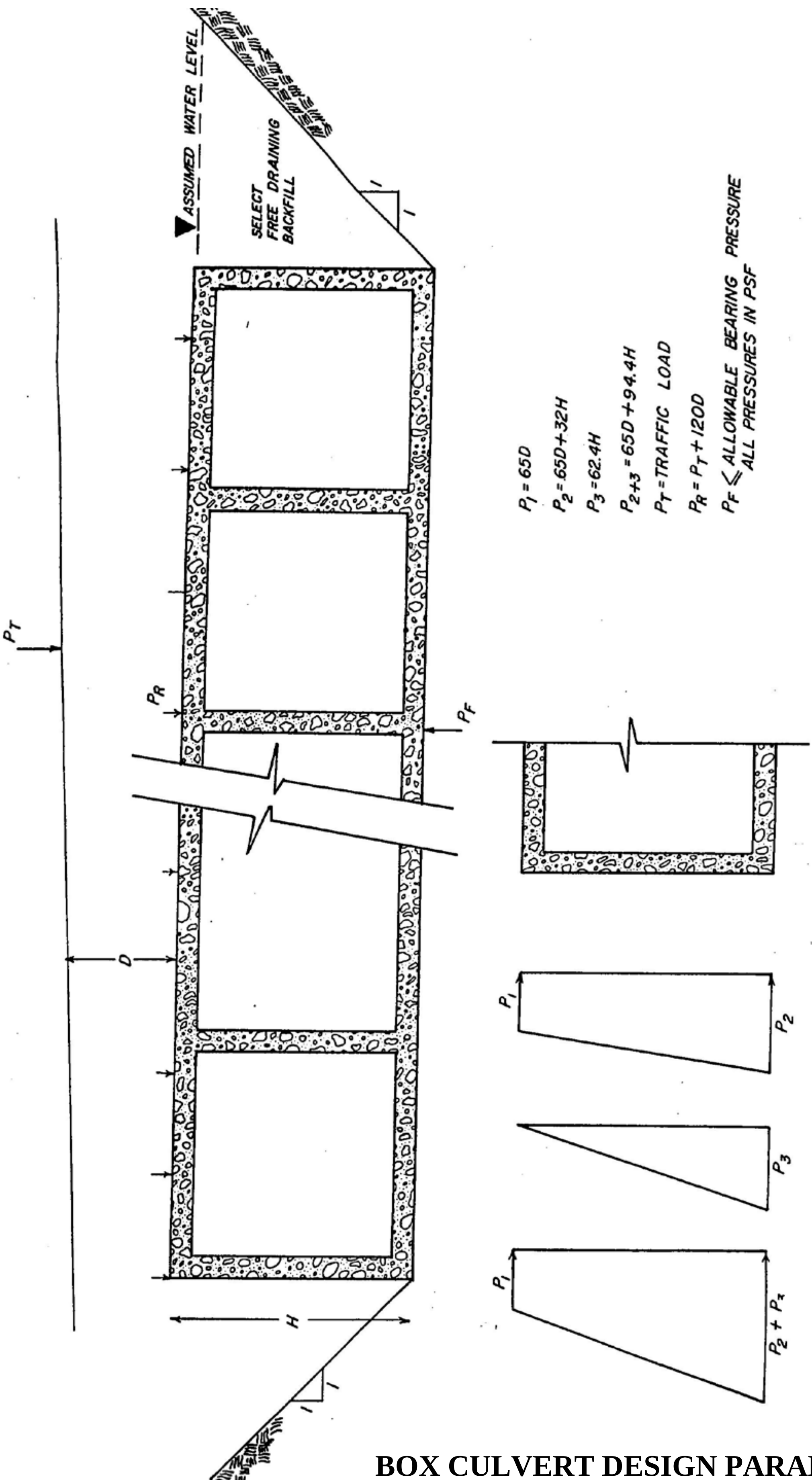
H = Depth of braced excavation (ft)

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

$\gamma$ = Submerged density of soils (pcf) = use 60 pcf

Notes:

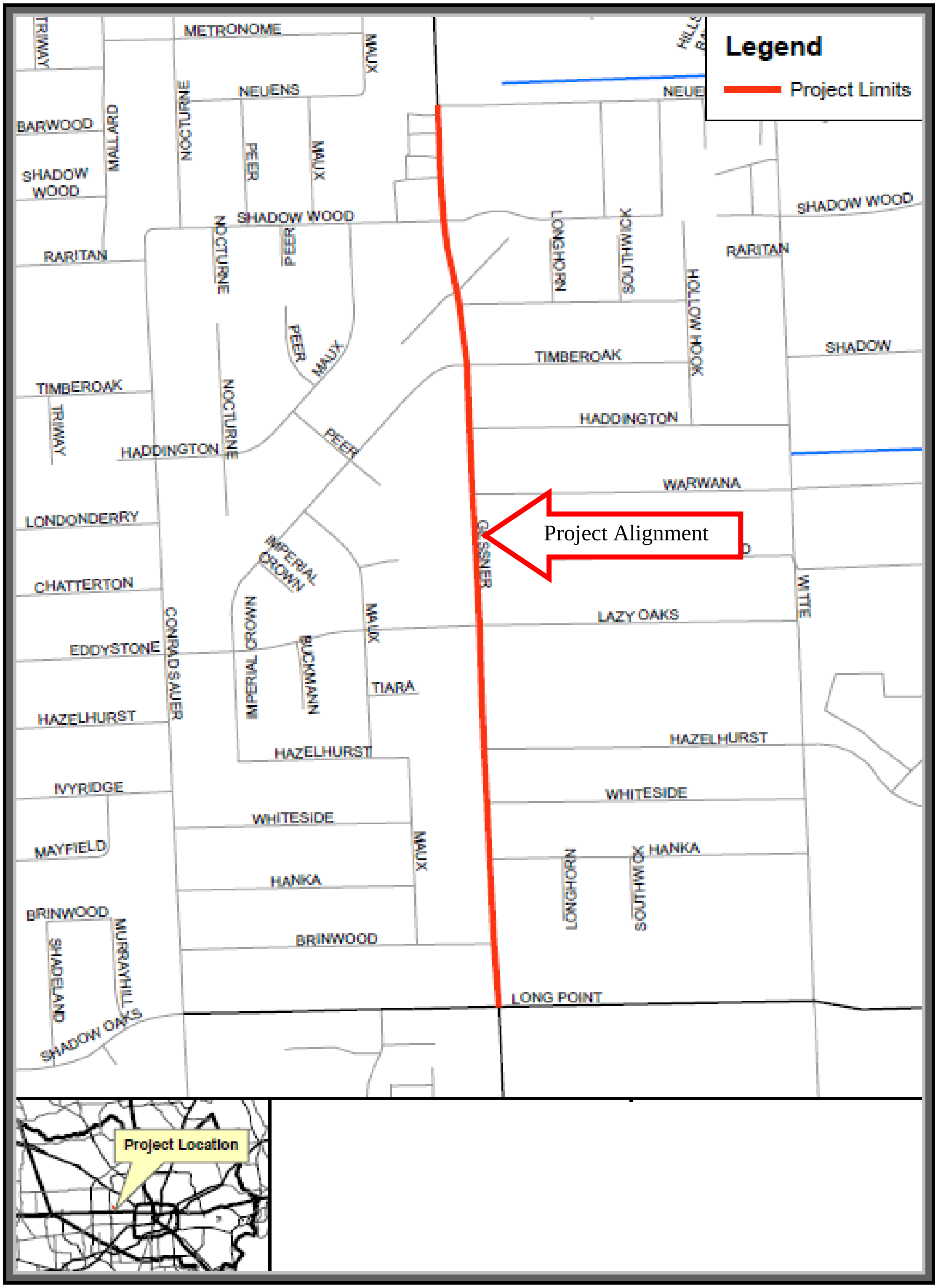
1. The above Active Pressure Equations account for the groundwater at the surface.
2. The final lateral pressures should be reviewed prior to construction.
3. Trench excavation and construction should be observed by a geotechnical engineer.
4. The means and methods for a safe excavation is the responsibility of the contractor.
5. In case of layered soils, active pressure should be calculated based on the dominant or more critical soil conditions.




**BOX CULVERT DESIGN PARAMETERS**

# APPENDIX A

**Site Vicinity Map**
**Plan of Borings**
**Soil Stratigraphy**
**Logs of Borings**
**Key to Log Terms and Symbols**
**Summary of Laboratory Test Results**

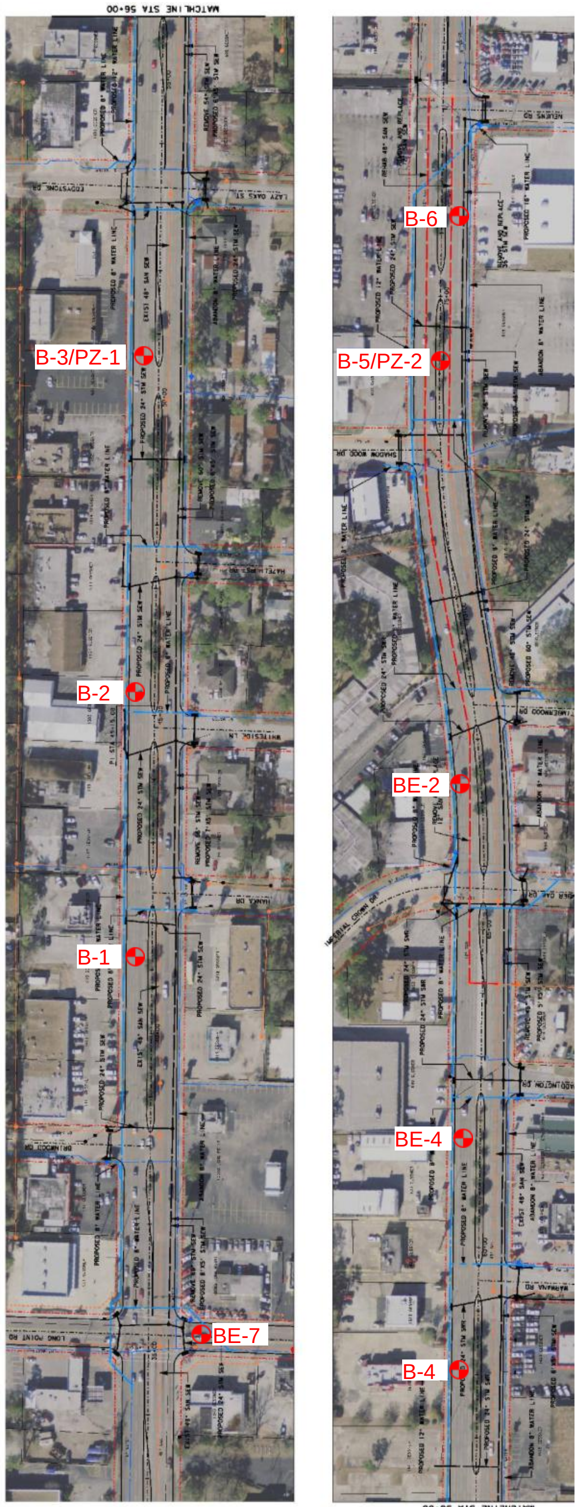



## SITE VICINITY MAP

PROJECT: Geotechnical Study, Proposed Gessner Road Paving and Drainage Improvements from Neuens Road to Long Point Road, WBS No. N-000809-0001-3, City of Houston, Texas

