FINAL
GEOTECHNICAL INVESTIGATION
MARTIN LUTHER KING BOULEVARD
RECONSTRUCTION: IH 610S TO BELLFORT
WBS NO. N-000801-0001-3
HOUSTON, TEXAS

SUBMITTED TO
ATKINS NA, INC.
1250 WOOD BRANCH PARK DRIVE, SUITE 300
HOUSTON, TEXAS 77079

BY
HVJ ASSOCIATES, INC.
HOUSTON, TEXAS
JUNE 24, 2013

REPORT NO. HG1018380
KEY MAP NOS. 534 N, S & W

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June 24, 2013

Mr. Phillip M. Williams, PE
Atkins NA, Inc.
1250 Wood Branch Park Drive, Suite 300
Houston, Texas 77079

Re: Geotechnical Investigation
Martin Luther King Boulevard Reconstruction: IH 610S to Bellfort
WBS No.: N-000801-0001-3
Owner: City of Houston
HVJ Report No. HG1018380

Dear Mr. Williams:

Submitted herein is the final report of our geotechnical investigation for the above referenced project. The study was conducted in general accordance with our proposal number HG1018380 dated November 9, 2010 (Revised December 9, 2010) and subject to the limitations presented in this report.

We appreciate the opportunity of working with you on this project. Please read the entire report and notify us if there are questions concerning this report or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.
Texas Firm Registration No. F-000646

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The seal appearing on this document was authorized by Ziad AlAawar, PE 107115 on June 24, 2013. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.

The following lists the pages which complete this report:

- Main Text – 24 pages
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1 EXECUTIVE SUMMARY

HVJ Associates, Inc. was retained by Atkins NA, Inc. to provide geotechnical services for the proposed Martin Luther King Boulevard reconstruction between IH 610S and Bellfort in Houston, Texas. The project also includes replacement of underground utilities and reconnecting the storm sewer line to the existing multiple box culvert at HCFCD channel, Salt Water Ditch. Based on the plan and profile drawings provided to us by Atkins NA, Inc., we understand that the invert depth of the proposed utilities range between 5 and 11 feet below the existing grade. The HCFCD ditch is located between Van Fleet Street and Doulton drive and the depth of the ditch at the location of the box culvert is about 10 feet below the existing grade. We also understand that the ditch will not be disturbed during the installation of utilities.

The purpose of this study is to provide design and construction recommendations for the proposed pavement reconstruction and underground utilities. This study in general was performed in accordance with the City of Houston Department of Public Works and Engineering Infrastructure Design Manual, July 2011.

Based on the subsurface soil conditions revealed by the soil borings, the findings and recommendations of this report are summarized below:

1. The subsurface soils at the site generally comprise of firm to very stiff fat clay, fat clay with sand and lean clay with sand to the termination depth of the borings. Loose to medium dense clayey sand, silty sand, silt and silt with sand was encountered between 10 and 20 feet in borings B-4 and B-17. Calcareous and ferrous nodules were encountered at various depths in most of the borings.

2. A review of surface faults was made from geologic literature and available in-house records. Based on our review, Pierce Junction salt dome is located at about 1.5 miles west of the project site. We believe that faulting will not impact the project site. A detailed fault study is beyond the scope of this study.

3. Groundwater was encountered at a depth of 16 feet and 17 feet in borings B-4 and B-7 during the drilling operations. Three piezometers were installed at boring locations B-4 (PZ-1), B-7 (PZ-2) and B-11 (PZ-3). Boring B-11 (PZ-3) was installed in accordance with HCFCD guidelines. The 24-hour water level reading in borings B-4 and B-11 was observed at a depth of 8 feet and 10 feet respectively. The 24-hour water level reading was dry in boring B-7. The 30-day water level reading in borings B-4 and B-11 was observed at a depth of 12.5 feet and the 30-day water level reading in boring B-7 was observed at a depth of 8 feet below the existing grade. Piezometer installation records and water level readings are presented in Appendix C of the report.

4. Recommendations for installation of utilities using both open cut and trenchless techniques are presented in this report. Augering operations should generally be in accordance with City of Houston Standard Specification, 02447.

5. The existing pavement were cored at all the boring locations prior to drilling and the core data revealed that the existing pavement generally consists of 1.5 to 3 inches of asphaltic concrete over 7 to 16.5 inches of concrete over existing ground. Details of existing pavement thickness and base material at each boring location are presented in the report.

6. Based on the traffic counts provided to us by Atkins NA, Inc. (City of Houston – Traffic Counts March 2009 for Martin Luther King Blvd from IH 610 South to South Bellfort), we have estimated a 10-inch thick concrete pavement for Martin Luther King Boulevard from IH-610 South to Bellfort for a 20-year design life period. Pavement design recommendations are presented in Section 8 of the report.

Please note that this executive summary does not fully relate our findings and opinions. Those findings and opinions are only presented through our full report.

2 INTRODUCTION

2.1 Project Description

HVJ Associates, Inc. was retained by Atkins NA, Inc. to provide geotechnical services for the proposed Martin Luther King Boulevard reconstruction between IH 610S and Bellfort in Houston, Texas. The project also includes replacement of underground utilities and reconnecting the storm sewer line to the existing multiple box culvert at HCFCD channel, Salt Water Ditch. Based on the plan and profile drawings provided to us by Atkins NA, Inc., we understand that the invert depth of the proposed utilities range between 5 and 11 feet below the existing grade. The HCFCD ditch is located between Van Fleet Street and Doulton drive and the depth of the ditch at the location of the box culvert is about 10 feet below the existing grade. We also understand that the ditch will not be disturbed during the installation of utilities.

The purpose of this study is to provide design and construction recommendations for the proposed pavement reconstruction and underground utilities. This study in general was performed in accordance with the City of Houston Department of Public Works and Engineering Infrastructure Design Manual, July 2011.

2.2 Geotechnical Investigation Program

The primary objectives of this study were to gather information on subsurface conditions at the site and to provide recommendations for the proposed pavement and utilities. The objectives were accomplished by:

1. Drilling seventeen soil borings to depths ranging between 15 and 20 feet below the existing grade to determine soil stratigraphy and to obtain samples for laboratory testing;

2. Installing three piezometers to gain an understanding of the groundwater conditions at the site and to evaluate the potential need for dewatering during construction;

3. Performing laboratory tests to determine physical and engineering characteristics of the soils; and

4. Performing engineering analyses to develop design guidelines and recommendations.

Subsequent sections of this report contain descriptions of the field exploration, laboratory-testing program, general subsurface conditions, design recommendations, and construction considerations.

3 FIELD INVESTIGATION

3.1 Geotechnical Borings

The field exploration program undertaken at the project site was performed on August 16, 2011. Subsurface conditions were investigated by drilling seventeen soil borings to a depth ranging between 15 and 20 feet below the existing grade. It was proposed to drill seventeen borings to depth 15 feet originally. However, according to the City of Houston design guidelines, we drilled additional 5 feet at two boring locations B-4 and B-17 as sand was encountered at the termination depth of the boring. The pavement was cored at sixteen boring locations prior to drilling and pavement thickness information was obtained. All boreholes were backfilled with grout in accordance with the City guidelines and patched at the surface, where applicable.

3.2 Sampling Methods

Soil samples were obtained continuously to the termination depth of the borings. Cohesive soil samples were obtained with a three-inch thin-walled (Shelby) tube sampler in general accordance with ASTM D-1587 standard. Granular cohesionless soils were sampled with the Standard Penetration Test (SPT) sampler in accordance with ASTM D1586 standard. Each sample was removed from the sampler in the field, carefully examined and then classified. The shear strength of the cohesive soils was estimated by a hand penetrometer in the field. Suitable portions of each sample were sealed and packaged for transportation to our laboratory.

Detailed descriptions of the soils encountered in the borings are given on the boring logs presented in Appendix A. A key to the soils classification and symbols used in the boring logs is also presented in Appendix A.

3.3 Water Level Measurements

Groundwater level in the borings was observed during the drilling operations. Three piezometers were installed at boring locations B-4 (PZ-1), B-7 (PZ-2) and B-11 (PZ-3). Boring B-11 (PZ-3) was installed in accordance with HCFCD guidelines. Water level readings in the piezometers were observed after 24 hours and 30 days of installation in borings B-4 and B-7; and after 24 hours, 15 days and 30 days of installation in boring B-11. Piezometer installation records are presented in Appendix C.

4 LABORATORY TESTING

Selected soil samples were tested in the laboratory to determine applicable physical and engineering properties. All tests were performed according to the relevant ASTM Standards. These tests consisted of moisture content measurements, pocket penetrometer, Percent Passing No. 200 Sieve, Atterberg Limits, unconfined compression, unconsolidated undrained, unit dry weight, California Bearing Ratio (CBR) and moisture-density relationship (Proctor) tests.

The Atterberg limits and percent passing number 200 sieve tests were utilized to verify field classification by the Unified Soils Classification System, and the compression tests were performed to obtain the undrained shear strength of the soil. Moisture density relationship and CBR tests were performed to estimate the pavement subgrade characteristics for pavement design. The type and number of tests performed for this investigation are summarized below:

Type of Test	Number of Tests
Moisture Content (ASTM D2216)	121
Atterberg Limits (ASTM D4318)	29
Percent Passing No. 200 Sieve (ASTM D1140)	31
Pocket Penetrometer	128
Unconsolidated Undrained Triaxial (ASTM D2850)	41
CBR (ASTM D 1883)	1
Proctor (ASTM D698)	1
Unit Dry Weight (ASTM D 2166/2850)	41

The laboratory test results are presented on the boring logs in Appendix A. A summary of laboratory test results are provided in Appendix B.

5 SITE CHARACTERIZATION

5.1 General Geology

There are two major surface geological formations that exist in the Houston area: the Beaumont formation and the Lissie formation. The Beaumont formation is a relatively younger formation generally found to the southeast of the Lissie formation. The Beaumont formation dips southeastward and extends beneath beach sand and waters of the Gulf of Mexico as far as the continental shelf. The project site is located in an area where the Beaumont formation is typically encountered.

The Beaumont formation was deposited on land near sea level in flat river deltas and in inter-delta regions. Soil deposition occurred in fresh water streams and in flood plains (as backwater marsh and natural levees). The courses of major streams and deltaic tributaries changed frequently during the period of deposition, generating within the Beaumont clay a complex stratification of sand, silt and clay deposits. Frequently, stream courses were diverted significant distances from a given point in a backwater marsh, and the water overlying the soil would evaporate since it was cut off from a drainage path. Such water, which would be highly alkaline, would precipitate large nodules of calcium carbonate (calcareous nodules) throughout the surface of evaporation. With the coming of the Second Wisconsin Ice Age, the nearby sea withdrew, leaving the formation several hundred feet above sea level and permitting the soil to desiccate. The process of desiccation compressed the clays in the formation such that they became significantly overconsolidated to a large depth. In addition to preconsolidating the soil, the process of desiccation, together with the later rewetting, produced a network of fissures and slickensides that are now closed but which represent potential planes of weakness in the soil.

5.2 Geologic Faulting

The tectonic history of the Texas Gulf Coast includes a relatively stable depositional cycle since the Cretaceous Period (about 65 million years). During this period the area has been subjected to deposition of clays, silts, and sands resulting in over 30 thousand feet of sedimentary rocks. Underlying this clastic sequence are salt formations, which have migrated upwards to produce the typical salt dome features associated with the Texas Gulf Coast. In conjunction with salt movement, dewatering and compaction of some of the deeper sediments in the basin have resulted in the development of growth faults.

A review of surface faults was made from geologic literature and available in-house records. Based on our review, Pierce Junction salt dome is located at about 1.5 miles west of the project site. We believe that faulting will not impact the project site. A detailed fault study is beyond the scope of this study.

5.3 Soil Stratigraphy

Our interpretation of soil and groundwater conditions at the project site is based on information obtained at the boring locations only. This information has been used as the basis for our conclusions and recommendations. Significant variations at areas not explored by the project boring may require reevaluation of our findings and conclusions.

The subsurface soils at the site generally comprise of firm to very stiff fat clay, fat clay with sand and lean clay with sand to the termination depth of the borings. Loose to medium dense clayey sand, silty sand, silt and silt with sand was encountered between 10 and 20 feet in borings B-4 and B-17. Calcareous and ferrous nodules were encountered at various depths in most of the borings.

Details of the subsurface stratigraphy encountered in the borings are shown on the boring logs presented in Appendix A.

5.4 Groundwater Conditions

Groundwater was encountered at a depth of 16 feet and 17 feet in borings B-4 and B-7 during the drilling operations. Three piezometers were installed at boring locations B-4 (PZ-1), B-7 (PZ-2) and B-11 (PZ-3). Boring B-11 (PZ-3) was installed in accordance with HCFCD guidelines. The 24-hour water level reading in borings B-4 and B-11 was observed at a depth of 8 feet and 10 feet respectively. The 24-hour water level reading was dry in boring B-7. The 30-day water level reading in borings B-4 and B-11 was observed at a depth of 12.5 feet and the 30-day water level reading in boring B-7 was observed at a depth of 8 feet below the existing grade. Piezometer installation records and water level readings are presented in Appendix C of the report.

It should be noted that groundwater levels determined during drilling may not accurately reflect the true groundwater conditions, and therefore should only be considered as approximate. Groundwater levels measured in open standpipe piezometers are, on the other hand are more accurate; however, these readings will fluctuate seasonally and in response to rainfall. Other factors that might impact piezometric groundwater levels include leakage from existing sewers and/or sanitary sewers.

6 UTILITIES DESIGN CRITERIA AND RECOMMENDATIONS

6.1 General

The project involves replacement of underground utilities along Martin Luther King Boulevard reconstruction between IH 610S and Bellfort in Houston, Texas. The actual invert depth of the proposed utilities is not available at the time of writing this proposal. However, we understand that the invert depth of the proposed utilities will not exceed 10 feet below the existing grade. Our analyses and recommendations for the installation of utilities using both augering and open cut techniques are presented below.

6.2 Geotechnical Parameters

Geotechnical design parameters are presented in the following table. Design parameters given in the table are based on field and laboratory test data obtained at boring locations only and at the approximate invert depth. It must be noted that because of the nature of the soil stratigraphy at this site, parameters at locations away from the borings may vary substantially from values reported in the table.

Boring No.	Street Name	Approximate Invert Depth (ft)	Soil Description at Invert Depth	Total Unit Weight (pcf)	Undrained Shear Strength (psf) / or Friction Angle (deg)	Allowable Bearing Pressure (psf)	E'n, Long Term (psi)
B-1	MLK Blvd	5-10	Stiff Fat Clay	124	1600	2600	600
B-2	MLK Blvd	5-10	Stiff Fat Clay w/Sand	127	1500	2500	600
B-3	MLK Blvd	5-10	Stiff to very stiff Lean Clay with Sand	117	1800	3000	600
B-4	MLK Blvd	5-10	Stiff to very stiff Sandy Lean Clay	136	1400	2300	600
B-5	MLK Blvd	5-10	Stiff to very stiff Lean Clay with Sand	114	1400	2300	600
B-6	MLK Blvd	5-11	Stiff to very stiff Fat Clay/Lean Clay	124	1200	2000	600
B-7	MLK Blvd	5-10	Stiff Fat Clay	110	1020	1700	600
B-8	MLK Blvd	5-10	Stiff to very stiff Fat Clay/Lean Clay	127	1400	2300	600
B-9	MLK Blvd	5-10	Stiff Fat Clay	119	1400	2300	600
B-10	MLK Blvd	5-10	Stiff Fat Clay/ Lean Clay with Sand	123	1100	1800	600
B-11	MLK Blvd	5-10	Stiff to very stiff Fat Clay	113	1320	2200	600
B-12	MLK Blvd	5-10	Stiff Fat Clay/ Lean Clay with Sand	117	1000	1600	300
B-13	MLK Blvd	5-10	Stiff to very stiff Fat Clay with Sand	122	1100	1800	600
B-14	MLK Blvd	5-10	Stiff Fat Clay with Sand	115	1000	1600	300
B-15	MLK Blvd	5-10	Stiff to very stiff Fat Clay/ Lean Clay w/Sand	126	1700	2800	600
B-16	MLK Blvd	5-10	Stiff to very stiff Fat Clay	108	1700	2800	600
B-17	MLK Blvd	5-10	Very stiff Lean Clay/ Sandy Lean Clay	117	2400	4000	1000

The values shown in the above table represent our interpretation of the soil properties based on the available laboratory and field test data. Use of the soil properties shown above may or may not be appropriate for a particular analysis, since choice of design parameters often depends on whether total or effective stress analysis is used, rate of loading, duration of loading, geometry of loaded area, and other factors. The total unit weight values shown above represent our interpretation of soil unit weight at natural moisture content. The undrained shear strength and allowable bearing pressure values represent our interpretation of the shear strength in clay soils based primarily on the results of unconfined compression tests and hand penetrometer tests. The allowable bearing pressures include a factor of safety of three.

Pipe Design. The loads imposed on underground pipes depend principally upon the method of installation, the weight of overburden soils, roadway traffic load, and loads due to existing surface structures. For design of rigid pipes installed using open-cut excavation methods, loads due to overburden and traffic can be determined from Plate 3.

The traffic load applied to the pipe can be calculated using 85% of wheel load with an impact factor of 1.5 for one foot of soil cover, 50% of wheel load with an impact factor of 1.35 for 2 feet of cover, and 30% of wheel load with an impact factor of 1.15 for 3 feet of cover. This results in a total design traffic load on the pipe or box culvert of about 1.28, 0.68 and 0.35 times the wheel load for 1, 2 and 3 feet of cover, respectively. For pipes or box culverts with four or more feet of cover, the traffic loads may be taken as a surcharge equivalent to 250 psf.

The design of flexible pipes requires the modulus of soil reaction of the native soil (E_n') in the trench wall as input. The E_n' values are based on empirical relationships to the soil consistency as defined by unconfined compression tests for cohesive soils. E_n' values for the native soils are presented in the above table. The E_n' values for short-term conditions in cohesive soils may be assumed to be 1.5 times the long-term values. These values are based on the soil data obtained at the boring locations only and may be used for the noted invert depth zone.

Pipe Bedding. Waterlines installed using open-cut trenches should be placed using City of Houston Drawing No. 02317-04. This drawing specifies that the bottom should be dry before placement of pipe. The sanitary sewer may be installed according to City of Houston Standard Drawing Nos. 02317-01, 02317-02 or 02317-03. The storm sewer may be installed using City of Houston standard bedding details as outlined on Standard Drawing Nos. 02317-02 or 02317-03. If needed, we recommend groundwater control in accordance with Section 01578 of City of Houston Standard Specifications be implemented to achieve stable trench conditions and satisfactory foundation base.

The excavations should be performed with equipment capable of providing a relatively clean bearing area. Stable soils are essential to provide a strong base during construction. In addition, stable soils enhance trench bottom stability, support for bedding compaction, and minimize possible pipe settlement. Whenever soft foundation soils are encountered during trench excavation, we recommend over excavating 3 feet below the base of the foundation and replacing with on-site soils compacted to at least 95% of maximum dry density in loose lifts not exceeding 8 inches.

Trench Backfill. Trench backfill for water lines, sanitary sewer, and storm sewers should be in accordance with Section 02317, Excavation and Backfill for Utilities, of the City of Houston Standard Specifications, July 2009. Backfill around the storm sewers, including manholes and other underground structures, should be in accordance with the provisions that are explained in the City of Houston Standard Details on Drawing Nos. 02317-02 and 02317-03. The backfill for the sanitary sewer lines should be in accordance with Drawing Nos. 02317-01, 02317-02 or 02317-03. The water line backfill should be in accordance with Drawing No. 02317-04.

Pipe embedment (bedding, haunching, and initial backfill) for water lines may consist of bank run sand, concrete sand, gem sand, pea gravel, crushed limestone, cement stabilized sand, or Class I, II and III embedment materials as specified in City of Houston Standard Specification Sections 02320 and 02321. For pipes that will be located under streets or within one foot of streets and curbs, pipe embedment should extend to a minimum of 12 inches above the top of pipe and should be compacted to 95% of maximum dry density determined by ASTM D698 as outlined in City of Houston specification 02317. However, the backfill up to 12 inches above the top of the pipe should be compacted carefully so as to prevent structural damage to the pipe. Trench zone backfill is that portion of trench backfill that extends vertically from the top of pipe embedment up to pavement subgrade or up to final grade when not beneath pavement. Trench zone backfill for water lines may consist of bank run sand, select fill, or random backfill material as specified in City of Houston Standard Specification Section 02320.

Trenches that are located partially within the limit of one foot from streets or curbs should be uniformly backfilled according to the paved area criteria. Backfill material may consist of in-situ soils or imported select fill. Imported select fill should consist of sandy clay with a liquid limit less than 40 and a plasticity index between 7 and 20. Excavated material fulfilling these criteria may be used as backfill. Fill material should be placed in loose lifts not exceeding eight inches, and should be compacted to 95 percent of the standard Proctor maximum dry density as determined by ASTM D 698.

6.3 Pressures on Primary and Permanent Liners

It is customary to place a primary liner immediately after excavation so that the ground is always supported. A permanent liner is then placed some time after the installation of the primary liner. The annular space between the liners is then filled with grout. The tunnel liners should be designed to support not only the ground loads but also the construction loads. Pressures on the liner with an example calculation of liner load due to earth and traffic load are presented on Plate 3. Deformation of the liner in the horizontal and vertical diameters can be expected due to soil-liner interaction. Experience with liner distortion in the Houston area suggest values in the range of 0.75 percent difference in length of the vertical and horizontal diameters; with shortening of the vertical diameter in most cases. To the extent that the tunnel liner reduces the soil deformation due to the rigidity of the liner, bending moments will be developed in the liner. The lining will be adequate with respect to bending if it can be deformed, without overstress, by an amount equal to the expected change in diameter.

Buckling of the liner can be a problem if non-uniform support of the liner occurs. This sometimes happens if a local overcut situation occurs during tunneling which is not properly backfilled. Buckling can also occur if the liner is used as reaction for the tunneling equipment, and the tunneling equipment unevenly applies thrust loads.

6.4 Thrust Force Design Recommendations

Piping System Thrust Restraint. Unbalanced thrust forces will be developed in water lines due to changes in direction, cross-sectional areas, or when the pipe is terminated. These forces may cause joints to disengage if not adequately restrained. There will be a slight loss of head due to turbulence in bends in the pipes. This loss will cause a pressure change across the bend, but it is usually small enough to be neglected.

The thrust force may require more reaction than is available just from the pipe bearing against the backfill. In order to prevent intolerable movement and overstressing of the pipe, suitable buttressing should be provided. In general, thrust blocks, concrete encasement, restrained joints and tie rods are common methods of providing reaction for the thrust restraint design. The thrust restraint design provisions described in this section are based on the American Water Works Association Manual M9 (2008) Concrete Pressure Pipe.

Various types of thrust restraint systems are used depending on type of pipes and installation conditions. The force diagram shown on Plate 4 illustrates the thrust force generated by flow in a bend in the pipe. The equations for computing this thrust force are also given on this figure. An example computation of a thrust force generated by flow at a bend in a pipe for a surge pressure of 150 psi and a bend angle of 90 degrees is also presented on Plate 4.

Frictional Resistance. The unbalanced force produced by grade and alignment changes can also be resisted by friction on the pipe. The length of pipe will be formed by tying or welding joints together for the distance required to develop adequate capacity or by encasing the pipe in concrete. The resisting frictional force, F_R is computed as

$F_R = f\,(2W_e+W_w+W_p)$

Where:

f = Coefficient of friction between pipe and soil

W_e = Weight of soil over pipe in lb/ft

W_w = Weight of contained water in lb/ft

W_p = Weight of pipe in lb/ft

The friction value depends on the material in contact with the pipe and the soil used in the backfill around the pipe. For pipe surrounded by compacted sand or crushed stone, the friction between the pipe and soil may be based on a friction angle of 30 degrees. The allowable coefficient of friction, f, of 0.28, 0.23 and 0.18 can be used for concrete, steel and PVC pipes, respectively. This value includes a factor of safety of 2.0. The weight of soil above the pipe will depend on the soil unit weight and the pipe depth. For compacted soils used for backfill, a total unit weight of 125 pcf can be used. Tied joints are used to transmit thrust across joints. These ties may be welded or harnessed joints. Joints may be welded in the field in order to transmit the thrust involved. Information concerning types of harnessed joints available and size and pressure limitations can be obtained from the pipe manufacturers.

6.5 Utilities Installed by Trenchless Technique

We understand that trenchless construction methods may be used to install utilities at some locations along the alignment. The results of our soil borings indicate that mostly cohesive soils will be encountered at the pipe invert depth. It should be noted that due to variability in soil deposits any tunneling operations along the projected alignments could result in varying degrees of mixed face tunneling conditions where several types of soil material may be encountered at the tunneling face. Although the clays are typically stable, face stability problems can occur when water-bearing or soft soils are encountered. Even with dewatering systems operating, unstable flowing situation may occur.

Geotechnical Properties. Recommended ranges of engineering design soil parameters for the cohesive soils that may be encountered in the pipe zone are summarized below.

For cohesive soils:

Total Unit Weight	113 to 136 pcf
Submerged Unit Weight	50.6 to 73.6 pcf
Coefficient of Earth Pressure, K_o	1.0
Undrained Shear Strength	1000 to 2400 psf
Average Undrained Shear Strength	1400 psf
Poisson's Ratio	0.45
Young's Modulus	3000 to 14000 psi

Pipe Design. For pipes to be installed by tunneling techniques, whereby sections of pipe are jacked forward against the surrounding soil, pipes should be designed to resist significant bending moments, along with the jacking forces exerted on the pipe during installation. These loads generally exceed the overburden pressures that are typically determined based on the prism earth load to the ground surface, plus hydrostatic pressure and surcharge loads as shown on Plate 3. Therefore, pipes designed to resist construction loads during tunneling operations should have adequate strength for most long-term overburden and traffic loads.

During design, allowance should be made for any external loads, other than soil loads, which may be exerted on the pipe. These include loads from foundations for structures located near the water line and any possible future excavation to be performed near the water line. Much of the stability of the waterlines is due to the presence of relatively uniform stress conditions in the soil around the pipe. Relief of the earth loads on one side of the waterline due to subsequent adjacent excavation could cause an overstress of the pipe.