| SCALE: 1 INCH = 770 FEET | DATE: SEPTEMBER 2014 | PROJECT NO.: 13-825E |
|---|---|---|

NORTH

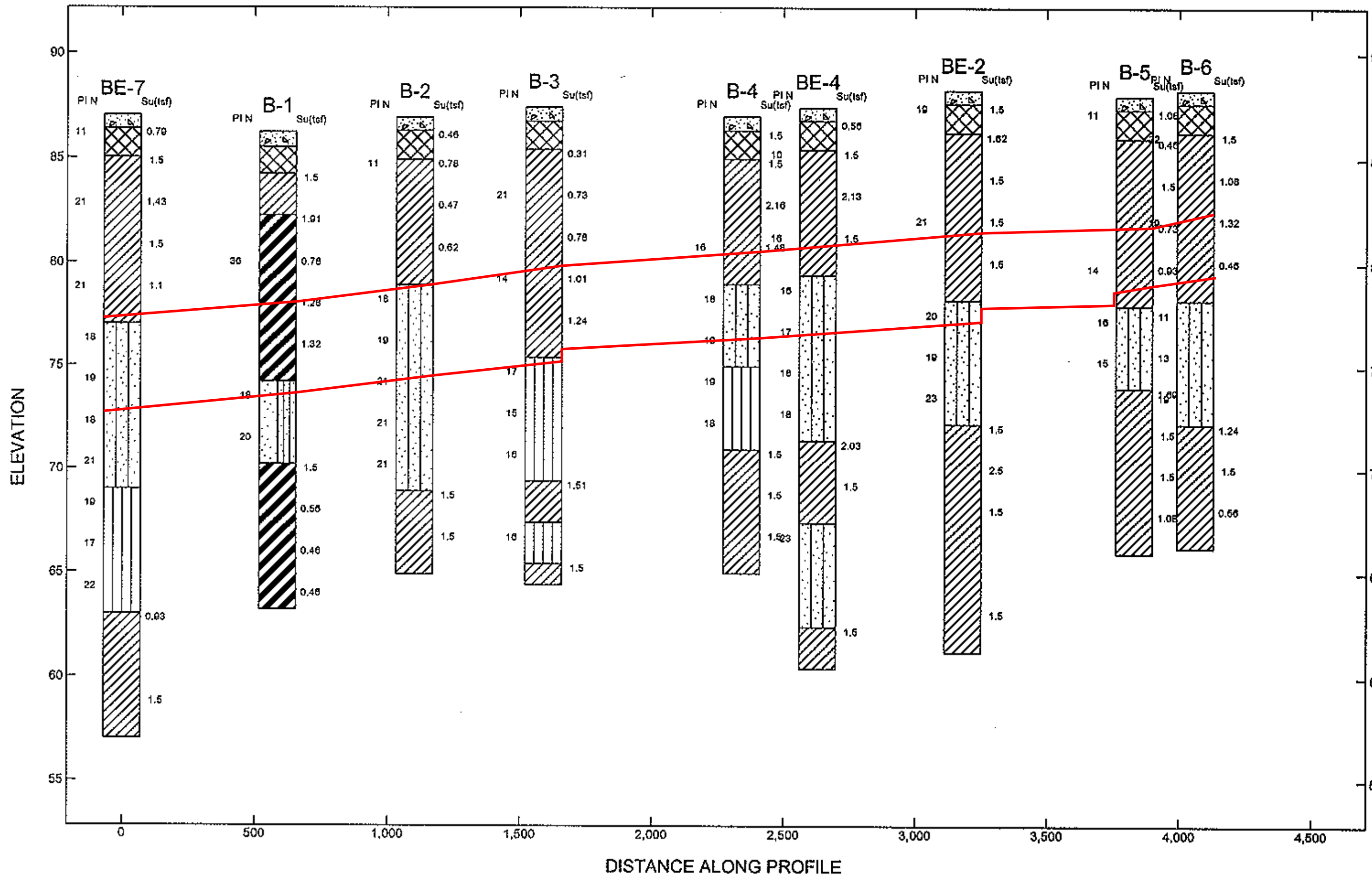



Note: B-1: Boring 1
PZ-1: Piezometer 1
BE-2: Environmental Boring 2

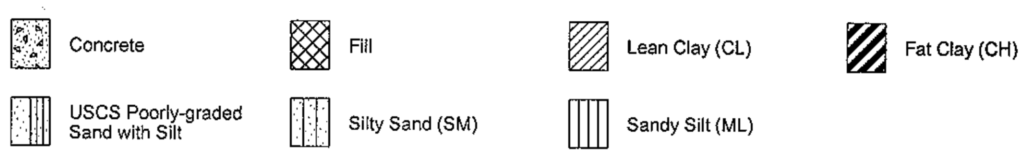
**PLAN OF BORINGS** (borings dimensions and locations are approximate)

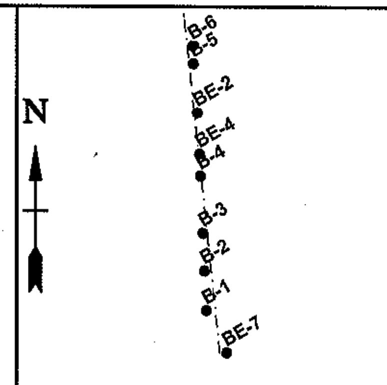
PROJECT: Geotechnical Study, Proposed Gessner Road Paving and Drainage Improvement from Neuens Road to Long Point Road, WBS No. N-000809-0001-3, City of Houston, Texas

| | | |
|---|---|---|
| SCALE: 1 INCH = 50 FEET | DATE: SEPTEMBER 2014 | PROJECT NO.: 13-825E |



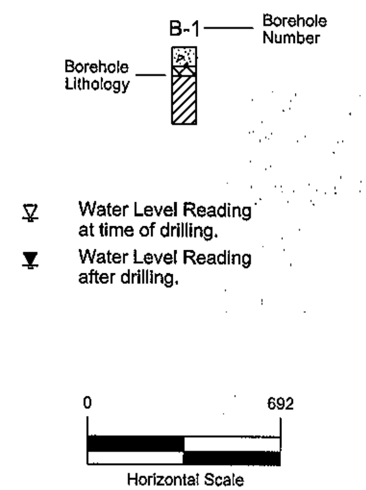

## Lithology Graphics




Site Map Scale 1 inch equals 2,540 feet

## Explanation




**Geotech Engineering and Testing**
800 Victoria Drive
Houston, Texas 77040

**Prop. Drainage and Pavement Improvements at Gessner Road**

City of Houston, Texas

| JOB NUMBER | PLATE NUMBER |
|---|---|
| WBS NO: N-000809-0001-3 | PLATE A-3 |

# LOG OF BORING NO. B-1

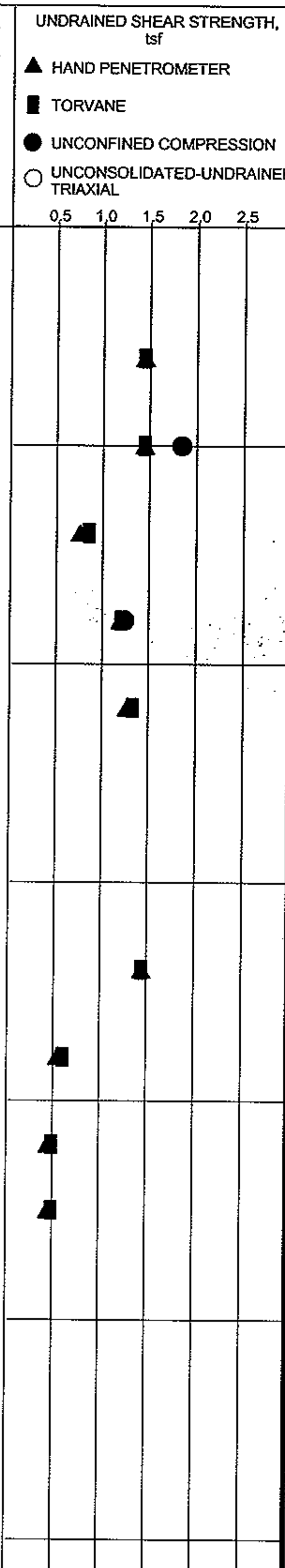


Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 40+92.33
DATE: 6-4-14 COMPLETION DEPTH: 23.0 ft.

ELEVATION: 86.22'
NORTHING: 13854567
EASTING: 3064531.7
OFFSET: 35.07' LT

| SPT N-VALUE blows per foot | OVM, ppm | DESCRIPTION | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CONCRETE PAVEMENT (8.5") | | | | | | | | | |
| | | FILL: SILTY SAND (SM), dark gray, brownish yellow, with root fibers, moist | 18 | | | | 34 | | | | |
| | | LEAN CLAY (CL), very stiff, light gray, brownish yellow, with root fibers, ferrous nodules, moist | 13 | | | | | | | | |
| | | FAT CLAY (CH), very stiff, light gray, brownish yellow, with root fibers to 6', ferrous and calcareous nodules, moist | 17 | | | | | | 118 | | |
| | | - stiff 6' to 8' | 26 | 58 | 22 | 36 | | | | | |
| | | | 26 | | | | | | 101 | | |
| | | | 31 | | | | | | | | |
| 18 | | POORLY GRADED SAND WITH SILT (SP-SM), medium dense, light brown, gray, moist | 18 | | | | 8 | | | | |
| 20 | | | 9 | | | | | | | | |
| | | FAT CLAY (CH), very stiff, light gray, brown, with ferrous and calcareous nodules, moist | 15 | | | | | | | | |
| | | - stiff 18' to 20' | 23 | | | | | | | | |
| | | - firm 20' to 23' | 21 | | | | | | | | |
| | | | 21 | | | | | | | | |




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 23 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. B-2



Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

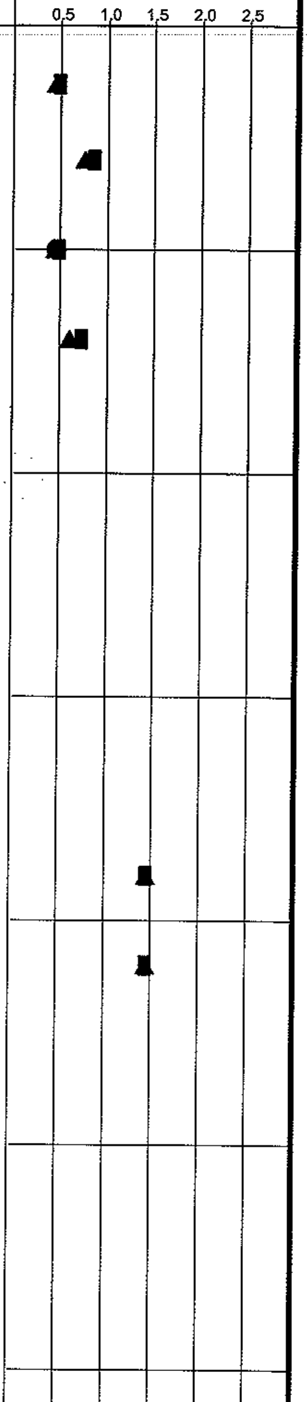
PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 46+11.29
DATE: 6-4-14 COMPLETION DEPTH: 22.0 ft.

ELEVATION: 86.92'
NORTHING: 13855085
EASTING: 3064507.5
OFFSET: 34.37' LT

| DEPTH, ft | SPT N-VALUE blows per foot | OVM, ppm | DESCRIPTION | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | CONCRETE PAVEMENT (7.5") | | | | | | | | | |
| | | | FILL: LEAN CLAY (CL), firm, light gray, with root fibers, ferrous and calcareous nodules, moist | 14 | | | | | | | | |
| | | | LEAN CLAY WITH SAND (CL), stiff, light gray, brownish yellow, with root fibers to 4', ferrous and calcareous nodules, sand seams, moist | 16 | 28 | 17 | 11 | | | | | |
| 5 | | | - firm 4' to 6' | 16 | | | | 68 | | 114 | | |
| | | | | 14 | | | | | | | | |
| | 18 | | SILTY SAND (SM), medium dense, light gray, brownish yellow, moist | 8 | | | | | | | | |
| 10 | 19 | | | 9 | | | | | | | | |
| | 21 | | | 8 | | | | 23 | | | | |
| 15 | 21 | | | 9 | | | | | | | | |
| | 21 | | | 16 | | | | | | | | |
| | | | LEAN CLAY (CL), very stiff, light gray, brownish yellow, with ferrous and calcareous nodules, moist | 14 | | | | | | | | |
| 20 | | | | 13 | | | | | | | | |
| 25 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |

UNDRAINED SHEAR STRENGTH, tsf

▲ HAND PENETROMETER
■ TORVANE
● UNCONFINED COMPRESSION
○ UNCONSOLIDATED-UNDRAINED TRIAXIAL




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 22 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. B-3



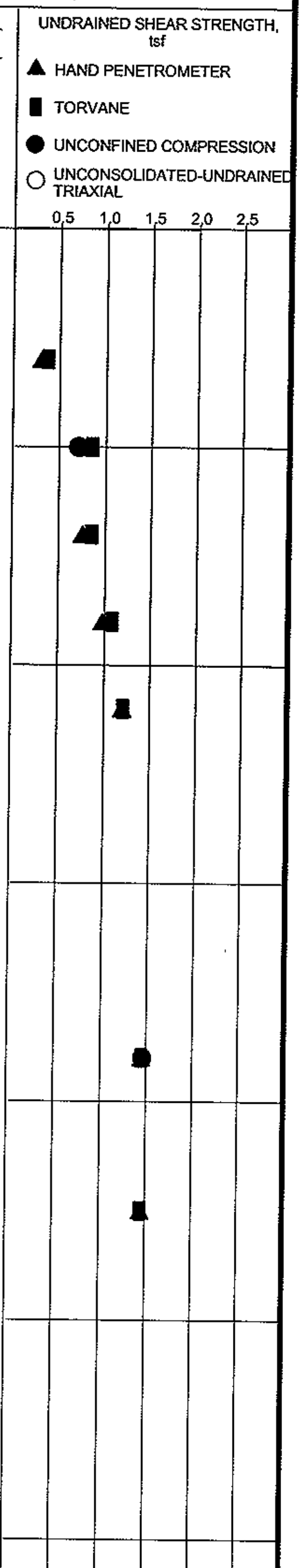
GEOTECH ENGINEERING & TESTING
Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 50+98.90
DATE: 6-4-14 COMPLETION DEPTH: 23.0 ft.

ELEVATION: 87.42'
NORTHING: 13855573
EASTING: 3064484.4
OFFSET: 35.28' LT

| DESCRIPTION |
|---|
| CONCRETE PAVEMENT (8") |
| FILL: SANDY SILT (ML), dark gray, with root fibers, moist |
| LEAN CLAY WITH SAND (CL), firm, light gray, with root fibers to 6', ferrous and calcareous nodules, sands<br>- stiff 4' to 8', light brown 4' to 6'<br>- brownish-yellow 6' to 12'<br>- very stiff 8' to 12' |
| SANDY SILT (ML), medium dense, light brown, gray, brownish yellow, moist<br>- light brown 14' to 18' |
| LEAN CLAY (CL), very stiff, light gray, light brown, with ferrous nodules, moist |
| SANDY SILT (ML), medium dense, light brown, moist |
| LEAN CLAY (CL), very stiff, light gray, moist |

| SPT N-VALUE, blows per foot | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|
| | 16 | | | | | | | | |
| | 19 | | | | 69 | | | | |
| | 15 | 39 | 18 | 21 | | | 119 | | |
| | 17 | | | | | | | | |
| | 15 | 32 | 18 | 14 | | | | | |
| | 15 | | | | | | | | |
| 17 | 17 | | | | 50 | | | | |
| 15 | 19 | | | | | | | | |
| 16 | 17 | | | | | | | | |
| | 14 | | | | | | 121 | | |
| 16 | 16 | | | | | | | | |
| | 17 | | | | | | | | |




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 23 ft.
WET ROTARY: ___ TO ___ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

# LOG OF BORING NO. B-4



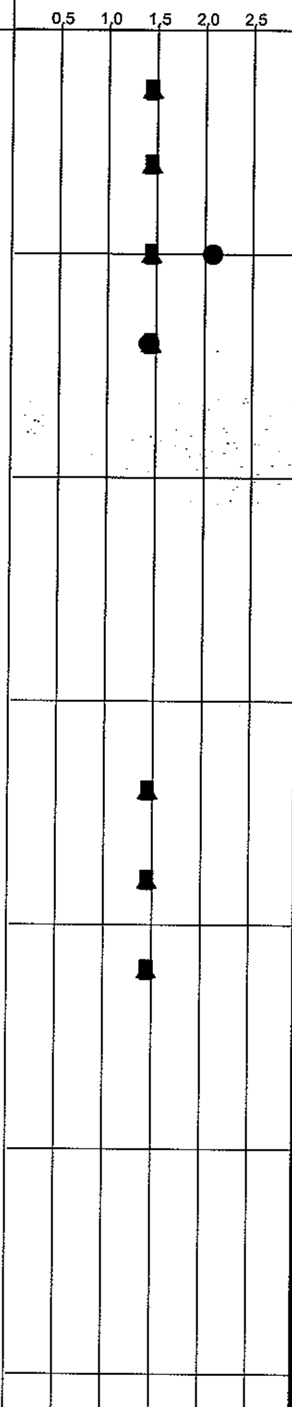
Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 58+51.43
DATE: 6-4-14 COMPLETION DEPTH: 22.0 ft.

ELEVATION: 86.99'
NORTHING: 13856324
EASTING: 3064451.3
OFFSET: 34.30' LT

| DEPTH, ft | SPT N-VALUE blows per foot | DESCRIPTION | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | CONCRETE PAVEMENT (8") | | | | | | | | | |
| | | FILL: LEAN CLAY (CL), very stiff, light gray, brownish yellow, with root fibers, ferrous and calcareous nodules, moist | 11 | | | | | | | | |
| | | LEAN CLAY (CL), very stiff, light gray, with root fibers to 4', ferrous and calcareous nodules, moist | 13 | | | | | | | | |
| 5 | | - hard 4' to 6' | 13 | | | | | | 122 | | |
| | | | 13 | 33 | 17 | 16 | | | 116 | | |
| | 18 | SILTY SAND (SM), medium dense, light gray, brownish yellow, moist | 6 | | | | | | | | |
| 10 | 19 | | 13 | | | | 42 | | | | |
| | 19 | SANDY SILT (ML), medium dense, light gray, brownish yellow, moist | 10 | | | | | | | | |
| 15 | 18 | | 11 | | | | 50 | | | | |
| | | LEAN CLAY (CL), very stiff, light gray, with ferrous and calcareous nodules, moist | 13 | | | | | | | | |
| | | | 12 | | | | | | | | |
| 20 | | - light brown, brownish yellow, 18' to 22' | 12 | | | | | | | | |
| 25 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |

UNDRAINED SHEAR STRENGTH, tsf
▲ HAND PENETROMETER
▮ TORVANE
● UNCONFINED COMPRESSION
○ UNCONSOLIDATED-UNDRAINED TRIAXIAL




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 22 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. B-5



Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 73+46.89
DATE: 6-4-14 COMPLETION DEPTH: 22.0 ft.

ELEVATION: 87.98'
NORTHING: 13857814
EASTING: 3064352.8
OFFSET: 11.50' RT

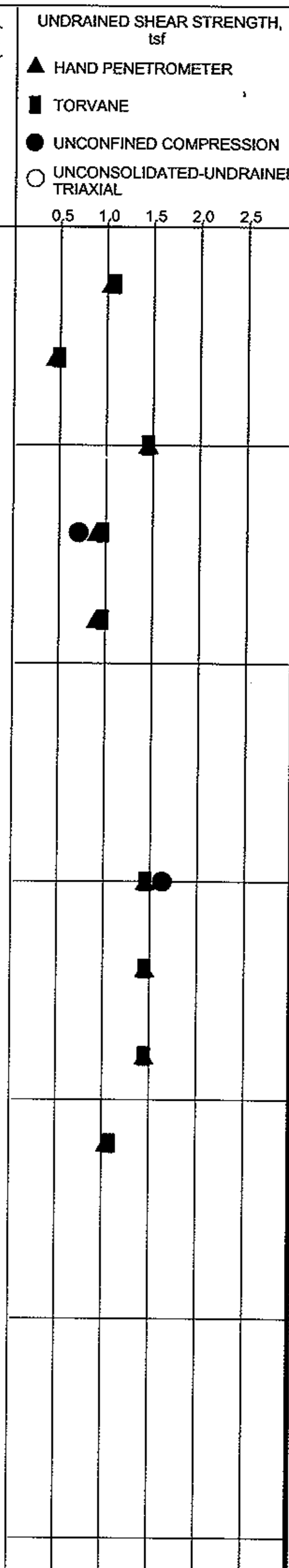
DEPTH, ft | SPT N-VALUE blows per foot | OVM, ppm | SYMBOL | SAMPLES

## DESCRIPTION

- CONCRETE PAVEMENT (7.5")
- FILL:LEAN CLAY (CL), very stiff, light gray, with root fibers, ferrous and calcareous nodules, moist
- LEAN CLAY (CL), firm, light gray, with root fibers to 6', ferrous and calcareous nodules, moist
  - very stiff 4' to 6', brownish yellow 4' to 10'
  - stiff 6' to 10'
- SILTY SAND (SM), medium dense, light gray, moist
- LEAN CLAY (CL), very stiff, light gray, brownish yellow, with ferrous and calcareous nodules, moist

| SPT N-VALUE blows per foot | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|
| | 14 | 26 | 15 | 11 | | | | | |
| | 17 | | | | | | | | |
| | 18 | | | | | | | | |
| | 19 | | | | | | 107 | | |
| | 16 | 31 | 17 | 14 | | | | | |
| 16 | 14 | | | | 25 | | | | |
| 15 | 17 | | | | | | | | |
| | 15 | | | | | | 119 | | |
| | 15 | | | | | | | | |
| | 16 | | | | | | | | |
| | 17 | | | | | | | | |

Depth scale: 0, 5, 10, 15, 20, 25, 30




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 22 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. B-6



Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 75+77.78
DATE: 6-6-14 COMPLETION DEPTH: 22.0 ft.