Influence of Tunneling on Adjacent or Overlying Structures. The construction of every tunnel in soils is associated with a change in the state of stress in the ground and with the corresponding strains and displacement. In particular, some degree of settlement of the overlying ground surface is always induced. If such settlement, referred to as subsidence, is excessive, it may cause damage to structures, roads and services located above the tunnel.

It should be noted that the existing foundation of the nearby structures and buried portion of existing pipelines within the zone of influence of the tunnel might be subject to possible distress due to tunnel-induced settlement. While the recommendations we are providing intend to reduce the settlement and distress to these structures and pipelines within the zone of influence, they still should be monitored before and for a period after tunneling operations are completed. Generally, settlements due to tunneling are not anticipated after the tunneling operations are completed.

In order to minimize settlement due to tunneling operations the contractor should use well-established techniques and provide temporary support, by advancing the primary liner continuously, as tunneling progresses. No voids should be allowed between any temporary support and the surrounding soils, and with that purpose the injection of cement grout should be considered if it is deemed necessary to fill the voids.

7 UTILITY CONSTRUCTION CONSIDERATIONS

7.1 General

This section is intended to address issues that might arise during construction. Our recommendations are intended for use as guidelines in dealing with particular soil conditions. The topics addressed in this section include trench excavation stability, groundwater control, open-cut construction and augering technique construction considerations. The recommendations contained herein are not intended to dictate construction methods or sequences. Instead they are provided solely to assist designers in identifying potential construction problems related to excavation, based upon findings derived from sampling. Depending upon the final design chosen for the project, the recommendations may also be useful to personnel who observe construction activity. Prospective contractors for the project must evaluate potential construction problems on the basis of their review of the contract documents, their own knowledge of and experience in the local area, and on the basis of similar projects in other localities, taking into account their own proposed methods and procedures.

7.2 Excavation Considerations

Excavations should satisfy two requirements. First, the soils above final grade must be removed without disturbing the soil below excavation grade, which will support constructed facilities. Second, the sides of the excavation must be stable to prevent damage to adjacent streets and facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least a few feet below the lowest excavation grade.

Excavation Stability. Excavations shall be shored, laid back to a stable slope or some other equivalent means may be used to provide safety for workers and adjacent structures. Earth pressures for braced excavations are presented on Plate 5. Assessment of the need for excavation sloping, use of trench boxes or other measures required to provide a stable excavation, and the use of appropriate construction practices and/or equipment is the contractor's responsibility. The following comments are intended to represent common solutions to stability problems encountered in similar soil conditions in the Houston area, and may not be construed as excavation system design recommendations. The excavation operations shall be performed in accordance with 29 CFR Part 1926 subpart P, as amended, including rules published in the Federal Register, Vol. 54, No. 209, dated October 31, 1989, as a minimum. In addition, the provisions of legislation enacted by the Texas Legislature and City of Houston should be satisfied.

Boring No.	Street Name	OSHA Soil Type			
		Depth of Trench (ft)			
		0 – 5	5 – 10	10 – 15	15 – 20
B-1	MLK Blvd	B	B	B	-
B-2	MLK Blvd	B	B	B	-
B-3	MLK Blvd	B	B	B	-
B-4	MLK Blvd	B	B	C	C
B-5	MLK Blvd	B	B	B	-
B-6	MLK Blvd	B	B	B	-
B-7	MLK Blvd	B	B	B	-
B-8	MLK Blvd	B	B	B	-
B-9	MLK Blvd	B	B	B	-
B-10	MLK Blvd	B	B	B	-
B-11	MLK Blvd	B	B	B	-
B-12	MLK Blvd	B	B	B	-
B-13	MLK Blvd	B	B	B	-
B-14	MLK Blvd	B	B	B	-
B-15	MLK Blvd	B	B	B	-
B-16	MLK Blvd	B	B	B	-
B-17	MLK Blvd	B	B	C	C

In general, it is our opinion that the pressure distribution (for braced walls) should be used for design of sheeting or trench boxes. To reduce the potential for ground movement adjacent to the top of the excavation, the bracing should be preloaded in stages as the excavation is deepened. The detailed earth pressure diagram for clay is presented on Plate 5. Whenever layers of both sand and clay are encountered like in borings B-4 and B-17, average unit weights of soil layers should be determined, and the pressure envelope for clay (Plate 5) can be used for the design. The planned construction will be performed along alignments near existing utility installations (either crossing or paralleling the new alignments). The contractors should be aware of potential excavation stability problems while working in the vicinity of old trenches and the excavation system should be designed to accommodate this weak material (trench backfill).

The vertical walls of excavations should be located a safe distance from existing utilities in order to prevent movement in the soil mass behind the excavation that may adversely affect the utilities. We recommend that the horizontal distance should be 4 feet for excavation depths of up to 10 feet.

7.3 Auger Construction Considerations

In augering, a launch pit is excavated and a horizontal boring rig is used to excavate an unsupported bore distance of up to 300 to 400 feet to a receive pit. Once the bore is excavated, dragging a tool through the bore cleans it, and then the pipe is dragged through the bore.

This technique is commonly used in the Houston area for installation of small diameter pipes at depths above the groundwater table. Augering operations should generally be in accordance with City of Houston Standard Specification, 02447.

Bore Stability. In auger construction, where the bore must stand open unsupported for a period of several hours, the structure of the soil is very important. Augering operations have encountered difficulties such as slowed production rates, ground surface settlement above the bore, and bore collapse in some soil conditions in the Houston area. We do not recommend augering in unstable soils or in soils below the water table without providing casing to prevent running ground condition. Firm to very stiff clay soils are generally suitable for augering, however, the secondary structure of the soil is an important consideration. Where a blocky, slickensided, or fissured condition is noted on the boring logs, the clay soil may slough excessively from the bore walls. This will lead to an excessive number of cleaning passes to allow passage of the pipe, and it will result in formations of large voids around the pipe. Collapse of these voids after pipe placement commonly results in noticeable settlement of the ground surface above the bore.

Loss of Ground. A properly designed and controlled augering operation can eliminate or reduce immediate soil movement and subsidence to a tolerable level. Nevertheless, some ground loss should be expected during any tunnel construction operation. With good construction techniques, ground loss can be held to acceptable levels. Generally, tunnels constructed beneath pavement and buried utilities can be expected to create a loosened subgrade or bedding condition which may lead to subsequent deformations.

Large ground loss can result from uncontrolled flowing ground. The potential for such ground loss exists wherever water-bearing sands or silts are encountered along the alignment. Careful dewatering of such layers will reduce the potential for development of flowing conditions, but local experience shows that complete dewatering is difficult to achieve as discussed in a later section.

Ground Control and Improvement. We recommend that tunnels be constructed using techniques that provide positive support to the soil during augering operations. Several measures are available to overcome adverse ground conditions including groundwater lowering and grouting. We expect that groundwater will be encountered in tunnels that are excavated below 16 feet. Groundwater control and dewatering recommendations are provided in Section 7.7 of this report.

7.4 Auger Pit Construction Considerations

It is our understanding that auger pits constructed for augering operations will vary in size depending on whether the pit is a drive or receive pit, the size of machine, and the length of auger pit. Pit construction should be in accordance with City of Houston Standard Specification 02447. Pit should be backfilled in accordance with City of Houston Standard Specification 02317. Bedding and backfill for water lines through auger pits should be in accordance with City of Houston Drawing No. 02447-01.

Pit Excavation Stability. Pit excavations shall be shored or some other equivalent means may be used to provide safety for workers and adjacent structures. Assessment of the need for excavation shoring or other measures required to provide a stable excavation, and the use of appropriate construction practices and/or equipment is the contractor's responsibility.

The lateral earth pressures recommended for short-term design are generally lower than the long-term pressures as the state of stress in the soil changes from "at rest" to "active" conditions immediately after excavation. In calculating the "design" lateral earth pressures, a combination of lateral soil pressures; hydrostatic water pressures; and surcharge loads need to be considered. We recommend that pressure distribution as shown on Plate 5 be used, and that the hydrostatic water pressure be computed by assuming the groundwater table to coincide with the ground surface. Calculation of these pressure components is explained on Plate 5 for clay soils. Whenever layers of both sand and clay are encountered like in boring B-4 and B-17, the average unit weight of layers should be calculated, and the pressure envelope for clay (Plate 5) can be used to design the cuts.

Pit Bottom Stability. Bottom instability results from inadequate shear strength in clay soils to resist stress relief at the base of the excavation, or from piping of water bearing granular soil. This mode of failure results in loss of ground at the ground surface outside the pit and heave of the excavation base inside the pit. Pits for augering operations are typically excavated approximately 4 feet below pipe invert depth. Whenever soft foundation soils are encountered during trench excavation, we recommend over excavating 3 feet below the base of the foundation and replacing with on-site soils compacted to at least 95% of maximum dry density in loose lifts not exceeding 8 inches.

Loss of Ground. Installation of pits may experience some loss of ground around the outside of the excavation due to sloughing of material into the excavation. If proper construction procedures are followed, little or no loss of ground should occur. If loss of ground is excessive, it may cause damage to structures, pavement and services located near the excavation. If loss of ground does occur, soft disturbed soils may develop beneath existing pavement and utilities located close to the excavation location. Corrective measures to address loss of ground problems often include improved dewatering and/or grouting around the pit from the ground surface or within the pit. Repairs associated with loss of ground often include replacement of paving near the top of the pit, and making up for ground loss through placement of cement stabilized sand fill.

7.5 Select Fill and General Earthwork Recommendations

Select fill required to raise the grade or backfill should consist of sandy clay with a liquid limit less than 40 and a plasticity index between 8 and 20. Fill material that is used should be placed in loose lifts not exceeding eight inches and should be compacted to 95 percent of standard Proctor maximum dry density as determined by ASTM D698.

7.6 Spoil Disposal

Spoil from construction will be generated from augering and trench excavations. Economically, possible uses of the cohesive spoil material may be limited to land reclamation, site grading, and final cover in sanitary landfill operations. Soils that will be excavated from this project area will consist primarily of cohesive soils, although a mixture of cohesive and cohesionless soils is expected at some locations within the project area. These soils may not be suitable for use in engineered fill.

7.7 Groundwater Control

Groundwater seepage may be expected during excavation depending upon the groundwater conditions at the time of construction. Assessment of the need for groundwater control and installation of appropriate dewatering equipment is the contractor's responsibility. The following comments are intended to represent common solutions to groundwater control problems encountered in similar soil conditions in the Houston area, and may not be construed as dewatering system design recommendations. A conventional pump and sump arrangement may be adequate if water bearing cohesive soils are encountered during trench excavations. Well points or eductors may be utilized to lower the groundwater level to at least three feet below the excavation level where water bearing cohesionless soils are encountered.

Well points are generally not effective below about 15 feet beneath the top of the well point, and deeper dewatering requires deep wells with submersible pumps and eductors.

Based on the subsurface soils encountered, we anticipate groundwater to be controlled using pump and sump arrangement at most of the boring locations except at boring locations B-4 and B-17 where we will be needing well points as well. In any case, the groundwater control system used must provide a relatively dry, stable base for construction. However, it should be noted that groundwater conditions will change due to rainfall and seasonal changes. Control of groundwater should be accomplished in a manner that will preserve the strength of the foundation soils; will not cause instability of the excavation; and will not result in damage to existing structures. Where necessary to this purpose, the water will be lowered in advance of excavation by pump and sump arrangement, wells, well points, or similar methods. Open pumping should not be permitted if it results in boils, loss of fines, softening of the subgrade, or excavation instability. Discharge should be arranged to facilitate sampling by the owner's representative or engineer.

8 PAVEMENT DESIGN RECOMMENDATIONS

8.1 General

We understand that the project involves reconstruction of Martin Luther King Boulevard between IH 610S and Bellfort in Houston, Texas. Pavement design recommendations presented in this report were developed in accordance with the "AASHTO Guide for Design of Pavement Structures", 1993 Edition.

8.2 Existing Pavement Thickness

The existing pavement within the project area was cored at sixteen boring locations prior to drilling. The existing pavement structure and thickness are presented in the following table:

Boring No.	Total Thickness (inch)	Asphalt Thickness (inch)	Concrete Thickness (inch)	Base Thickness and Description
B-1	18	1.5	16.5	-
B-2	9	2	7	-
B-3	10.5	3	7.5	-
B-4	10	2.5	7.5	-
B-5	10	2.5	7.5	-
B-6	9	2	7	-
B-7	9	2	7	-
B-8	10	2	8	-
B-9	10.5	2	8.5	-
B-10	10	2	8	-
B-12	10	2	8	-
B-13	9	2	7	-
B-14	9.5	2	7.5	-
B-15	9	2	7	-
B-16	9.5	2.5	7	-
B-17	10	2.5	7.5	-

The existing pavement were cored at all the boring locations prior to drilling and the core data revealed that the existing pavement generally consists of 1.5 to 3 inches of asphaltic concrete over 7 to 16.5 inches of concrete over existing ground.

8.3 Moisture Density Relationship

Based on the results of the standard Proctor test, presented on Plate D-1 of Appendix D, the maximum dry density of the composite sample was determined to be 101.7 pounds per cubic foot (pcf) at optimum moisture content of 19.5 percent.

8.4 CBR Value

One California Bearing Ratio (CBR) test was performed on the composite sample obtained from the all the boring locations at the top 2 feet below pavement. A design CBR of 1.2 was estimated at 95% of the maximum dry density. The results of the CBR test are presented on Plates D-2 and D-3 of Appendix D.