ELEVATION: 88.25'
NORTHING: 13858043
EASTING: 3064341.9
OFFSET: 11.07' LT

UNDRAINED SHEAR STRENGTH, tsf: ▲ HAND PENETROMETER; ■ TORVANE; ● UNCONFINED COMPRESSION; ○ UNCONSOLIDATED-UNDRAINED TRIAXIAL (scale 0.5, 1.0, 1.5, 2.0, 2.5)

| DEPTH, ft | SPT N-VALUE blows per foot | OVM, ppm | DESCRIPTION | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | CONCRETE PAVEMENT (7.5") | | | | | | | | | |
| | | | FILL: SILTY SAND (SM), dark brown, with root fibers, moist | 7 | | | | | | | | |
| | | | LEAN CLAY (CL), very stiff, light gray, brownish yellow, with root fibers to 6', ferrous and calcareous nodules, moist | 9 | 40 | 18 | 22 | | | | | |
| 5 | | | | 10 | | | | | | | | |
| | | | | 12 | 37 | 18 | 19 | 84 | | | | |
| | | | - firm 8' to 10' | 13 | | | | | | | | |
| 10 | | | SILTY SAND (SM), medium dense, light gray, brownish yellow, moist | | | | | | | | | |
| | 11 | | | 8 | | | | | | | | |
| | 13 | | | 11 | | | | | | | | |
| 15 | 19 | | | 12 | | | | 18 | | | | |
| | | | LEAN CLAY (CL), very stiff, light gray, brownish yellow, with ferrous and calcareous nodules, moist | 14 | | | | | | | | |
| | | | | 17 | | | | | | | | |
| 20 | | | - stiff 20' to 22' | 12 | | | | | | | | |

WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 22 ft.
WET ROTARY: ___ TO ___ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. BE-2



GEOTECH ENGINEERING & TESTING

Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

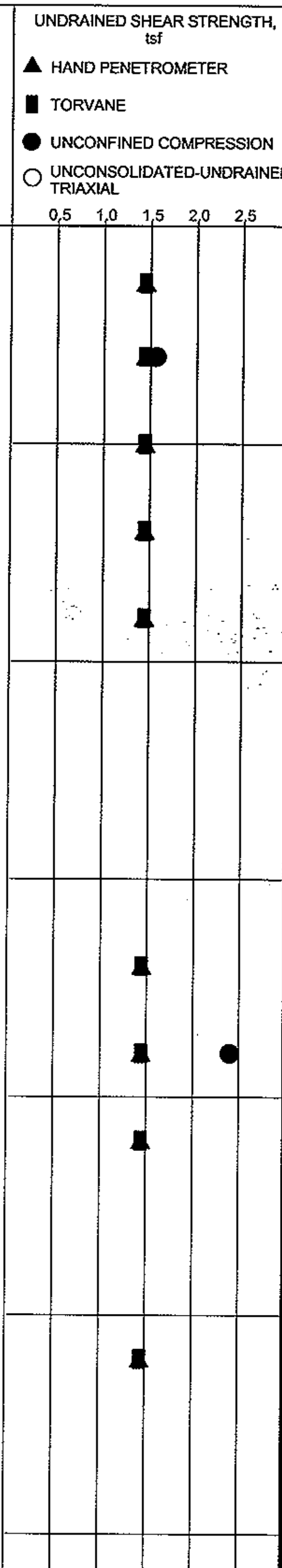
PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 66+95.57
DATE: 6-5-14 COMPLETION DEPTH: 27.0 ft.

ELEVATION: 88.24'
NORTHING: 13857165
EASTING: 3064409.7
OFFSET: 34.35' LT

| DEPTH, ft | SPT N-VALUE blows per foot | OVM, ppm | DESCRIPTION |
|---|---|---|---|
| 0 | | | CONCRETE PAVEMENT (7.5") |
| | | | FILL: LEAN CLAY (CL), very stiff, light gray, brownish yellow, with root fibers, ferrous and calcareous nodules, moist |
| | | | LEAN CLAY (CL), very stiff, light brown, brownish yellow, with root fibers to 4', ferrous and calcareous nodules, moist<br>- light gray 4' to 8' |
| 10 | | | SILTY SAND (SM), medium dense, light gray, brownish yellow, moist |
| | 20 | | |
| | 19 | | |
| 15 | 23 | | |
| | | | LEAN CLAY (CL), very stiff, light gray, brownish yellow, with ferrous and calcareous nodules, moist<br>- hard 18' to 20' |
| 20 | | | |
| 25 | | | |
| 30 | | | |

| NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|
| 16 | 37 | 18 | 19 | | | | | |
| 13 | | | | | | 117 | | |
| 13 | | | | | | | | |
| 14 | 40 | 19 | 21 | | | | | |
| 13 | | | | | | | | |
| 6 | | | | 37 | | | | |
| 3 | | | | | | | | |
| 3 | | | | 15 | | | | |
| 15 | | | | | | | | |
| 14 | | | | | | 122 | | |
| 15 | | | | | | | | |
| 15 | | | | | | | | |

UNDRAINED SHEAR STRENGTH, tsf




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 27 ft.
WET ROTARY: ___ TO ___ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. BE-4



Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 61+39.95
DATE: 6-5-14 COMPLETION DEPTH: 27.0 ft.

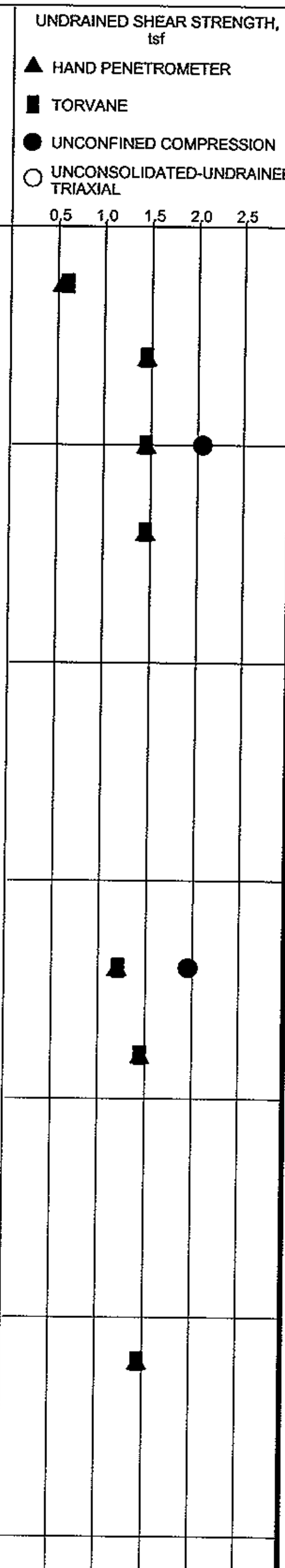
ELEVATION: 87.42'
NORTHING: 13856613
EASTING: 3064438.8
OFFSET: 33.59' LT

## DESCRIPTION

- CONCRETE PAVEMENT (7.5")
- FILL: LEAN CLAY (CL), stiff, light brown, gray, with ferrous and calcareous nodules, moist
- LEAN CLAY (CL), very stiff, light gray, reddish brown, brownish yellow, with ferrous and calcareous nodules, moist
  - hard 4' to 6'
- SILTY SAND (SM), medium dense, light gray, moist
- LEAN CLAY (CL), hard, light gray, light brown, reddish brown, brownish yellow, with ferrous and calcareous nodules, moist
  - very stiff 18' to 20'
- SILTY SAND (SM), medium dense, light gray, brownish yellow, moist
- LEAN CLAY (CL), very stiff, light gray, brownish yellow, with ferrous and calcareous nodules, moist

| SPT N-Value (blows per foot) | OVM, ppm | Natural Moisture Content, % | Liquid Limit, % | Plastic Limit, % | Plasticity Index, % | Percent Passing No. 200 Sieve | Suction (pF) | Dry Unit Weight, pcf | Percent Compaction | Passing/Failing (P/F) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 14 | | | | | | | | |
| | | 14 | 25 | 15 | 10 | | | | | |
| | | 15 | | | | | | 118 | | |
| | | 15 | 32 | 16 | 16 | | | | | |
| 16 | | 10 | | | | 28 | | | | |
| 17 | | 9 | | | | | | | | |
| 18 | | 14 | | | | | | | | |
| 18 | | 18 | | | | | | | | |
| | | 15 | | | | | | 117 | | |
| | | 15 | | | | | | | | |
| 23 | | 17 | | | | | | | | |
| | | 12 | | | | | | | | |

Depth, ft: 0, 5, 10, 15, 20, 25, 30




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 27 ft.
WET ROTARY: ___ TO ___ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# LOG OF BORING NO. BE-7



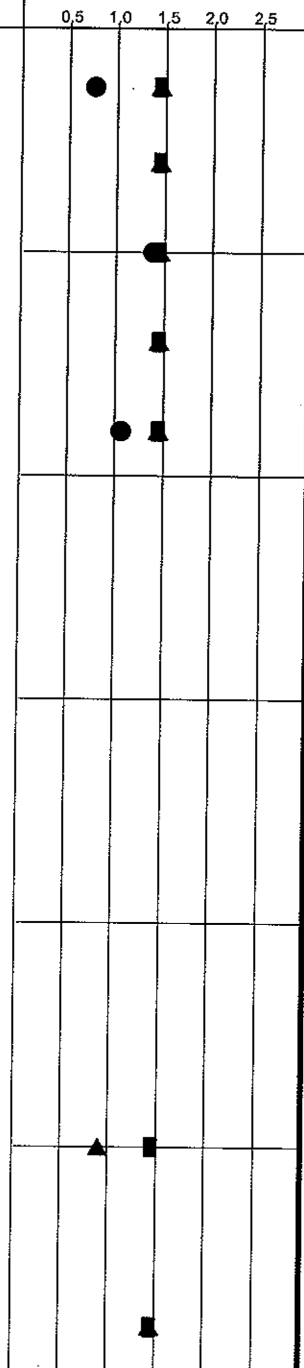
Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Prop. Drainage and Pavement Improvements at Gessner Road
LOCATION: City of Houston, Texas
WBS NO: N-000809-0001-3 STATION NO.: 35+21.55
DATE: 6-6-14 COMPLETION DEPTH: 30.0 ft.

ELEVATION: 87.02'
NORTHING: 13854008
EASTING: 3064798.8
OFFSET: 204.54' LT

| DEPTH, ft | SPT N-VALUE blows per foot | OVM, ppm | DESCRIPTION | NATURAL MOISTURE CONTENT, % | LIQUID LIMIT, % | PLASTIC LIMIT, % | PLASTICITY INDEX, % | PERCENT PASSING NO. 200 SIEVE | SUCTION (pF) | DRY UNIT WEIGHT, pcf | PERCENT COMPACTION | PASSING/FAILING (P/F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | CONCRETE PAVEMENT (7.5") | | | | | | | | | |
| | | | FILL: LEAN CLAY (CL), stiff, gray, brownish yellow, with ferrous and calcareous nodules, moist | 15 | 26 | 15 | 11 | | | 114 | | |
| | | | LEAN CLAY (CL), very stiff, light gray, brownish yellow, with ferrous and calcareous nodules, moist | 17 | | | | | | | | |
| 5 | | | | 16 | 38 | 17 | 21 | | | 113 | | |
| | | | | 13 | | | | | | | | |
| | | | | 15 | 39 | 18 | 21 | | | 109 | | |
| 10 | 18 | | SILTY SAND (SM), medium dense, light gray, brownish yellow, moist | 10 | | | | | | | | |
| | 19 | | | 6 | | | | 17 | | | | |
| 15 | 18 | | | 10 | | | | | | | | |
| | 21 | | | 8 | | | | 30 | | | | |
| | 19 | | SANDY SILT (ML), medium dense, light gray, light brown, moist | 21 | | | | | | | | |
| 20 | 17 | | | 23 | | | | | | | | |
| | 22 | | | 25 | | | | | | | | |
| 25 | | | LEAN CLAY (CL), stiff, light brown, with ferrous and calcareous nodules, moist | 20 | | | | | | | | |
| | | | - very stiff 28' to 30' | 27 | | | | | | | | |
| 30 | | | | | | | | | | | | |

UNDRAINED SHEAR STRENGTH, tsf
▲ HAND PENETROMETER
■ TORVANE
● UNCONFINED COMPRESSION
○ UNCONSOLIDATED-UNDRAINED TRIAXIAL




WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 30 ft.
WET ROTARY: ___ TO ___ ft.