8.5 Rigid Pavement Design Recommendations

The recommendations presented in this report for the pavement design were developed in accordance with the "AASHTO Guide for Design of Pavement Structures", 1993 Edition. The design procedure for determining concrete slab thickness for rigid pavements is based on an extension of the algorithms that were originally developed from the AASHTO Road Test. The categories required for the design of pavement includes: (a) design variables, (b) performance criteria, (c) pavement structural characteristics, (d) material properties for structural design, and (e) reinforcement variables. Parameters relative to these categories are discussed below.

8.6 Traffic Load and Design Period

Assuming 85% trucks cars, 10% lightly loaded trucks, 3% buses (as MLK is a METRO bus route), 2% heavy duty trucks, 2% growth rate and a 20-year design life period, we have estimated a traffic loading of 5.8 million 18-Kip equivalent signal axle load (ESAL) for Martin Luther King Boulevard between IH 610S and Bellfort. This estimate is made based on the 24 hour traffic counts provided to us Atkins NA, Inc (18,669 on Martin Luther King Boulevard NB & SB between IH 610 South and South Bellfort as of March 2009).

Reliability Level and Overall Standard Deviation. Based on City of Houston guidelines, reliability (R) of 95 percent was selected for the pavement design performance. A mean value of the overall standard deviation (S_o) was selected to be 0.35 for Portland cement concrete pavement.

Serviceability. The serviceability of a pavement is defined as its ability to serve the type of traffic that uses the facility. The condition of the pavement after the performance period is characterized by a Terminal Serviceability Index (P_t), which is a function of the pavement structure. We recommend that a Terminal Serviceability Index of 2.5 be used for all pavements. Since the time at which a given pavement structure reaches its terminal serviceability depends on traffic volume and the original or initial serviceability (P_o), some consideration also must be given to the selection of P_o. As obtained at the AASHTO Road Test, a P_o value of 4.5 was selected.

Drainage. The treatment for the expected level of drainage for a rigid pavement is through the use of a drainage coefficient, C_d. A C_d value of 1.2 was selected for good quality of drainage.

Load Transfer. The load transfer coefficient, J, is a factor used in rigid pavement design to account for the ability of a concrete pavement structure to transfer load across discontinuities, such as joints.

Based on the values developed by AASHTO, a mean value of the load transfer coefficient (J) of 3.2 was selected for the design of jointed reinforced concrete pavement with tied curbs.

Loss of Support. This factor, LS, was included in the design of rigid pavement to account for the potential loss of support arising from subbase erosion and/or differential vertical soil movement. An LS value of 1.0 was selected according to the AASHTO suggestion for the condition of stabilized soils beneath the pavement.

Effective Modulus of Subgrade Reaction. Based on the California Bearing Ratio test result, we have estimated a subgrade resilient modulus of 1,800 psi. The modulus of subgrade reaction, K, was computed to be 120 pci. However, AASHTO recommends that the composite K-value be adjusted to account for the potential loss of support arising from subbase erosion. Based on the loss of support factor (LS) described previously (LS=1.0), an effective modulus of subgrade reaction (k) was found to be 53 pci.

Concrete Elastic Modulus and Modulus of Rupture. Based on the City of Houston Standard Specification 02751, a mean value of 600 psi for S'c is considered appropriate for the design.

A value of 3.37×10^6 psi was used for the modulus of elasticity of the concrete (E_c) using the correlation recommended by the American Concrete Institute.

$$E_c = 57{,}000(f'c)^{0.5}$$

Where,
E_c = elastic modulus of concrete in psi and,
f'c = compressive strength of concrete in psi; a value of 3500 psi is used here.

8.7 Rigid Pavement Design Considerations

The estimated and/or assumed values for the parameters relative to these categories are summarized in the following table:

Parameter	Value
Subgrade Resilient Modulus, M_R	1,800 psi
Subbase Thickness, D_{sb}	8 inches
Compressive Strength of Concrete f'c	3,500 psi
Subbase Elastic Modulus, E_{sb}	30,000 psi
Loss of Support Factor, LS	1.0
Concrete Elastic Modulus, E_c	3.37×10^6 psi
Mean Concrete Modulus of Rupture, S'_c	600 psi
Load Transfer Coefficient, J	3.2
Drainage Coefficient, C_d	1.2
Design Serviceability Loss, D psi	2.0
Reliability, R	95%
Overall Standard Deviation, S_o	0.35

Rigid Pavement Thickness and Load Capacity. Based on the above parameters, we have estimated a 10-inch thick concrete pavement for MLK Boulevard for a 20-year design life period. In addition, we recommend that eight inches of the subgrade soils be stabilized with 8% lime.

Reinforcing Steel Requirement. Longitudinal and transverse reinforcing steel is required to resist warping stresses in the pavement section and to hold pavement cracks that develop tightly closed.

In addition, reinforcement is required at pavement joints in order to prevent deflections across the joint.

We recommend using steel reinforcement for concrete pavement including the bar size and spacing in accordance to City of Houston standard drawing 02751-01.

8.8 Structural Fill

Structural fill required to replace in-situ material beyond the pavement limits or to raise the design grade should consist of sandy clay with a liquid limit less than 40 and a plasticity index between 8 and 20. Fill material that is used should be placed in loose lifts not exceeding eight inches and should be compacted to 95 percent of the maximum dry density as determined by ASTM D 698.

8.9 Preparation of Subgrade

The surficial soils mostly consist of cohesive fat clays and sandy lean clays. We recommend stabilizing the top six inches of the subgrade soil beneath the proposed concrete pavement with lime. Stabilization of the subgrade will increase the modulus of subgrade reaction and provide subgrade stability for construction during inclement weather. Subgrade stabilization will enhance long-term pavement performance by reducing the tendency of the soil to displace from beneath pavement by pumping. We recommend the following procedures for subgrade preparation.

1. Clear the proposed development area. Grubbing operations should be performed to remove root systems of any trees cleared within the limits of the proposed construction.

2. Strip the surface soil to suitable depths. In areas where soft, compressible or loose soils are encountered, additional stripping may be required. Stripping should extend a minimum of two feet beyond the edge of the proposed pavement.

3. Surfaces exposed after stripping should be proof-rolled in accordance with TxDOT Standard Specification Item 216 or equivalent City of Houston specification. If rutting develops, tire pressures should be reduced. The purpose of the proof-rolling operation is to identify any underlying zones or pockets of soft soils and to remove such weak materials.

4. Before stabilizing the subgrade, scarify the upper eight inches of exposed surface as required, mix with lime and compact it to 95 percent of standard proctor maximum dry density (ASTM D698). We recommend that eight inches of the subgrade soils be stabilized with 8% lime for estimation purposes. The actual amount of lime should be determined for subgrade soils by conducting laboratory tests on the exposed subgrade material during construction. Construction of lime-stabilized subgrade should conform to City of Houston Section 02336.

9 BOX CULVERT DESIGN RECOMMENDATIONS

9.1 General

The project alignment crosses HCFCD ditch between Van Fleet Street and Doulton drive. The project includes reconnecting the storm sewer line to the existing multiple box culvert at the location of this ditch. We understand that the invert depth of the box culvert at this location is about 10 feet below the existing grade. Boring B-11 was drilled at this location to provide foundation recommendations of the box culvert.

9.2 Culvert Structure Foundation Recommendations

We understand that the box culvert is founded at a depth of 10 feet below the existing grade. Design guidelines and recommendations for the culvert installed by open-cut techniques are discussed in the following sections. Based on the information provided to us by Atkins NA, Inc., we understand that the existing ditch will not be disturbed during the installation of culvert. However, boring B-11 was drilled in accordance with HCFCD design guidelines.

Geotechnical Parameters. Geotechnical parameters for design are presented in the following table. Shear strength parameters given in the table are based on field and laboratory data obtained at boring location B-11 only within the given invert depth zone. It must be noted also that because of the nature of soil deposits, parameters at locations away from the borings may vary substantially from values reported in the table.

Table of Geotechnical Design Parameters

Boring No.	Location	App. Invert Depth (feet)	Soil Consistency & Description	Total Unit Weight (pcf)	Undrained Shear Strength (psf)
B-11	MLK Boulevard @ HCFCD Ditch	10	Stiff to very stiff Fat Clay	113	1320

The values shown in the above table represent our interpretation of the soil properties based on the available laboratory and field test data. Use of the soil properties shown above may or may not be appropriate for a particular analysis since choice of design parameters often depends on whether total or effective stress analysis is used, rate of loading, duration of loading, geometry of loaded area, and other factors. The total unit weight value shown above represent our interpretation of soil unit weight at natural moisture content.

Design Lateral Pressure. The soil pressure exerted on a pipe wall is mainly a function of the type of backfill and its method of placement. Over-compaction of backfill behind walls and utilization of highly plastic expansive clay backfill are practices that generally produce the highest wall pressures. In these cases, horizontal earth pressures exceeding the vertical earth pressure can be expected. Design at-rest lateral pressures for pipe walls may be calculated for each backfill type using the equivalent fluid densities for drained level backfill as stated in the following Table.

Lateral Earth Pressure of Culvert Backfill

Fill Type	Equivalent Fluid Density (pcf)
Select Cohesive Soil (PI<20)	70
Bank Sand	40
On Site Cohesive Soil (PI >20)	90

Over-compaction of the backfill should be avoided to prevent the increase of lateral earth pressures on the pipe. The recommended design pressures do not include a groundwater pressure component. We recommend that the culvert structure be designed to resist groundwater pressures.

Allowable Bearing Capacity. Based on boring B-11, cohesive soils are expected within the foundation zone of the structure. An allowable net bearing capacity of 2,200 psf can be used for designing the culvert structure with the base of the culvert at 10 feet below existing grade. The maximum pressure including the culvert and weight of soil above the pipe at the base of the foundation should not exceed the allowable bearing pressure.

Vertical Soil Loads. Loading on the top of the pipe may be calculated using a total soil unit weight of 130 pounds per cubic foot (pcf). For buoyancy calculations, the unit weight of soil should be taken as 65 pcf, which assumes a water table at the ground surface.

Bedding and Backfill. Bedding and backfilling should be performed in accordance with Harris County Flood Control Standard Specification 02316 for Structural Excavating and Backfilling. Soils that will be removed from the excavation will consist of fat clays. Fat clays are not suitable to be used as a backfill material. Placing and compacting backfill should be in accordance with Sections 3.5 and 3.6 of HCFCD standard specification 02316.

10 MONITORING

10.1 Excavation Safety

As required under OSHA regulations, the contractor should provide a "competent person" to inspect trench excavations daily before the start of work, as needed during the shift, and after every rainstorm or other hazard increasing occurrence. When the competent person finds evidence of a hazardous condition, exposed workers should be removed from the hazardous area until the necessary precautions have been taken to ensure their safety. A competent person means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to workers, and who has authorization to take prompt corrective measures to eliminate them.

10.2 Preconstruction Survey

We recommend that a preconstruction survey be performed prior to any tunneling operations. As part of the survey, a complete visual record should be made of all structures along the tunnel alignment. This survey should be comprised of a combined photographic and video taped documentation of the condition of the surrounding structures. Settlement sensitive structures and structures with pre-existing damage should be of particular concern during the visual record process.

In addition to the visual record, a review of the operating conditions of facilities located within a horizontal distance equal to approximately twice the invert depth from the centerline of the tunnel is recommended. Particular attention should be paid to the conditions of existing utilities near the tunnel bore. Existing leaking utilities need to be identified and repaired prior to tunneling to prevent tunneling difficulties due to infiltration of water or sewage into the bore. The location of settlement sensitive utilities should be established and a monitoring program implemented to determine whether tunneling operations are proceeding without loss of ground prior to the tunnel being driven near the utility.

10.3 Construction Monitoring - Tunneling

We recommend that surface elevations along the tunnel alignment be monitored prior to, at intervals during, and after construction. Ground surface settlements can be measured by taking precise leveling measurements, by standard surveying methods, on settlement monuments installed in the ground along the centerline of the tunnel.

The monuments should be suitably protected against vandalism and accidental damage. Survey benchmarks should be established in close proximity to the alignment but outside the influence of any settlement trough.

10.4 Construction Materials Testing

We recommend that backfill be monitored by an accredited testing laboratory to verify that construction is performed in conformance with project specifications. HVJ Associates routinely provides these services and would be pleased to do so for this project.

11 DESIGN REVIEW

HVJ Associates should be retained to review the final design plans and specifications for this project. During all excavation, grading and construction phases of this project, HVJ should provide the materials testing verification and observation services so our geotechnical recommendations may be interpreted and implemented correctly.

12 LIMITATIONS

This investigation was performed for the exclusive use of Atkins NA, Inc. and the City of Houston for the proposed Martin Luther King Boulevard Reconstruction Project between IH 610S and Bellfort in Houston, Texas. HVJ Associates, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ Associates, Inc. makes no warranty, express or implied. The analyses and recommendations contained in this report are based on data obtained from subsurface exploration, laboratory testing, the project information provided to us and our experience with similar soils and site conditions. The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. Should any subsurface conditions other than those described in our boring logs be encountered, HVJ Associates, Inc. should be immediately notified so that further investigation and supplemental recommendations can be provided.

PLATES

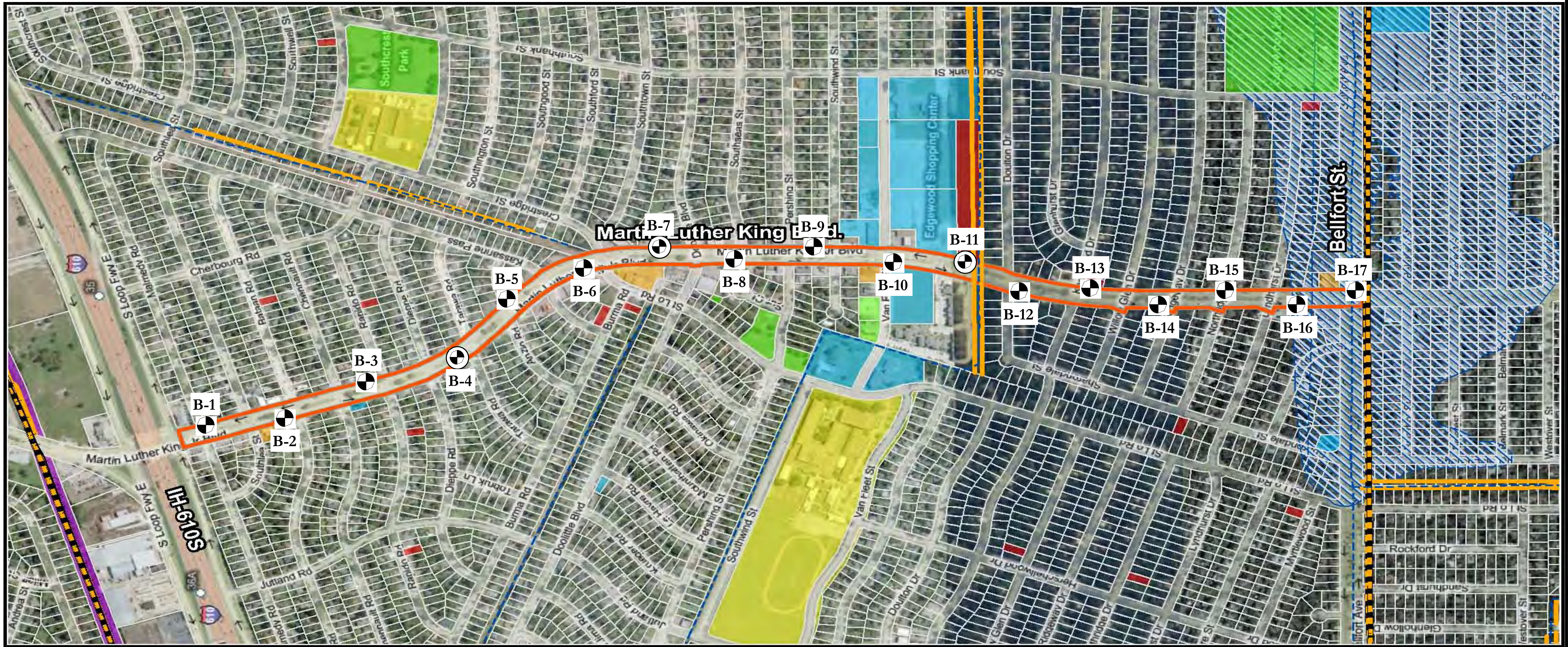
N

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 9/9/11	APPROVED BY: SV	PREPARED BY: NL

SITE VICINITY PLAN
MLK BOULEVARD RECONSTRUCTION:
IH 610 SOUTH TO BELLFORT

PROJECT NO.: HG1018380	DRAWING NO.: PLATE 1



N

Datum: NAD 83
Projection: UTM
Zone: 15
Units: Meters

Legend		
N-000801 Project Corridor	Houston ISD	Utility Easement
HCAD Land Parcels	Harris County Owned Land	Pipeline
Gas Station	City of Houston Owned Land	Ditch
Church	Southern Pacific Railroad Company	Railroad
	FEMA 100 Year Floodplain	

Feet
0 300 600 1,200 1,800

PBSJ

Selection No. N08
Project Location Map
N-000801: Martin Luther King Boulevard
Reconstruction from IH-610S to Bellfort
Park Place Quadrangle
Harris County, Texas

Sheet 4 of 5	Scale: 1" = 600'
Job No.: p100016895	Date: Aug 17, 2010

File:N:\TRANS\p100016895\projects\mxd\B_N000801_RFQE11_08

LEGEND:

APPROXIMATE BORING LOCATIONS

APPROXIMATE PIEZOMETER LOCATIONS

HVJ ASSOCIATES
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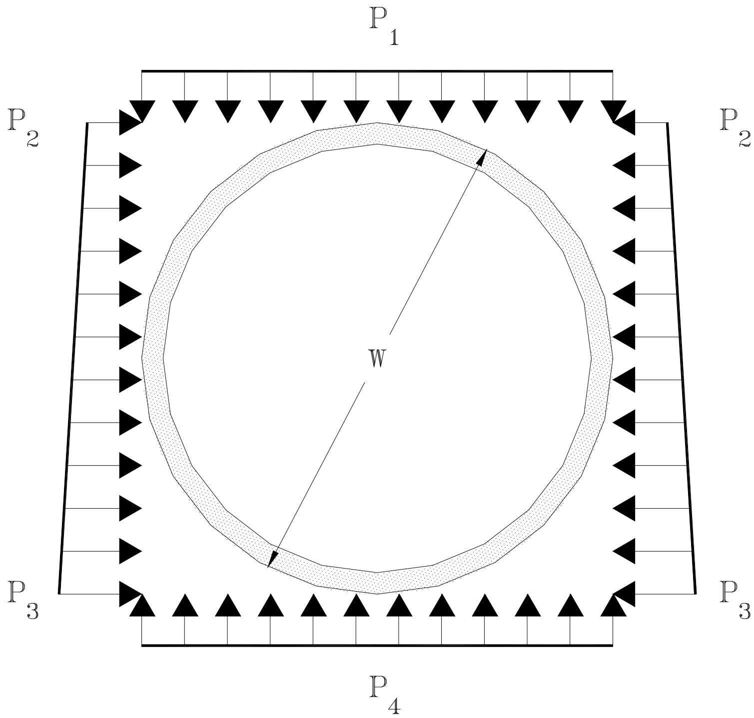
	APPROVED BY:	PREPARED BY:
9/9/2011	SV	NL

PLAN OF BORINGS
MLK BOULEVARD RECONSTRUCTION:
IH 610 SOUTH TO BELLFORT

PROJECT NO.:	DRAWING NO.:
HG1018380	PLATE 2



For

$D_w \le H$

$P_1 = \gamma D_w + (H - D_w)(\gamma - \gamma_w) + P_s + (H - D_w)\gamma_w$

$P_2 = [\gamma D_w + (H - D_w)(\gamma - \gamma_w) + P_s]K_o + (H - D_w)\gamma_w$

$P_3 = [\gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s]K_o + (H + W - D_w)\gamma_w$

$P_4 = \gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s + (H + W - D_w)\gamma_w$

For

$H < D_w < H + W$

$P_1 = H\gamma + P_s$

$P_2 = (\gamma H + P_s)K_o$

$P_3 = [\gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s]K_o + (H + W - D_w)\gamma_w$

$P_4 = \gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s + (H + W - D_w)\gamma_w$

For

$D_w \ge (H + W)$

$P_1 = H\gamma + P_s$

$P_2 = (\gamma H + P_s)K_o$

$P_3 = [(H + W)\gamma + P_s]K_o$

$P_4 = (H + W)\gamma + P_s$

Where

P_1, P_2, P_3 = Pressure imposed on pipe, psf
D_w = Depth of groundwater, feet
H = Depth of top of pipe from ground surface, feet
W = Diameter of pipe, feet
γ = Total Unit weight of soil, pcf
γ_w = Unit weight of water, pcf
P_s = Surcharge load, psf
K_o = Coefficient of earth pressure, (1.0 for clays and 0.5 for sands)

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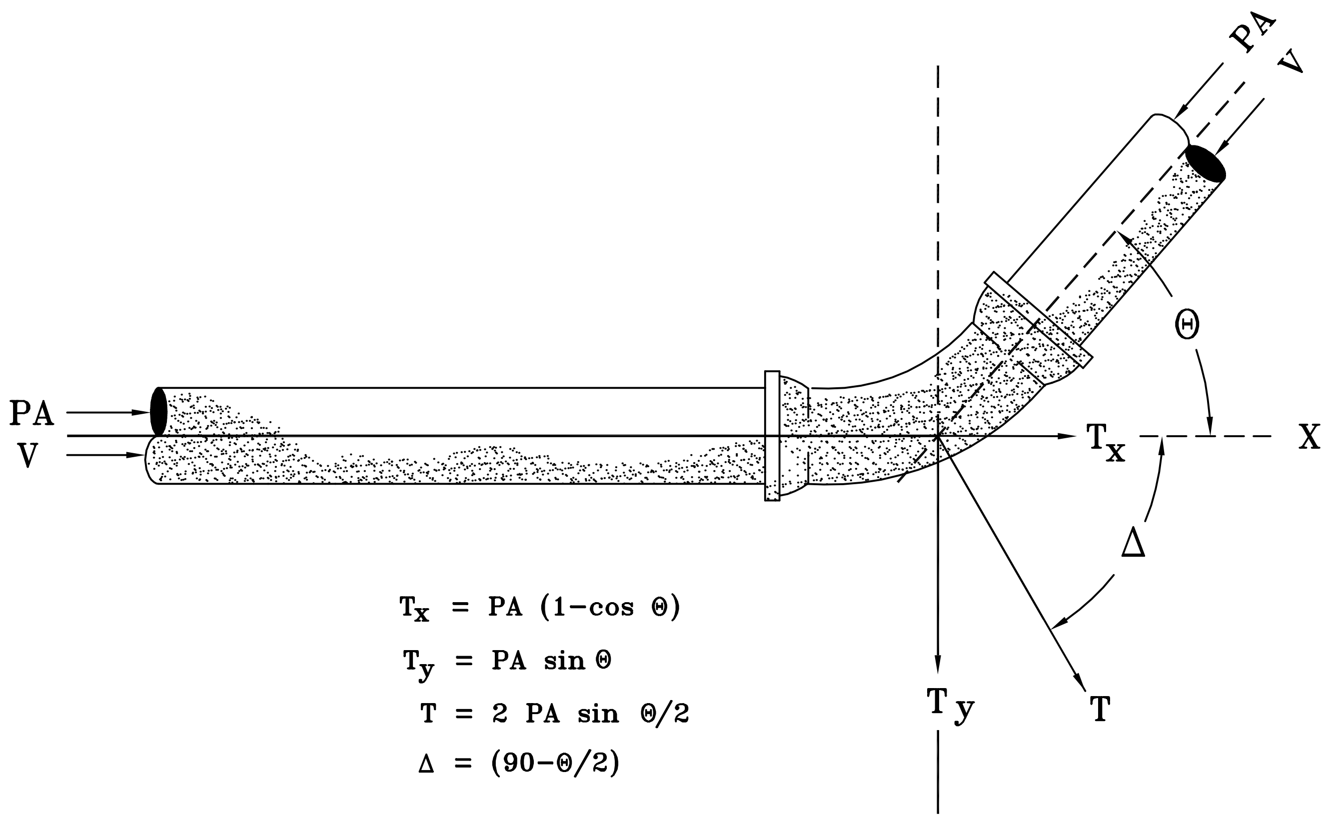
DATE: 9/9/2011	APPROVED BY: SV	PREPARED BY: NL

RIGID PIPE AND TUNNEL LINER LOADS

PROJECT NO.: HG1018380	DRAWING NO.: PLATE 3



$T_x = PA\ (1-\cos\Theta)$

$T_y = PA\ \sin\Theta$

$T = 2\ PA\ \sin\ \Theta/2$

$\Delta = (90-\Theta/2)$

Where:

- T is the resultant force on the bend.
- T_x is the component of thrust force in x-direction.
- T_y is the component of thrust force in y-direction.
- P is the maximum sustained pressure.
- A is the pipe cross-sectional area.
- Θ is the bend deflection angle.
- Δ is the angle between T and X-axis.
- V is the fluid velocity.
- D is the inside diameter of conduit.