DRILLED BY: GET(T)
LOGGED BY: Eric

OVM2 13-825E.GPJ OVM.GDT 9/19/14

# KEY TO LOG TERMS AND SYMBOLS

## UNIFIED SOIL CLASSIFICATIONS

| Symbol | Material Descriptions |
|---|---|
| GW | WELL GRADED-GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES |
| GP | POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES |
| GM | SILTY GRAVELS, GRAVEL-SAND SILT MIXTURES |
| GC | CLAY GRAVELS, GRAVEL-SAND CLAY MIXTURES |
| SW | WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| SP | POORLY GRADED SANDS, OR GRAVELLY SANDS, LITTLE OR NO FINES |
| SM | SILTY SANDS, SAND-SILT MIXTURES a |
| SC | CLAYEY SANDS, SAND-SILT MIXTURES b |
| ML | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY |
| CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS |
| OL | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| 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 MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS |
| PT | PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT |
| | FILL SOILS |

## TERMS CHARACTERIZING SOIL STRUCTURE

| | | |
|---|---|---|
| Slickensided | - | Having incline planes of weakness that are slick and glossy in appearance. |
| Fissured | - | Containing shrinkage cracks frequently filled with fine sand or silt: usually vertical. |
| Laminated | - | Composed of thin layers of varying colors and soil sample texture. |
| Interbedded | - | Composed of alternate layers of different soil types. |
| Calcareous | - | Containing appreciable quantities of calcium carbonate. |
| Well Graded | - | Having wide range in grain sizes and substantial amounts of all intermediate particle sizes. |
| Poorly Graded | - | Predominantly of one grain size, or having a range of sizes with some intermediate sizes missing. |
| Pocket | - | Inclusion of material of different texture that is smaller than the diameter of the sample. |
| Parting | - | Inclusion less than 1/8-inch thick extending through the sample. |
| Seam | - | Inclusion 1/8- to 3-inch thick extending through the sample. |
| Layer | - | Inclusion greater than 3-inch thick extending through the sample. |
| Interlayered | - | Soils sample composed of alternating layers of different soil types. |
| Intermixed | - | Soil samples composed of pockets of different soil type and layered or laminated structure is not evident. |

COARSE GRAINED SOILS (major portion retained on No. 200 Sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Conditions rated according to standard penetration test (SPT)* as performed in the field.

| Descriptive Terms | Blows Per Foot* |
|---|---|
| Very Loose | 0 – 4 |
| Loose | 5 – 10 |
| Medium Dense | 11 – 30 |
| Dense | 31 – 50 |
| Very Dense | over 50 |

* 140 pound weight having a free fall of 30-inch

### SOIL SAMPLERS

- SHELBY TUBE SAMPLER
- STANDARD PENETRATION TEST
- AUGER SAMPLING

FINE GRAINED SOILS (major portion passing No. 200 Sieve): Include (1) inorganic or organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength as indicated by hand penetrometer readings or by unconfined compression tests.

| Descriptive Term | Undrained Shear Strength Ton/Sq. Ft. |
|---|---|
| Very Soft | Less than 0.13 |
| Soft | 0.13 to 0.25 |
| Firm | 0.25 to 0.50 |
| Stiff | 0.50 to 1.00 |
| Very Stiff | 1.00 to 2.00 |
| Hard | 2.00 or higher |

**NOTE:** Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of weakness or cracks in the soil. The consistency ratings of such soils are based on hand penetrometer readings.

### TERMS CHARACTERIZING ROCK PROPERTIES

| | |
|---|---|
| VERY SOFT OR PLASTIC | Can be remolded in hand: corresponds in consistency up to very stiff in soils. |
| SOFT | Can be scratched with fingernail. |
| MODERATELY HARD | Can be scratched easily with knife; cannot be scratched with fingernail. Difficult to scratch with knife. |
| VERY HARD | Cannot be scratched with knife. |
| POORLY CEMENTED OR FRIABLE | Easily crumbled. |
| CEMENTED | Bounded Together by chemically precipitated materials. |
| UNWEATHERED | Rock in its natural state before being exposed to atmospheric agents. |
| SLIGHTLY WEATHERED | Noted predominantly by color change with no disintegrated zones. |
| WEATHERED | Complete color change with zones of slightly decomposed rock. |
| EXTREMELY WEATHERED | Complete color change with consistency, texture, and general appearance or soil. |

| SUMMARY OF LABORATORY TEST RESULTS<br><br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | PL (%) | PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | 1 | 0 | 2 | UD | | 18 | | | | | 34 | | | | | Fill: Silty Sand (SM) |
| | 2 | 2 | 4 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 17 | 118 | | | | | 1.91 | | 1.5 | 1.5 | Fat Clay (CH) |
| | 4 | 6 | 8 | UD | | 26 | | 58 | 22 | 36 | | | | 0.88 | 0.78 | Fat Clay (CH) |
| | 5 | 8 | 10 | UD | | 26 | 101 | | | | | 1.28 | | 1.25 | 1.24 | Fat Clay (CH) |
| | 6 | 10 | 12 | UD | | 31 | | | | | | | | 1.38 | 1.32 | Fat Clay (CH) |
| | 7 | 12.5 | 14 | SPT | 18 | 18 | | | | | 8 | | | | | Poorly Graded Sand with Silt (SP-SM) |
| | 8 | 14.5 | 16 | SPT | 20 | 9 | | | | | | | | | | Silty Sand (SM) |
| | 9 | 16 | 18 | UD | | 15 | | | | | | | | 1.5 | 1.5 | Fat Clay (CH) |
| | 10 | 18 | 20 | UD | | 23 | | | | | | | | 0.62 | 0.56 | Fat Clay (CH) |
| | 11 | 21 | 23 | UD | | 21 | | | | | | | | 0.5 | 0.46 | Fat Clay (CH) |

LEGEND:
- UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD
- SS = SPLIT SPOON SAMPLE
- AG = AUGER CUTTINGS
- SPT = STANDARD PENETRATION TEST
- LL = LIQUID LIMIT
- PL = PLASTIC LIMIT
- PI = PLASTIC INDEX
- UU = TRIAXIAL COMPRESSION

NOTES:

PLATE A-14

| SUMMARY OF LABORATORY TEST RESULTS<br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | SPT | WATER CONTENT( %) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | PL (%) | PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-2 | 1 | 0 | 2 | UD | | 14 | | | | | | | | 0.5 | 0.46 | Fill: Lean Clay (CL) |
| | 2 | 2 | 4 | UD | | 16 | | 28 | 17 | 11 | | | | 0.88 | 0.78 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 16 | 114 | | | | 68 | 0.47 | | 0.5 | 0.46 | Lean Clay with Sands (CL) |
| | 4 | 6 | 8 | UD | | 14 | | | | | | | | 0.75 | 0.62 | Lean Clay (CL) |
| | 5 | 8.5 | 10 | SPT | 18 | 8 | | | | | | | | | | Silty Sand (SM) |
| | 6 | 10.5 | 12 | SPT | 19 | 9 | | | | | | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 21 | 8 | | | | | 23 | | | | | Silty Sand (SM) |
| | 8 | 14.5 | 16 | SPT | 21 | 9 | | | | | | | | | | Silty Sand (SM) |
| | 9 | 16.5 | 18 | SPT | 21 | 16 | | | | | | | | | | Silty Sand (SM) |
| | 10 | 18 | 20 | UD | | 14 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20 | 22 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

| LEGEND: | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD<br>SS = SPLIT SPOON SAMPLE<br>AG = AUGER CUTTINGS<br>SPT = STANDARD PENETRATION TEST | LL = LIQUID LIMIT<br>PL = PLASTIC LIMIT<br>PI = PLASTIC INDEX<br>UU = TRIAXIAL COMPRESSION | NOTES: |
|---|---|---|---|

| SUMMARY OF LABORATORY TEST RESULTS | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX |
|---|---|
| | COH WBS NUMBER: N-000809-0001-3 |
| Geotechnical Consultant's Name: Geotech Engineering and Testing | CONSULTANT PROJECT NUMBER: 13-825E |

| BORING NO. | SAMPLE | | | | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS | | | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) | | | | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | | | | LL (%) | PL (%) | PI (%) | | UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | |
| B-3 | 1 | 0 | 2 | UD | | 16 | | | | | | | | | | Fill: Sandy Silt (ML) |
| | 2 | 2 | 4 | UD | | 19 | | | | | 69 | | | 0.38 | 0.31 | Lean Clay with Sands (CL) |
| | 3 | 4 | 6 | UD | | 15 | 119 | 39 | 18 | 21 | | 0.73 | | 0.88 | 0.85 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 17 | | | | | | | | 0.88 | 0.78 | Lean Clay (CL) |
| | 5 | 8 | 10 | UD | | 15 | | 32 | 18 | 14 | | | | 1.12 | 1.01 | Lean Clay (CL) |
| | 6 | 10 | 12 | UD | | 15 | | | | | | | | 1.25 | 1.24 | Lean Clay (CL) |
| | 7 | 12.5 | 14 | SPT | 15 | 17 | | | | | 50 | | | | | Sandy Silt (ML) |
| | 8 | 14.5 | 16 | SPT | 17 | 19 | | | | | | | | | | Sandy Silt (ML) |
| | 9 | 16.5 | 18 | SPT | 16 | 17 | | | | | | | | | | Sandy Silt (ML) |
| | 10 | 18 | 20 | UD | | 14 | 121 | | | | | 1.51 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20.5 | 22 | SPT | 16 | 16 | | | | | | | | | | Sandy Silt (ML) |
| | 12 | 22 | 23 | UD | | 17 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |

| LEGEND: | | | |
|---|---|---|---|
| | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD | LL = LIQUID LIMIT | NOTES: |
| | SS = SPLIT SPOON SAMPLE | PL = PLASTIC LIMIT | |
| | AG = AUGER CUTTINGS | PI = PLASTIC INDEX | |
| | SPT = STANDARD PENETRATION TEST | UU = TRIAXIAL COMPRESSION | |

| SUMMARY OF LABORATORY TEST RESULTS<br><br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | PL (%) | PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-4 | 1 | 0 | 2 | UD | | 11 | | | | | | | | 1.5 | 1.5 | Fill: Lean Clay (CL) |
| | 2 | 2 | 4 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 13 | 122 | | | | | 2.16 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 13 | 116 | 33 | 17 | 16 | | 1.48 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 5 | 8.5 | 10 | SPT | 18 | 6 | | | | | | | | | | Silty Sand (SM) |
| | 6 | 10.5 | 12 | SPT | 19 | 13 | | | | | 42 | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 19 | 10 | | | | | | | | | | Sandy Silt (ML) |
| | 8 | 14.5 | 16 | SPT | 18 | 11 | | | | | 50 | | | | | Sandy Silt (ML) |
| | 9 | 16 | 18 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 10 | 18 | 20 | UD | | 12 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20 | 22 | UD | | 12 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |

| LEGEND: | | | NOTES: |
|---|---|---|---|
| | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD | LL = LIQUID LIMIT | |
| | SS = SPLIT SPOON SAMPLE | PL = PLASTIC LIMIT | |
| | AG = AUGER CUTTINGS | PI = PLASTIC INDEX | |
| | SPT = STANDARD PENETRATION TEST | UU = TRIAXIAL COMPRESSION | |