Sample Calculation:

Given: P = 150 psi, D = 1.0' = 12" For: $\Theta = 90^\circ$
$A = (\pi D^2)/4 = 113.1\ in^2$

Find: $T = 2\ PA\ \sin\Theta/2 = 2 \times 150 \times 113.1 \times \sin(90^\circ/2)$
= 23,992 lb = 24.0 kips

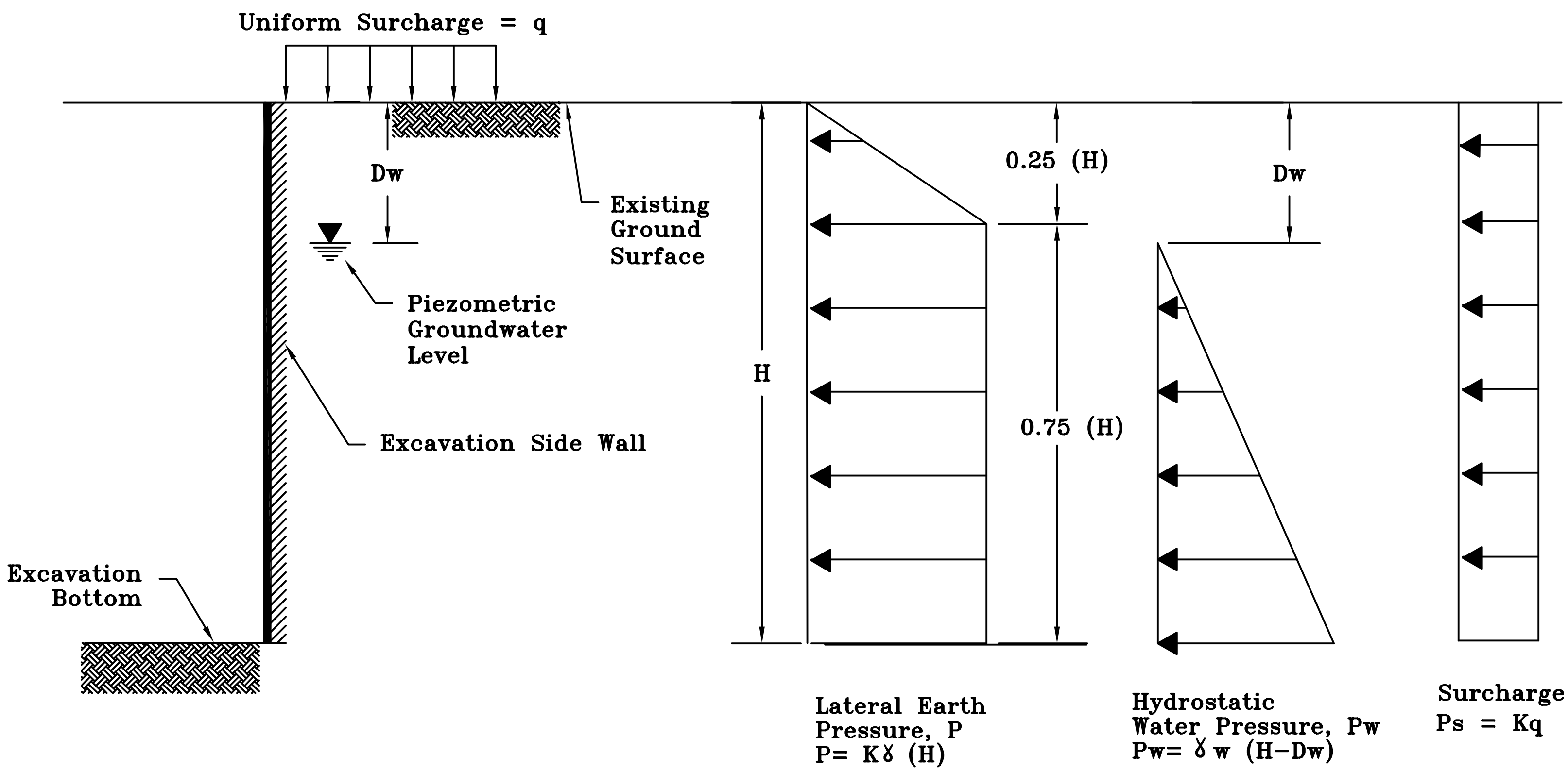
$T_x = PA\ (1-\cos\Theta) = 150 \times 113.1 \times (1-\cos 90^\circ)$
= 16,969 lb = 17.0 kips

$T_y = PA\ \sin\Theta = 150 \times 113.1 \times \sin(90^\circ)$
= 16,969 lb = 17.0 kips

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

THRUST FORCE ACTING ON A BEND

PROJECT NO.: HG1018380
DRAWING NO.: PLATE 4



H, (ft) = Depth to Excavation Bottom

Ps, (psf) = Surcharge loading adjacent to Excavation wall

Dw, (ft) = Depth to groundwater below Existing grade
= Zero for temporary excavation

K = Lateral Earth Pressure coefficient
= Ka "active" for short−term conditions (use 0.50)
= Ko "at rest" for long−term conditions (use 1.0)

γ, (pcf) = Total unit weight above water table or submerged unit weight below groundwater level

γw, (pcf) = Unit weight of water = 62.4 pcf

Note: The pressure diagram shown is not appropriate for design of cantilever walls.

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BRACED EXCAVATION
LATERAL EARTH PRESSURE DIAGRAM (CLAY)

PROJECT NO.: HG1018380

DRAWING NO.: PLATE 5

APPENDIX A

BORING LOGS AND KEY TO TERMS AND SYMBOLS

LOG OF BORING

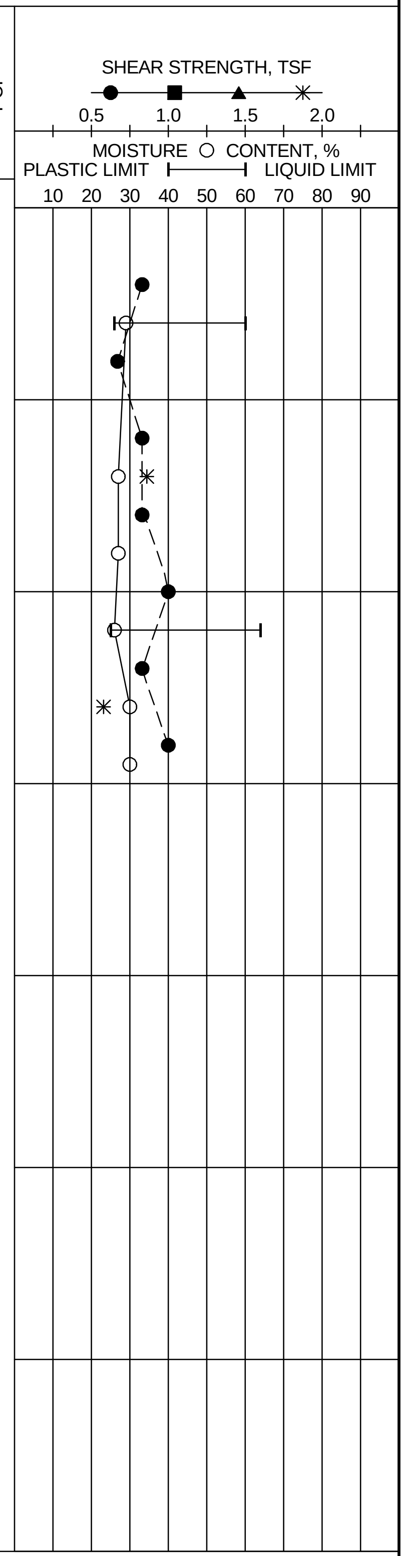
Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3

Boring No.: B-1 | Date: 8/16/2011 | Elevation: 36.39 feet

Groundwater during drilling: --- | Northing: 3,130,583.0 | Station: 175+35.48

Groundwater after 24 hrs: --- | Easting: 13,816,440.0 | Offset: 43.00 RT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 1.5'' Asphalt, 16.5'' Concrete		
		Stiff dark gray and brown FAT CLAY (CH)	95.2	
				97
10		-w/ calcareous nodules 10'-12'		
				86



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

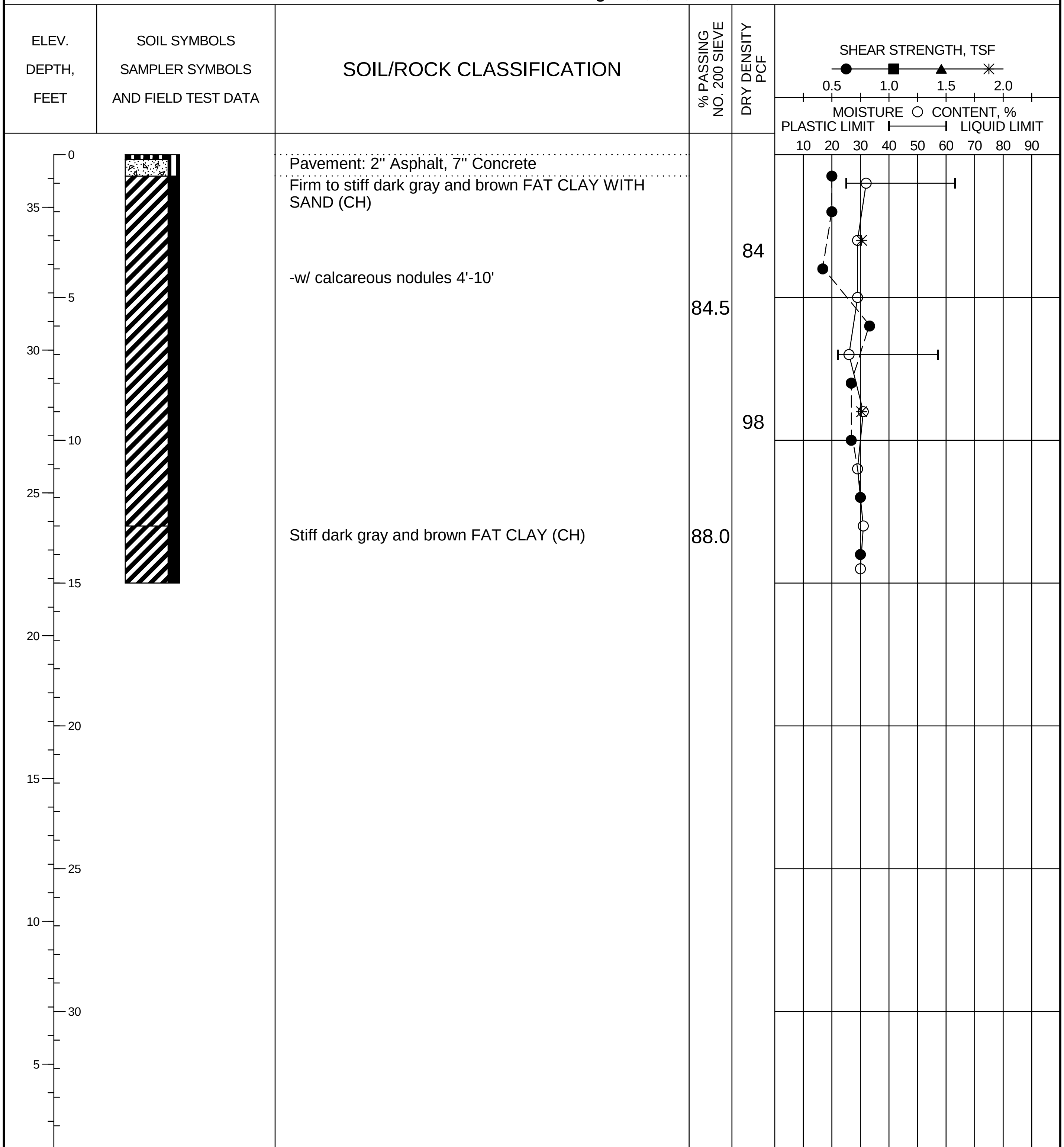
See Plate 2 for boring location.

PLATE A-1

HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-2 | Date: 8/16/2011 | Elevation: 36.84 feet
Groundwater during drilling: --- | Northing: 3,130,663.5 | Station: 170+84.70
Groundwater after 24 hrs: --- | Easting: 13,815,988.6 | Offset: 41.24 LT



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-2

HVJ ASSOCIATES

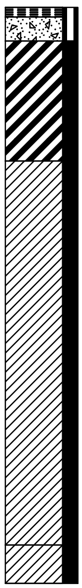
LOG OF BORING

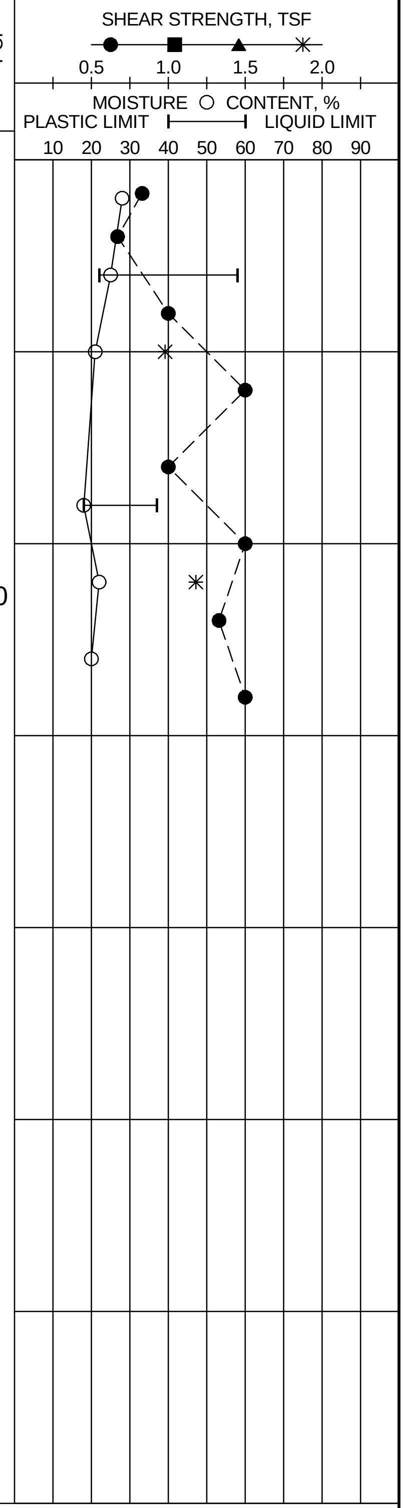
Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-3 | Date: 8/16/2011 | Elevation: 36.91 feet
Groundwater during drilling: --- | Northing: 3,130,884.8 | Station: 166+81.01
Groundwater after 24 hrs: --- | Easting: 13,815,640.6 | Offset: 42.81 RT