PLATE A-17

| SUMMARY OF LABORATORY TEST RESULTS<br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | SAMPLE DEPTH (FT) Top | SAMPLE DEPTH (FT) Bottom | SAMPLE TYPE | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | ATTERBERG LIMITS PL (%) | ATTERBERG LIMITS PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | SHEAR STRENGTH (TSF) UU TEST (CONFINING PRESSURE. TSF) | SHEAR STRENGTH (TSF) TORVANE | SHEAR STRENGTH (TSF) POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-5 | 1 | 0 | 2 | UD | | 14 | | 26 | 15 | 11 | | | | 1.12 | 1.08 | Fill: Lean Clay (CL) |
| | 2 | 2 | 4 | UD | | 17 | | | | | | | | 0.5 | 0.46 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 18 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 19 | 107 | | | | | 0.73 | | 1 | 0.93 | Lean Clay (CL) |
| | 5 | 8 | 10 | UD | | 16 | | 31 | 17 | 14 | | | | 1 | 0.93 | Lean Clay (CL) |
| | 6 | 10.5 | 12 | SPT | 16 | 14 | | | | | 25 | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 15 | 17 | | | | | | | | | | Sandy Silt (ML) |
| | 8 | 14 | 16 | UD | | 15 | 119 | | | | | 1.69 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 9 | 16 | 18 | UD | | 15 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 10 | 18 | 20 | UD | | 16 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20 | 22 | UD | | 17 | | | | | | | | 1.12 | 1.08 | Lean Clay (CL) |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

| LEGEND: | | | |
|---|---|---|---|
| | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD | LL = LIQUID LIMIT | NOTES: |
| | SS = SPLIT SPOON SAMPLE | PL = PLASTIC LIMIT | |
| | AG = AUGER CUTTINGS | PI = PLASTIC INDEX | |
| | SPT = STANDARD PENETRATION TEST | UU = TRIAXIAL COMPRESSION | |

| SUMMARY OF LABORATORY TEST RESULTS<br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE | | | | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS | | | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) | | | | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | | | | LL (%) | PL (%) | PI (%) | | UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | |
| B-6 | 1 | 0 | 2 | UD | | 7 | | | | | | | | | | Fill: Silty Sand (SM) |
| | 2 | 2 | 4 | UD | | 9 | | 40 | 18 | 22 | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 10 | | | | | | | | 1.12 | 1.08 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 12 | | 37 | 18 | 19 | 84 | | | 1.38 | 1.32 | Lean Clay (CL) |
| | 5 | 8 | 10 | UD | | 13 | | | | | | | | 0.5 | 0.46 | Lean Clay (CL) |
| | 6 | 10.5 | 12 | SPT | 11 | 8 | | | | | | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 13 | 11 | | | | | | | | | | Silty Sand (SM) |
| | 8 | 14.5 | 16 | SPT | 19 | 12 | | | | | 18 | | | | | Silty Sand (SM) |
| | 9 | 16 | 18 | UD | | 14 | | | | | | | | 1.25 | 1.24 | Lean Clay (CL) |
| | 10 | 18 | 20 | UD | | 17 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20 | 22 | UD | | 12 | | | | | | | | 0.62 | 0.56 | Lean Clay (CL) |

| LEGEND: | | | |
|---|---|---|---|
| | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD<br>SS = SPLIT SPOON SAMPLE<br>AG = AUGER CUTTINGS<br>SPT = STANDARD PENETRATION TEST | LL = LIQUID LIMIT<br>PL = PLASTIC LIMIT<br>PI = PLASTIC INDEX<br>UU = TRIAXIAL COMPRESSION | NOTES: |

| SUMMARY OF LABORATORY TEST RESULTS<br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | PL (%) | PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE-2 | 1 | 0 | 2 | UD | | 16 | | 37 | 18 | 19 | | | | 1.5 | 1.5 | Fill: Lean Clay (CL) |
| | 2 | 2 | 4 | UD | | 13 | 117 | | | | | 1.62 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 14 | | 40 | 19 | 21 | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 5 | 8 | 10 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 6 | 10.5 | 12 | SPT | 20 | 6 | | | | | 37 | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 19 | 3 | | | | | | | | | | Silty Sand (SM) |
| | 8 | 14.5 | 16 | SPT | 23 | 3 | | | | | 15 | | | | | Silty Sand (SM) |
| | 9 | 16 | 18 | UD | | 15 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 10 | 18 | 20 | UD | | 14 | 122 | | | | | 2.5 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20 | 22 | UD | | 15 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 12 | 25 | 27 | UD | | 15 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

| LEGEND: | | | NOTES: |
|---|---|---|---|
| | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD | LL = LIQUID LIMIT | |
| | SS = SPLIT SPOON SAMPLE | PL = PLASTIC LIMIT | |
| | AG = AUGER CUTTINGS | PI = PLASTIC INDEX | |
| | SPT = STANDARD PENETRATION TEST | UU = TRIAXIAL COMPRESSION | |

| SUMMARY OF LABORATORY TEST RESULTS<br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | PL (%) | PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE-4 | 1 | 0 | 2 | UD | | 14 | | | | | | | | 0.62 | 0.56 | Fill: Lean Clay (CL) |
| | 2 | 2 | 4 | UD | | 14 | | 25 | 15 | 10 | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 15 | 118 | | | | | 2.13 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 15 | | 32 | 16 | 16 | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 5 | 8.5 | 10 | SPT | 16 | 10 | | | | | 28 | | | | | Silty Sand (SM) |
| | 6 | 10.5 | 12 | SPT | 17 | 9 | | | | | | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 18 | 14 | | | | | | | | | | Silty Sand (SM) |
| | 8 | 14.5 | 16 | SPT | 18 | 18 | | | | | | | | | | Silty Sand (SM) |
| | 9 | 16 | 18 | UD | | 15 | 117 | | | | | 2.03 | | 1.25 | 1.24 | Lean Clay (CL) |
| | 10 | 18 | 20 | UD | | 15 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 11 | 20.5 | 22 | SPT | 23 | 17 | | | | | | | | | | Silty Sand (SM) |
| | 12 | 25 | 27 | UD | | 12 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

| LEGEND: | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD<br>SS = SPLIT SPOON SAMPLE<br>AG = AUGER CUTTINGS<br>SPT = STANDARD PENETRATION TEST | LL = LIQUID LIMIT<br>PL = PLASTIC LIMIT<br>PI = PLASTIC INDEX<br>UU = TRIAXIAL COMPRESSION | NOTES: |
|---|---|---|---|

| SUMMARY OF LABORATORY TEST RESULTS<br>Geotechnical Consultant's Name: Geotech Engineering and Testing | PROJECT NAME: PROPOSED GESSNER ROAD DRAINAGE & PAVEMENT IMPROVEMENTS, COH, TX<br>COH WBS NUMBER: N-000809-0001-3<br>CONSULTANT PROJECT NUMBER: 13-825E |
|---|---|

| BORING NO. | SAMPLE NO. | DEPTH (FT) Top | DEPTH (FT) Bottom | TYPE | SPT | WATER CONTENT(%) | DRY DENSITY (pct) | ATTERBERG LIMITS LL (%) | PL (%) | PI (%) | PERCENT PASSING SIEVE 200 (%) | SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST | UU TEST (CONFINING PRESSURE. TSF) | TORVANE | POCKET PENETRO METER | TYPE OF MATERIAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BE-7 | 1 | 0 | 2 | UD | | 15 | 114 | 26 | 15 | 11 | | 0.79 | | 1.5 | 1.5 | Fill: Lean Clay (CL) |
| | 2 | 2 | 4 | UD | | 17 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 3 | 4 | 6 | UD | | 16 | 113 | 38 | 17 | 21 | | 1.43 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 4 | 6 | 8 | UD | | 13 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | 5 | 8 | 10 | UD | | 15 | 109 | 39 | 18 | 21 | | 1.1 | | 1.5 | 1.5 | Lean Clay (CL) |
| | 6 | 10.5 | 12 | SPT | 18 | 10 | | | | | | | | | | Silty Sand (SM) |
| | 7 | 12.5 | 14 | SPT | 19 | 6 | | | | | 17 | | | | | Silty Sand (SM) |
| | 8 | 14.5 | 16 | SPT | 18 | 10 | | | | | | | | | | Silty Sand (SM) |
| | 9 | 16.5 | 18 | SPT | 21 | 8 | | | | | 30 | | | | | Silty Sand (SM) |
| | 10 | 18.5 | 20 | SPT | 19 | 21 | | | | | | | | | | Sandy Silt (ML) |
| | 11 | 20.5 | 22 | SPT | 17 | 23 | | | | | | | | | | Sandy Silt (ML) |
| | 12 | 22.5 | 24 | SPT | 22 | 25 | | | | | | | | | | Sandy Silt (ML) |
| | 13 | 24 | 26 | UD | | 20 | | | | | | | | 1 | 0.93 | Lean Clay (CL) |
| | 14 | 28 | 30 | UD | | 27 | | | | | | | | 1.5 | 1.5 | Lean Clay (CL) |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

| LEGEND: | | | NOTES: |
|---|---|---|---|
| | UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD | LL = LIQUID LIMIT | |
| | SS = SPLIT SPOON SAMPLE | PL = PLASTIC LIMIT | |
| | AG = AUGER CUTTINGS | PI = PLASTIC INDEX | |
| | SPT = STANDARD PENETRATION TEST | UU = TRIAXIAL COMPRESSION | |

PLATE A-22

# APPENDIX B

## Piezometer Installation and Abandonment Report

## STATE OF TEXAS WELL REPORT for Tracking #366758

| | | | |
|---|---|---|---|
| Owner: | **GEOTECH ENGINEERING AND TESTING** | Owner Well #: | **B-3/PZ-1** |
| Address: | **800 VICTORIA DRIVE**<br>**HOUSTON , TX 77022** | Grid #: | **65-12-5** |
| Well Location: | **CITY OF HOUSTON (GESSNER RD)**<br>**HOUSTON , TX 77043** | Latitude: | **29° 47' 56" N** |
| Well County: | **Harris** | Longitude: | **095° 32' 41" W** |
| Elevation: | **No Data** | GPS Brand Used: | **GOOGLE EARTH** |
| Type of Work: | **New Well** | Proposed Use: | **Monitor** |

| | |
|---|---|
| Drilling Date: | Started: **6/5/2014**<br>Completed: **6/5/2014** |
| Diameter of Hole: | Diameter: **7 in From Surface To 23 ft** |
| Drilling Method: | **Bored** |
| Borehole Completion: | **Straight Wall** |
| Annular Seal Data: | 1st Interval: **From 23 ft to 11 ft with 6 SAND (#sacks and material)**<br>2nd Interval: **From 11 ft to 2 ft with 2.3 BENT.CHIPS (#sacks and material)**<br><br>3rd Interval: **From 2 ft to 0 ft with 1.2 CEMENT (#sacks and material)**<br>Method Used: **HANDMIX**<br>Cemented By: **MEDI**<br>Distance to Septic Field or other Concentrated Contamination: **No Data**<br>Distance to Property Line: **No Data**<br>Method of Verification: **No Data**<br>Approved by Variance: **No Data** |
| Surface Completion: | **Alternative Procedure Used** |

| | |
|---|---|
| Water Level: | Static level: **No Data**<br>Artesian flow: **No Data** |
| Packers: | **BENTONITE CHIPS 3/8 11'-9'** |
| 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**<br>Depth of Strata: **No Data**<br>Chemical Analysis Made: **No Data**<br>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: | **MATHERS ENVIRONMENTAL DRILLING INC.**<br>**12243 B. FM 529**<br>**HOUSTON , TX 77041** |
| Driller License Number: | **54933** |
| Licensed Well Driller Signature: | **SHANNON MATHERS** |
| Registered Driller Apprentice Signature: | **No Data** |
| 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 #**366758**) 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'' CONCRETE**
**8''-2' FILL SANDY SILT, DARK GRAY**
**2'-12' LEAN CLAY, LIGHT GRAY**
**12'-18' SANDY SILT, LIGHT BROWN, GRAY**
**18'-20' LEAN CLAY, LIGHT GRAY, LIGHT BROWN**
**20'-23' LEAN CLAY, STIFF. LIGHT GRAY, WITH SANDS**

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
**2'' NEW PLASTIC SCREEN SLOT 0.010 23'-13' SCH.40**
**2'' NEW PLASTIC RISER 13'-0 SCH.40**

## STATE OF TEXAS WELL REPORT for Tracking #366762

| | | | |
|---|---|---|---|
| Owner: | **GEOTECH ENGINEERING AND TESTING** | Owner Well #: | **B-5/PZ-2** |
| Address: | **800 VICTORIA DRIVE<br>HOUSTON , TX 77022** | Grid #: | **65-12-5** |
| Well Location: | **CITY OF HOUSTON (GESSNER RD)<br>HOUSTON , TX 77043** | Latitude: | **29° 48' 17" N** |
| Well County: | **Harris** | Longitude: | **095° 32' 42" W** |
| Elevation: | **No Data** | GPS Brand Used: | **GOOGLE EARTH** |
| Type of Work: | **New Well** | Proposed Use: | **Monitor** |

| | |
|---|---|
| Drilling Date: | Started: **6/5/2014**<br>Completed: **6/5/2014** |
| Diameter of Hole: | Diameter: **7 in From Surface To 22 ft** |
| Drilling Method: | **Bored** |
| Borehole Completion: | **Straight Wall** |
| Annular Seal Data: | 1st Interval: **From 22 ft to 10 ft with 6 SAND (#sacks and material)**<br>2nd Interval: **From 10 ft to 2 ft with 2.3 BENT.CHIPS (#sacks and material)**<br><br>3rd Interval: **From 2 ft to 0 ft with 1.2 CEMENT (#sacks and material)**<br>Method Used: **HANDMIX**<br>Cemented By: **MEDI**<br>Distance to Septic Field or other Concentrated Contamination: **No Data**<br>Distance to Property Line: **No Data**<br>Method of Verification: **No Data**<br>Approved by Variance: **No Data** |
| Surface Completion: | **Alternative Procedure Used** |

| | |
|---|---|
| Water Level: | Static level: **No Data**<br>Artesian flow: **No Data** |
| Packers: | **BENTONITE CHIPS 3/8 10'-8'** |
| 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**<br>Depth of Strata: **No Data**<br>Chemical Analysis Made: **No Data**<br>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: | **MATHERS ENVIRONMENTAL DRILLING INC.**<br>**12243 B. FM 529**<br>**HOUSTON , TX 77041** |
| Driller License Number: | **54933** |
| Licensed Well Driller Signature: | **SHANNON MATHERS** |
| Registered Driller Apprentice Signature: | **No Data** |
| 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 #**366762**) on your written request.

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

| DESC. & COLOR OF FORMATION MATERIAL | CASING, BLANK PIPE & WELL SCREEN DATA |
|---|---|
| From (ft) To (ft) Description | Dia. New/Used Type Setting From/To |
| **0-7.5'' CONCRETE** | **2'' NEW PLASTIC SCREEN SLOT 0.010 22'-13' SCH.40** |
| **7.5''-1.5' FILL, LEAN CLAY, LIGHT GRAY** | **2'' NEW PLASTIC RISER 13'-0 SCH.40** |
| **1.5'-10' LEAN CLAY, FIRM, LIGHT GRAY** | |
| **10'-14' SILTY SAND, MEDIUM LIGHT GRAY** | |
| **14'-22' LEAN CLAY, VERY STIFF, LIGHT GRAY BROWNISH YELLOW** | |

## STATE OF TEXAS PLUGGING REPORT for Tracking #95392

| | | | |
|---|---|---|---|
| Owner: | **GEOTECH ENGINEERING & TESTING** | Owner Well #: | **B-3/PZ-1** |
| Address: | **800 VICTORIA DRIVE<br>HOUSTON , TX 77022** | Grid #: | **65-12-5** |
| Well Location: | **CITY OF HOUSTON (GESSNER RD)<br>HOUSTON , TX 77043** | Latitude: | **29° 47' 56" N** |
| Well County: | **Harris** | Longitude: | **095° 32' 41" W** |
| | | GPS Brand Used: | **GOOGLE EARTH** |

| | |
|---|---|
| Well Type: | **Monitor** |

### HISTORICAL DATA ON WELL TO BE PLUGGED

| | |
|---|---|
| Original Well Driller: | **SHANNON MATHERS** |
| Driller's License Number of Original Well Driller: | **54933** |
| Date Well Drilled: | **6/5/2014** |
| Well Report Tracking Number: | **366758** |
| Diameter of Borehole: | **7'' inches** |
| Total Depth of Borehole: | **23' feet** |

| | |
|---|---|
| Date Well Plugged: | **7/3/2014** |
| Person Actually Performing Plugging Operation: | **SHANNON MATHERS** |
| License Number of Plugging Operator: | **54933** |
| Plugging Method: | **Tremmie pipe cement from bottom to top.** |
| Plugging Variance #: | **No Data** |
| Casing Left Data: | 1st Interval: **2 inches diameter, From 23 ft to 3 ft**<br>2nd Interval: **No Data**<br>3rd Interval: **No Data** |

| | |
|---|---|
| Cement/Bentonite Plugs Placed in Well: | 1st Interval: **From 23 ft to 0 ft; Sack(s)/type of cement used: 3 BGS. CEMENT**<br>2nd Interval: **No Data**<br>3rd Interval: **No Data**<br>4th Interval: **No Data**<br>5th Interval: **No Data** |

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| | |
|---|---|
| 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: | **MATHERS ENVIRONMENTAL DRILLING INC.**<br>**12243 B. FM 529**<br>**HOUSTON , TX 77041** |
| Plug Installer License Number: | **54933** |
| Licensed Plug Installer Signature: | **SHANNON MATHERS** |
| Registered Plug Installer Apprentice Signature: | **No Data** |
| Apprentice Registration Number: | **No Data** |
| Plugging Method Comments: | **No Data** |

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Please include the plugging report's tracking number (Tracking #**95392**) 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 #95393

| | | | |
|---|---|---|---|
| Owner: | **GEOTECH ENGINEERING & TESTING** | Owner Well #: | **B-5/PZ-2** |
| Address: | **800 VICTORIA DRIVE<br>HOUSTON , TX 77022** | Grid #: | **65-12-5** |
| Well Location: | **CITY OF HOUSTON (GESSNER RD)<br>HOUSTON , TX 77043** | Latitude: | **29° 48' 17" N** |
| Well County: | **Harris** | Longitude: | **095° 32' 42" W** |
| | | GPS Brand Used: | **GOOGLE EARTH** |

| | |
|---|---|
| Well Type: | **Monitor** |

### HISTORICAL DATA ON WELL TO BE PLUGGED

| | |
|---|---|
| Original Well Driller: | **SHANNON MATHERS** |
| Driller's License Number of Original Well Driller: | **54933** |
| Date Well Drilled: | **6/5/2014** |
| Well Report Tracking Number: | **366762** |
| Diameter of Borehole: | **7'' inches** |
| Total Depth of Borehole: | **22' feet** |

| | |
|---|---|
| Date Well Plugged: | **7/3/2014** |
| Person Actually Performing Plugging Operation: | **SHANNON MATHERS** |
| License Number of Plugging Operator: | **54933** |
| Plugging Method: | **Tremmie pipe cement from bottom to top.** |
| Plugging Variance #: | **No Data** |
| Casing Left Data: | 1st Interval: **2 inches diameter, From 22 ft to 3 ft**<br>2nd Interval: **No Data**<br>3rd Interval: **No Data** |

| | |
|---|---|
| Cement/Bentonite Plugs Placed in Well: | 1st Interval: **From 22 ft to 0 ft; Sack(s)/type of cement used: 3 BGS. CEMENT**<br>2nd Interval: **No Data**<br>3rd Interval: **No Data**<br>4th Interval: **No Data**<br>5th Interval: **No Data** |

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| | |
|---|---|
| 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: | **MATHERS ENVIRONMENTAL DRILLING INC.**<br>**12243 B. FM 529**<br>**HOUSTON , TX 77041** |
| Plug Installer License Number: | **54933** |
| Licensed Plug Installer Signature: | **SHANNON MATHERS** |
| Registered Plug Installer Apprentice Signature: | **No Data** |
| Apprentice Registration Number: | **No Data** |
| Plugging Method Comments: | **No Data** |

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Please include the plugging report's tracking number (Tracking #**95393**) on your written request.

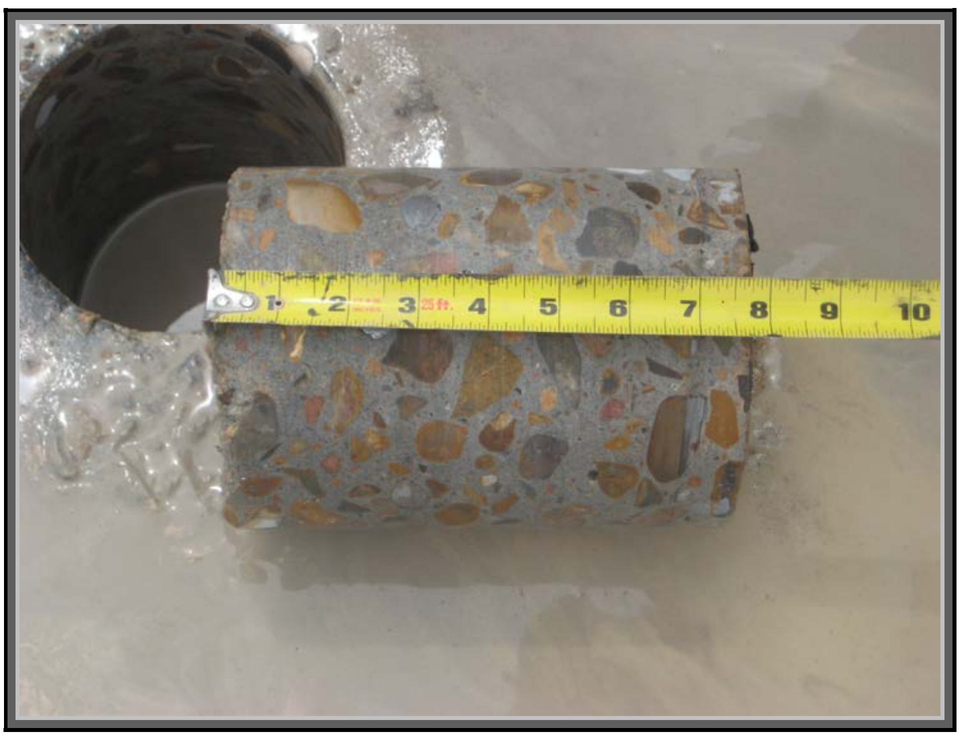
**Texas Department of Licensing & Regulation**
**P.O. Box 12157**
**Austin, TX 78711**
**(512) 463-7880**

# APPENDIX C

## Project Site Pictures

**PROJECT PICTURES**
Project No. 13-825E

**P-1 (A Picture of Pavement Coring Operations)**




**P-2 (A Picture of Core Thickness Measurements)**

**PROJECT PICTURES**
Project No. 13-825E

**P-3 (A Picture of Drilling Operations on Gessner Road)**


**P-4 (A Picture of Drilling Operations on Gessner Road)**

**PROJECT PICTURES**
Project No. 13-825E

**P-5 (A Picture of Piezometer Installations)**


**P-6 (A Picture of Piezometer Installations)**

**PROJECT PICTURES**
Project No. 13-825E


**P-7 (A Picture of Water Level Measurement in Piezometers)**

**P-8 (A Picture of Water Level Measurement in Piezometers)**

## APPENDIX D

## OSHA Soil Classification

## OSHA SOIL CLASSIFICATION

General

Occupational Safety and Health Administration (OSHA) has required a trench protective system for trenches deeper than five-ft. Trenches that are deeper than five-ft, should be shored, sheeted, braced or laid back to a stable slope, or some other appropriate means of protection should be provided where workers might be exposed to moving ground or caving. OSHA developed a soil classification system to be used as a guideline in determining protective requirements for trench excavations.

OSHA classification system categorizes the soil and rock in four types based on shear strength and stability. These classifications are summarized in the following report sections.

Stable Rock

means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A Soil

means cohesive soils with an unconfined compressive strength of 1.5-ton per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, silty clay loam, sandy clay loam, caliche and hardpan. No soil is Type A if:

- The soil is fissured; or
- The soil is subject to vibration from heavy traffic, pile driving or similar effects; or

The soil has been previously disturbed; or

- The soil is part of a slope, layered system where the layers dip into the excavation on a slope of 4(h): 1(v) or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B Soil

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; or
- Granular cohesionless soils including: angular gravel, silt, silt loam, sandy loam, and in some case, silty clay loam and sandy clay loam; or
- Previously disturbed soils except those which would otherwise be classified as Type C soil; or
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

- o Dry rock that is not stable; or
- o Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than 4(h): 1(v), but only if the material would otherwise be classified as Type B.

Type C Soil

- o Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
- o Granular soils including gravel, sand, and loamy sand; or
- o Submerged soil or soil from which water is freely seeping; or
- o Submerged rock that is not stable; or
- o Materials in a sloped, layered system where the layers dip into the excavation on a slope 4 (h) : 1(v) or steeper.