ELEV.	DEPTH, FEET	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
	0	Pavement: 3" Asphalt, 7.5" Concrete		
		Stiff dark gray FAT CLAY (CH)		
		Stiff to very stiff reddish brown and gray LEAN CLAY WITH SAND (CL)		97
			83.8	
		-w/ calcareous nodules 8'-14'		
				100
		Very stiff reddish brown LEAN CLAY (CL)	94.5	

Elevation scale: 35, 30, 25, 20, 15, 10, 5
Depth scale: 0, 5, 10, 15, 20, 25, 30, 35

SOIL SYMBOLS, SAMPLER SYMBOLS AND FIELD TEST DATA





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-3

HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3

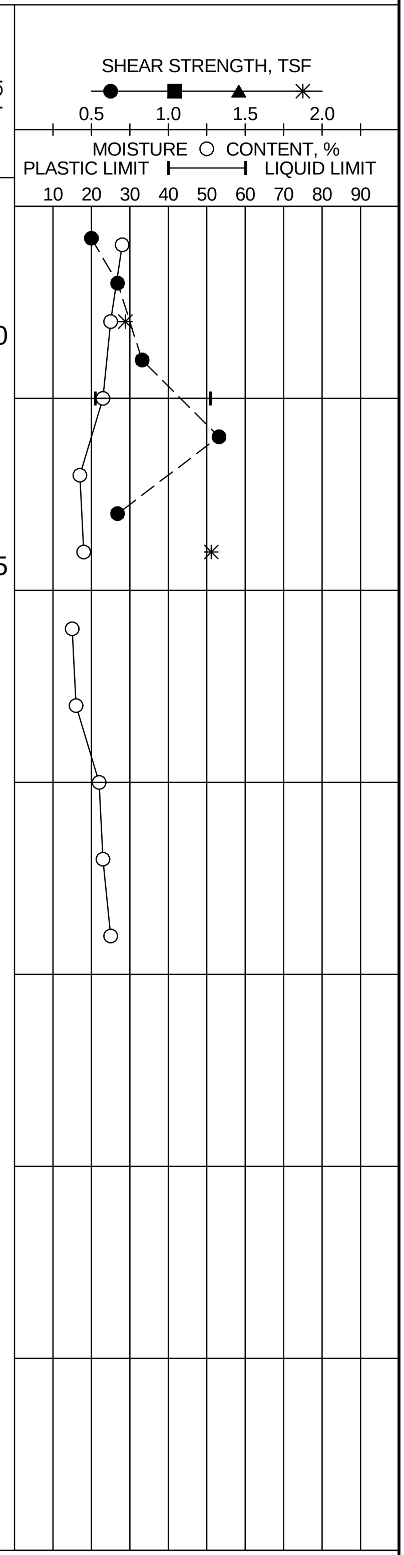
Boring No.: B-4 | Date: 8/16/2011 | Elevation: 37.45 feet

Groundwater during drilling: 16 feet | Northing: 3,130,955.4 | Station: 162+56.67

Groundwater after 24 hrs: --- | Easting: 13,815,213.1 | Offset: 42.31 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2.5" Asphalt, 7.5" Concrete		
		Stiff dark gray FAT CLAY (CH)		100
6		Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)		115
10		Loose to medium dense brown CLAYEY SAND (SC)	23.3	
14	4-3-2			
16	7-9-13		12.6	
18	11-13-10	Medium dense brown SILT WITH SAND (ML)	71.3	

Elevation scale: 35, 30, 25, 20, 15, 10, 5. Depth scale: 0, 5, 10, 15, 20, 25, 30, 35.



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-4

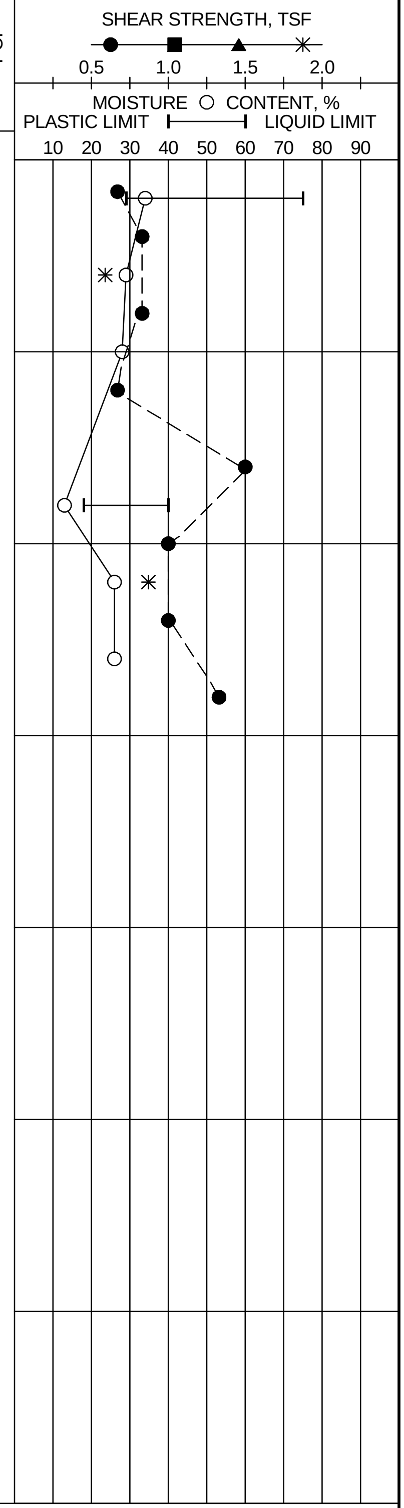
HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-5 | Date: 8/16/2011 | Elevation: 37.42 feet
Groundwater during drilling: --- | Northing: 3,131,265.3 | Station: 157+94.91
Groundwater after 24 hrs: --- | Easting: 13,814,863.8 | Offset: 42.62 RT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2.5" Asphalt, 7.5" Concrete		
		Stiff dark gray and brown FAT CLAY (CH)		86
		Stiff to very stiff brown and gray LEAN CLAY (CL)	85.7	
		-w/ calcareous nodules 8'-10'		
10		Stiff to very stiff brown and gray FAT CLAY (CH) -w/ calcareous nodules 10'-14'		91
15			93.9	

Elevation scale: 35, 30, 25, 20, 15, 10, 5. Depth scale: 0, 5, 10, 15, 20, 25, 30, 35.



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

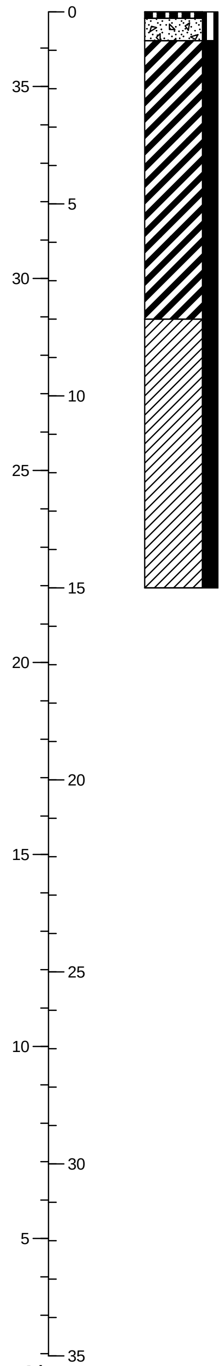
PLATE A-5

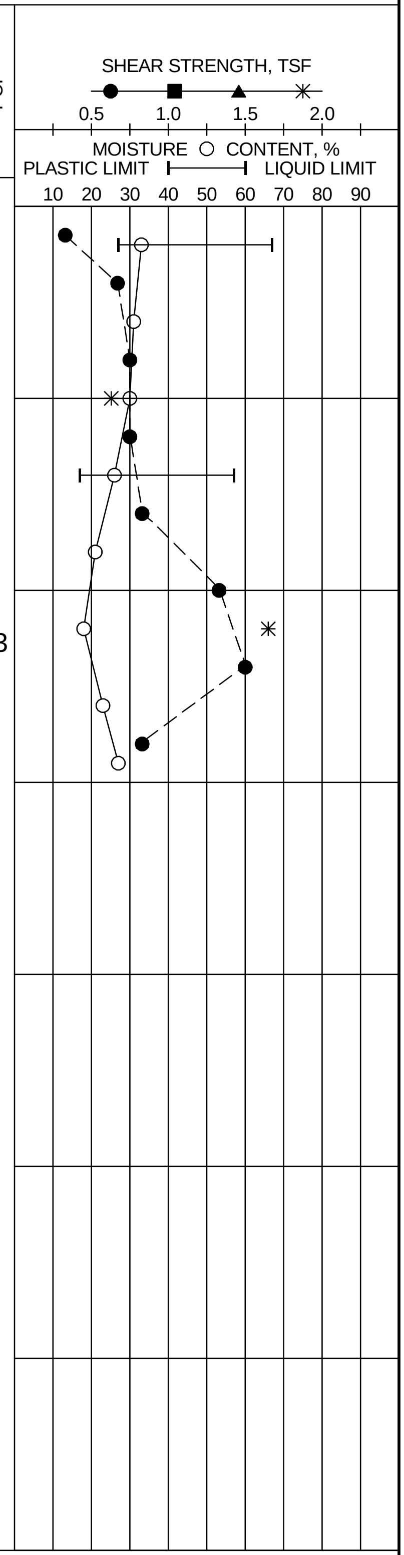
HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-6 | Date: 8/16/2011 | Elevation: 36.94 feet
Groundwater during drilling: --- | Northing: 3,131,536.5 | Station: 153+55.21
Groundwater after 24 hrs: --- | Easting: 13,814,512.6 | Offset: 42.71 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 7" Concrete		
		Firm to stiff dark gray and brown FAT CLAY (CH)		
5				96
8		Stiff to very stiff reddish brown and gray LEAN CLAY (CL) -w/ calcareous nodules 8'-12'		
11.5				113
13.5			95.0	





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-6

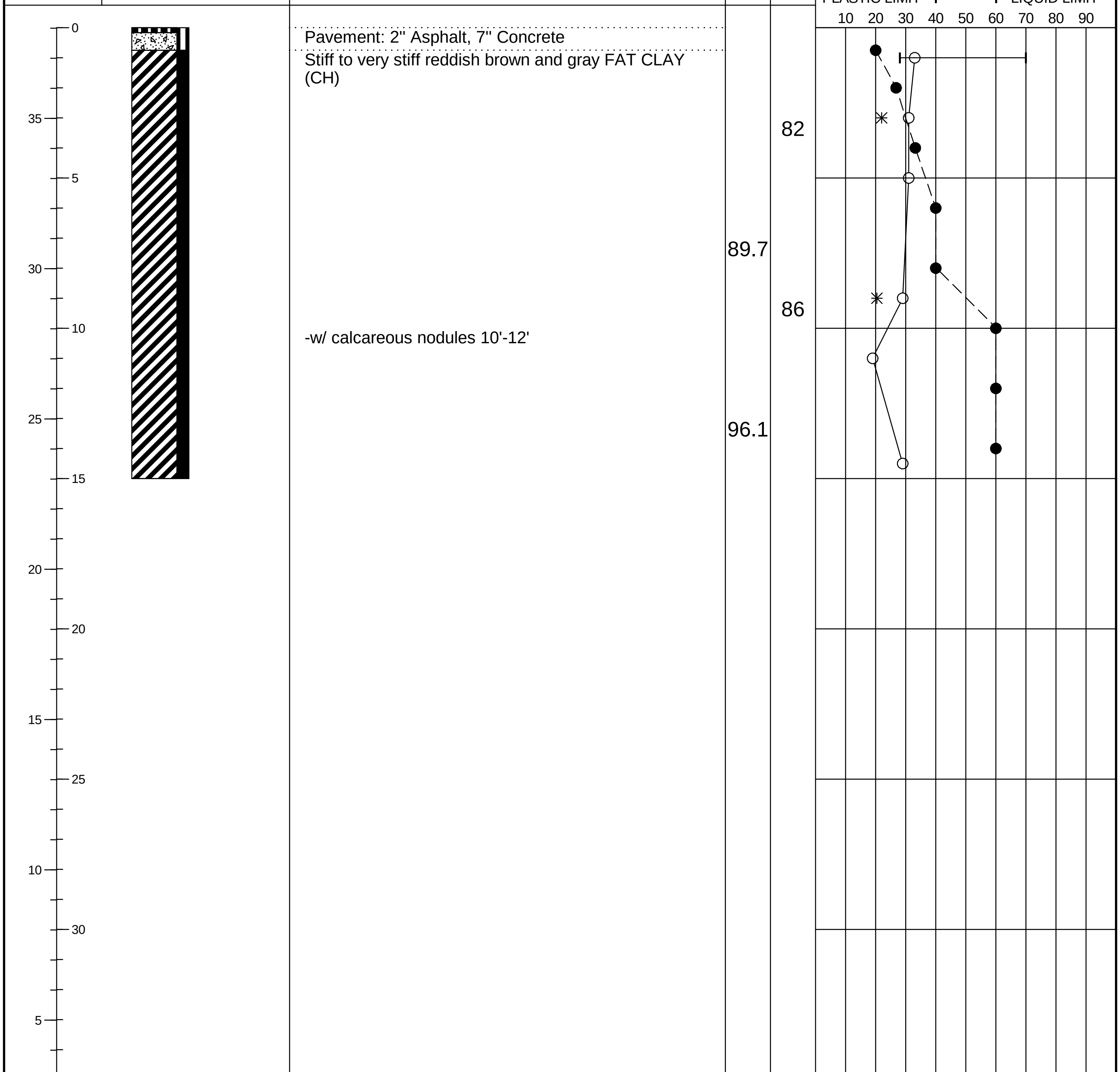
HVJ ASSOCIATES

LOG OF SOIL BORING HG-10-18380.GPJ HVJ.GDT 6/3/13

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-7 | Date: 8/16/2011 | Elevation: 38.02 feet
Groundwater during drilling: --- | Northing: 3,131,899.1 | Station: 148+90.30
Groundwater after 24 hrs: --- | Easting: 13,814,212.9 | Offset: 45.06 RT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF / MOISTURE CONTENT, %
0		Pavement: 2" Asphalt, 7" Concrete			
		Stiff to very stiff reddish brown and gray FAT CLAY (CH)			
				82	
			89.7		
				86	
10		-w/ calcareous nodules 10'-12'			
			96.1		