Under the assumption that appropriate groundwater control measures are carried out, and the groundwater table, if present, is lowered and maintained at least 3 feet below the excavation depths, the stable cohesive soils (CL) & (CH), with unconfined compressive strength greater than 0.5 tsf, are classified as OSHA soil Type "B". The granular soils, which are less stable, are classified as OSHA soil Type "C".

Based on our geotechnical exploration and laboratory test results details of soil classifications at each boring are summarized below:

**OSHA SOIL TYPE**

| Boring No. | Depth Range [(1)], ft | Soil Type | OSHA Soil Classification |
|---|---|---|---|
| B-1 | 0 – 2 | Fill: Silty Sand (SM) | C |
| | 2 – 4 | Lean Clay (CL) | B |
| | 4 – 12 | Fat Clay (CH) | B |
| | 12 – 16 | Poorly Graded Sand with Silt (SP-SM) | C |
| | 16 – 21 | Fat Clay (CH) | B |
| | 21 – 23 | Fat Clay (CH) | C |
| B-2 | 0 – 2 | Fill: Lean Clay (CL) | C |
| | 2 – 4 | Lean Clay (CL) | B |
| | 4 – 8 | Lean Clay with Sands (CL) | C |
| | 8 – 18 | Silty Sand (SM) | C |
| | 18 – 22 | Lean Clay (CL) | B |

| Boring No. | Depth Range [1], ft | Soil Type | OSHA Soil Classification |
|---|---|---|---|
| B-3 | 0 – 2 | Fill: Sandy Silt (ML) | B |
| | 2 – 4 | Lean Clay with Sands (CL) | C |
| | 4 – 12 | Lean Clay (CL) | B |
| | 12 – 18 | Sandy Silt (ML) | B |
| | 18 – 20 | Lean Clay (CL) | B |
| | 20 – 22 | Sandy Silt (ML) | B |
| | 22 – 23 | Lean Clay (CL) | B |
| B-4 | 0 – 2 | Fill: Lean Clay (CL) | B |
| | 2 – 8 | Lean Clay (CL) | B |
| | 8 – 12 | Silty Sand (SM) | C |
| | 12 – 16 | Sandy Silt (ML) | B |
| | 16 – 22 | Lean Clay (CL) | B |
| B-5 | 0 – 2 | Fill: Lean Clay (CL) | B |
| | 2 – 4 | Lean Clay (CL) | C |
| | 4 – 10 | Lean Clay (CL) | B |
| | 10 – 14 | Silty Sand (SM) | C |
| | 14 – 22 | Lean Clay (CL) | B |
| B-6 | 0 – 2 | Fill: Silty Sand (SM) | C |
| | 2 – 8 | Lean Clay (CL) | B |
| | 8 – 10 | Lean Clay (CL) | C |
| | 10 – 16 | Silty Sand (SM) | C |
| | 16 – 22 | Lean Clay (CL) | B |
| BE-2 | 0 – 2 | Fill: Lean Clay (CL) | B |
| | 2 – 10 | Lean Clay (CL) | B |
| | 10 – 16 | Silty Sand (SM) | C |
| | 16 – 27 | Lean Clay (CL) | B |

| Boring No. | Depth Range [(1)], ft | Soil Type | OSHA Soil Classification |
|---|---|---|---|
| BE-4 | 0 – 2 | Fill: Lean Clay (CL) | B |
| | 2 – 8 | Lean Clay (CL) | B |
| | 8 – 16 | Silty Sand (SM) | C |
| | 16 – 20 | Lean Clay (CL) | B |
| | 20 – 25 | Silty Sand (SM) | C |
| | 25 – 27 | Lean Clay (CL) | B |
| BE-7 | 0 – 2 | Fill: Lean Clay (CL) | B |
| | 2 – 10 | Lean Clay (CL) | B |
| | 10 – 18 | Silty Sand (SM) | C |
| | 18 – 24 | Sandy Silt (ML) | B |
| | 24 – 30 | Lean Clay (CL) | B |

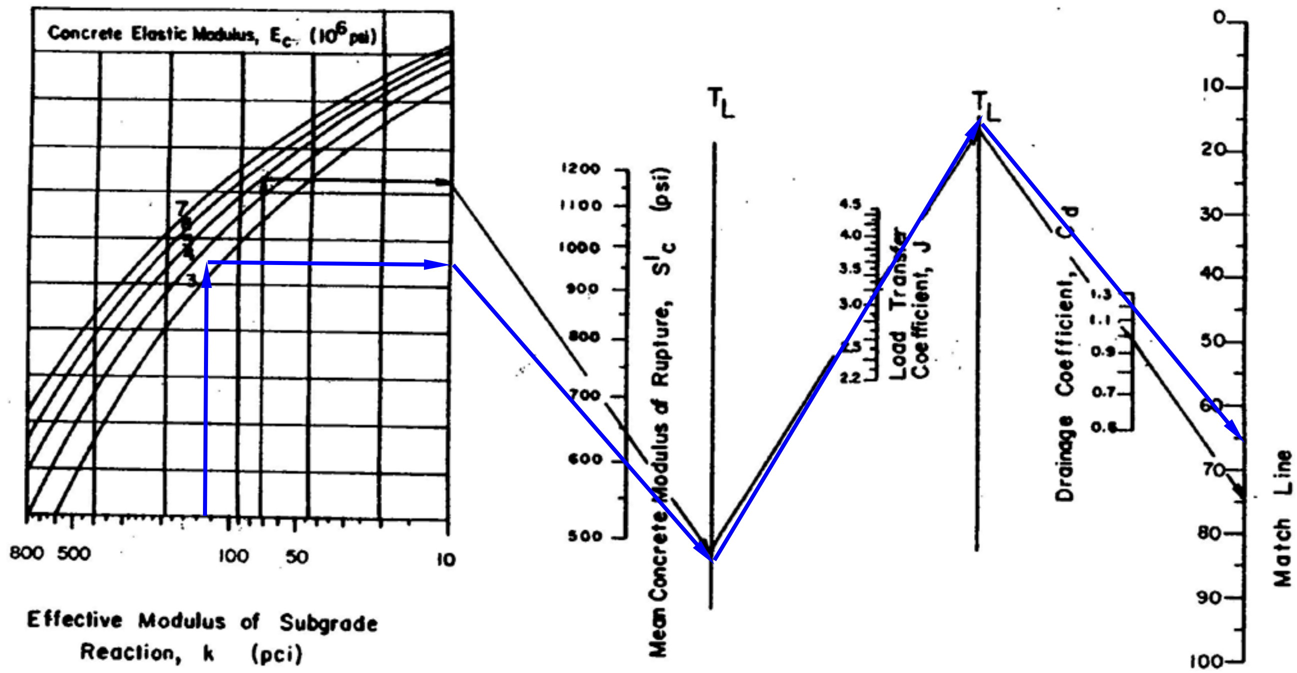
Note: 1. Refer to each boring log for soils stratigraphy

## APPENDIX E

## Pavement Design Computations

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 7.35*\log_{10}(D+1) - 0.06 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.5 - 1.5}\right]}{1 + \frac{1.624*10^7}{(D+1)^{8.46}}} + (4.22-0.32p_t)*\log_{10}\left[\frac{S'_c * C_d \left[D^{0.75} - 1.132\right]}{215.63*J\left[D^{0.75} - \frac{18.42}{(E_c/k)^{0.25}}\right]}\right]$$




Legend :

Pavement Design for This Study

Calculation:

k = 130 pci

$E_c = 3.60 \times 10^6$

$S_c$ = 600 psi

J = 3.2

$C_d$ = 1.2

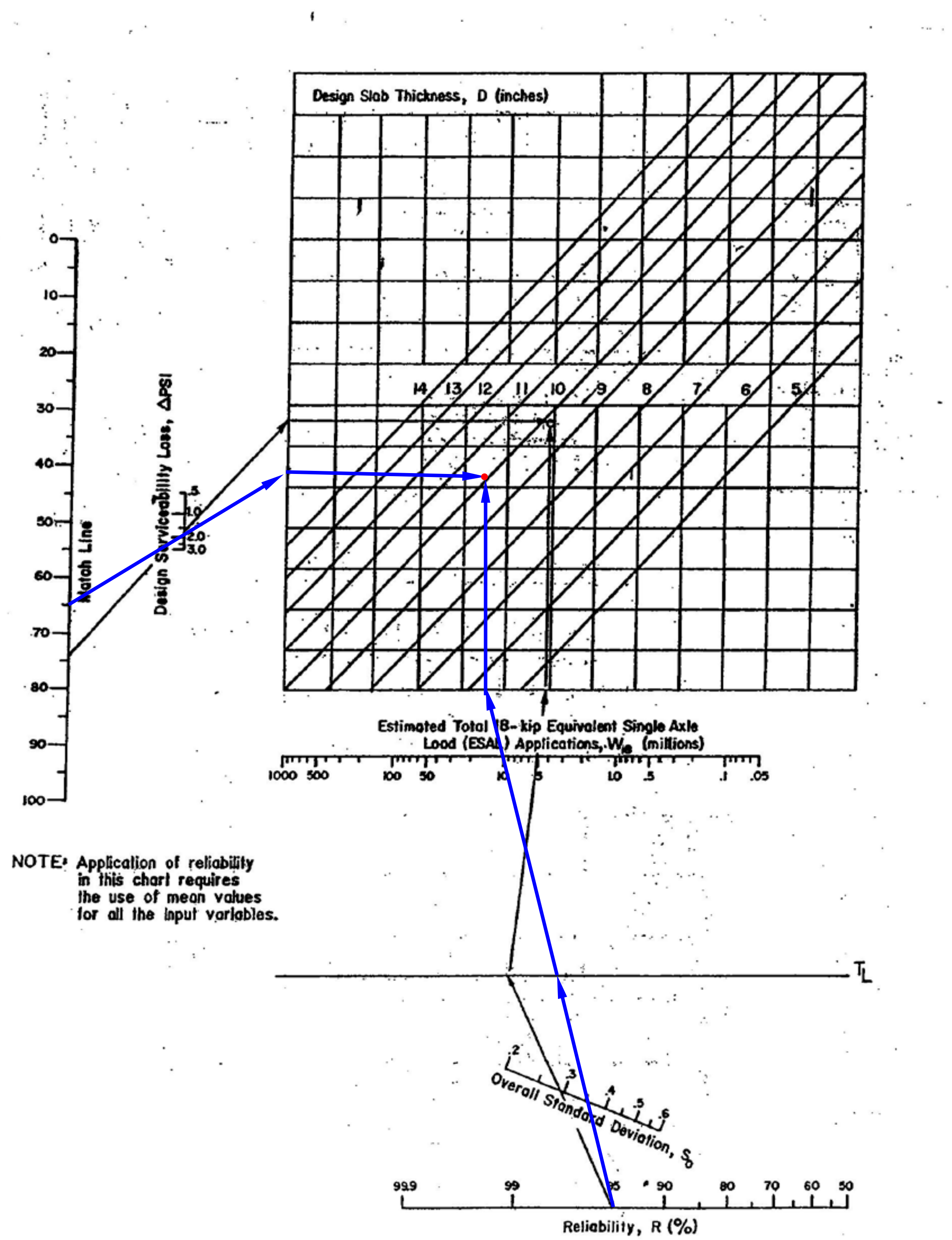
$S_0$ = 0.35

R = 95%

ΔPSI = 4.5-2.5 = 2.0

Solution:

| $W_{18}$ (18kip ESAL x $10^6$) | Concrete Pavement Thickness, inch(es) |
|---|---|
| 10.0 | 10.0 |




**DESIGN CHART FOR RIGID PAVEMENTS BASED ON USING MEAN VALUES FOR EACH INPUT VARIABLES (SEGMENT 2)**