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-7

HVJ ASSOCIATES

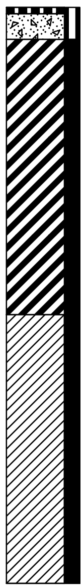
LOG OF SOIL BORING HG-10-18380.GPJ HVJ.GDT 6/3/13

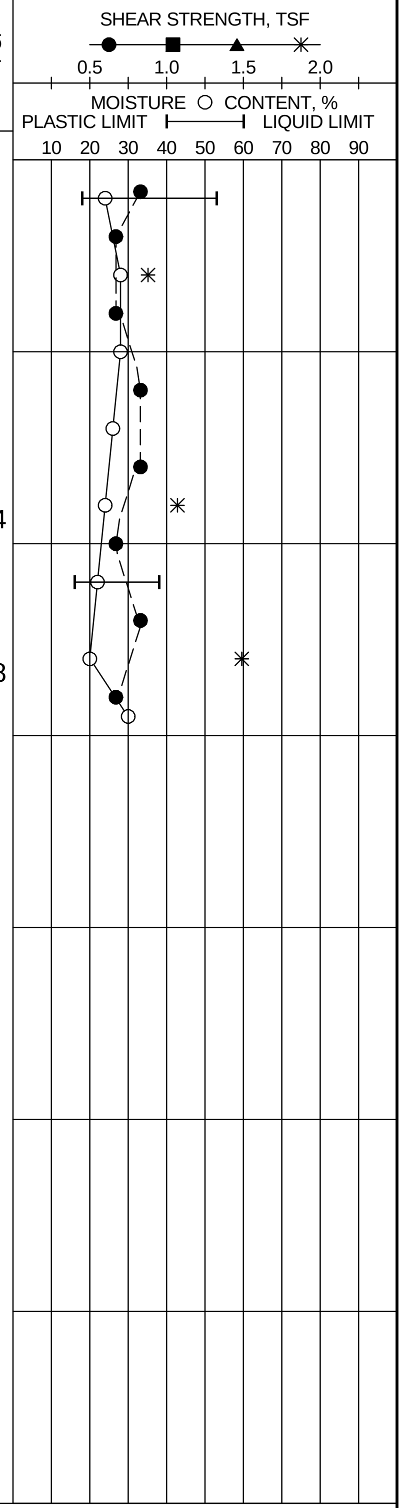
LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort
Project No.: HG1018380
WBS No.: N-000801-0001-3
Boring No.: B-8
Date: 8/16/2011
Elevation: 38.14 feet
Groundwater during drilling: ---
Northing: 3,131,914.7
Station: 144+26.32
Groundwater after 24 hrs: ---
Easting: 13,813,741.1
Offset: 42.39 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 8" Concrete		
		Stiff dark gray and brown FAT CLAY (CH)		87
			94.6	
8		Stiff to very stiff reddish brown and gray LEAN CLAY (CL) -w/ calcareous nodules 8'-14'		104
				108
15			90.8	

Elevation scale: 35, 30, 25, 20, 15, 10, 5; Depth scale: 0, 5, 10, 15, 20, 25, 30, 35





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

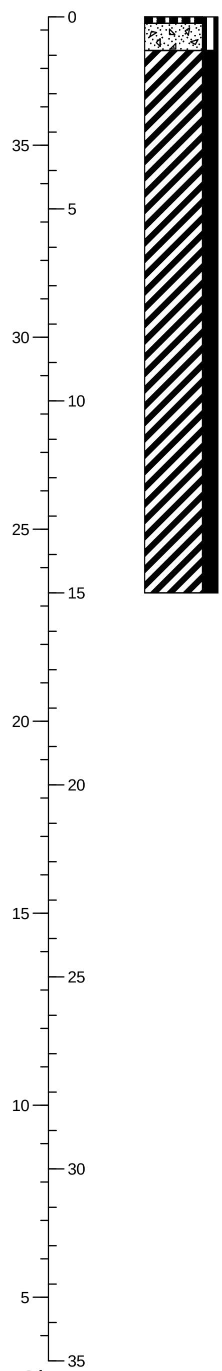
PLATE A-8

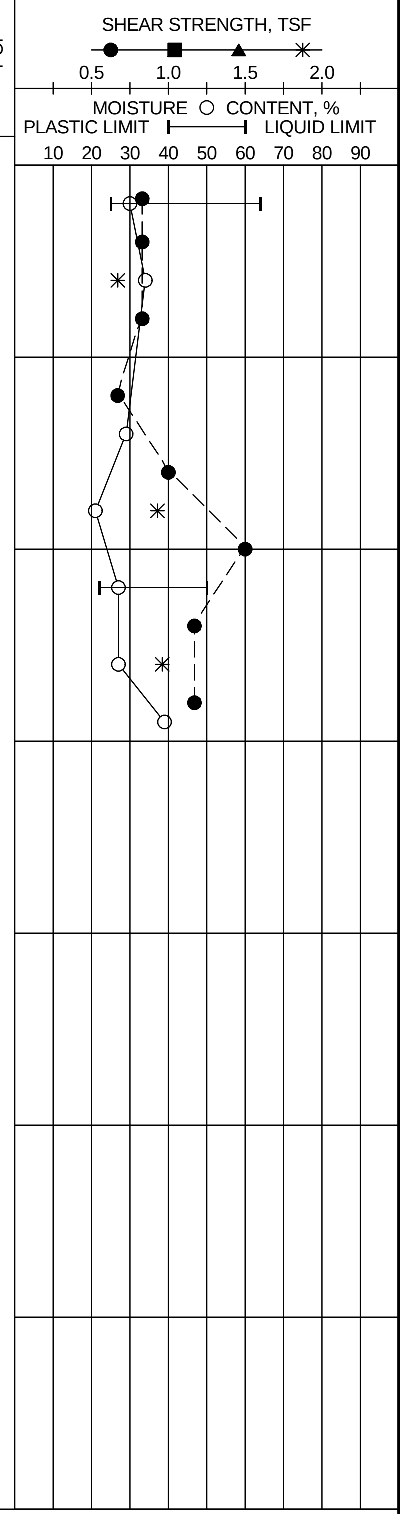
HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-9 | Date: 8/16/2011 | Elevation: 38.34 feet
Groundwater during drilling: --- | Northing: 3,132,023.8 | Station: 139+99.87
Groundwater after 24 hrs: --- | Easting: 13,813,320.3 | Offset: 41.22 RT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 8.5" Concrete		
		Stiff to very stiff dark gray and reddish brown FAT CLAY (CH)		
35				89
5			93.2	
10				99
25				99
15				





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-9

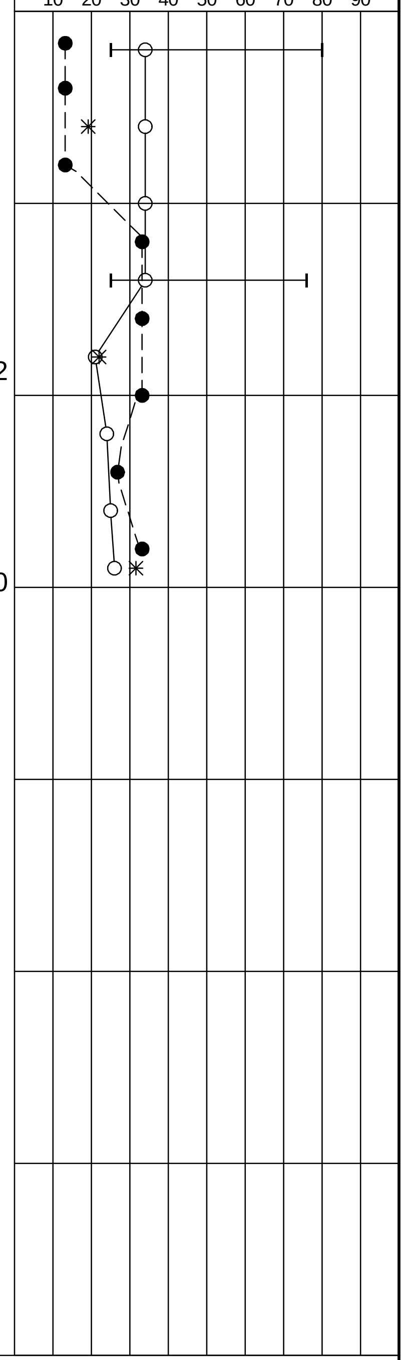
HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-10 | Date: 8/16/2011 | Elevation: 37.98 feet
Groundwater during drilling: --- | Northing: 3,131,966.3 | Station: 135+28.26
Groundwater after 24 hrs: --- | Easting: 13,812,844.7 | Offset: 43.01 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 8" Concrete		
		Firm to stiff dark gray and brown FAT CLAY (CH)		
35				85
5			98.1	
		-w/ calcareous nodules 8'-12'		
30		Stiff brown and gray LEAN CLAY WITH SAND (CL)		
10				102
25			83.3	
15				100
20				
20				
15				
25				
10				
30				
5				
35				

SHEAR STRENGTH, TSF: 0.5 1.0 1.5 2.0
MOISTURE ○ CONTENT, %
PLASTIC LIMIT ├──┤ LIQUID LIMIT
10 20 30 40 50 60 70 80 90



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

HVJ ASSOCIATES

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Phone (281)-933-7388
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LOG OF BORING B-11

DATE: 8/16/11

SURFACE ELEVATION: 37.5 Feet

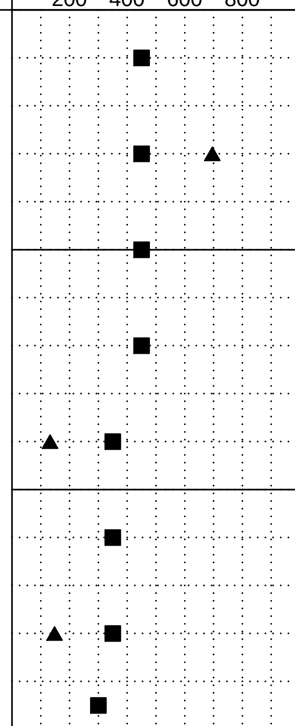
PROJECT: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Houston, Texas WBS No. N-000801-0001-3

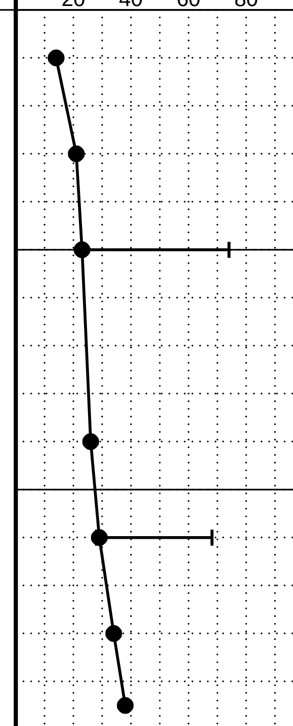
PROJECT NO.: HG1018380 BORING TYPE: FLIGHT AUGER

LOCATION

Northing: 3132072.3404
Easting: 13812441.4504

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	UU SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	Shelby Tube	CH		<u>FAT CLAY WITH SAND (CH)</u>, hard, very high plasticity, reddish brown and gray, moist w/ calcareous nodules at 6'-8'	P=4.5					14					
	Shelby Tube				P=4.5	90	3.48	3.94	3	21					
5	Shelby Tube				P=4.5					23	74	23	51		
	Shelby Tube				P=4.5									83	
	Shelby Tube	CH		<u>FAT CLAY (CH)</u>, stiff to very stiff, high plasticity, reddish brown and gray, moist	P=3.5	90	0.66	8.30	6	26					
10	Shelby Tube		Measured		P=3.5					29	68	28	40		
	Shelby Tube				P=3.5	84	0.74	14.56	9	34					
15	Shelby Tube				P=3.0					38					
				Bottom of boring at 15'											





Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Ground water was not encountered during drilling. 24-hour water level reading was observed at 10 ft.

Sample Key: SPT Shelby Tube Disturbed

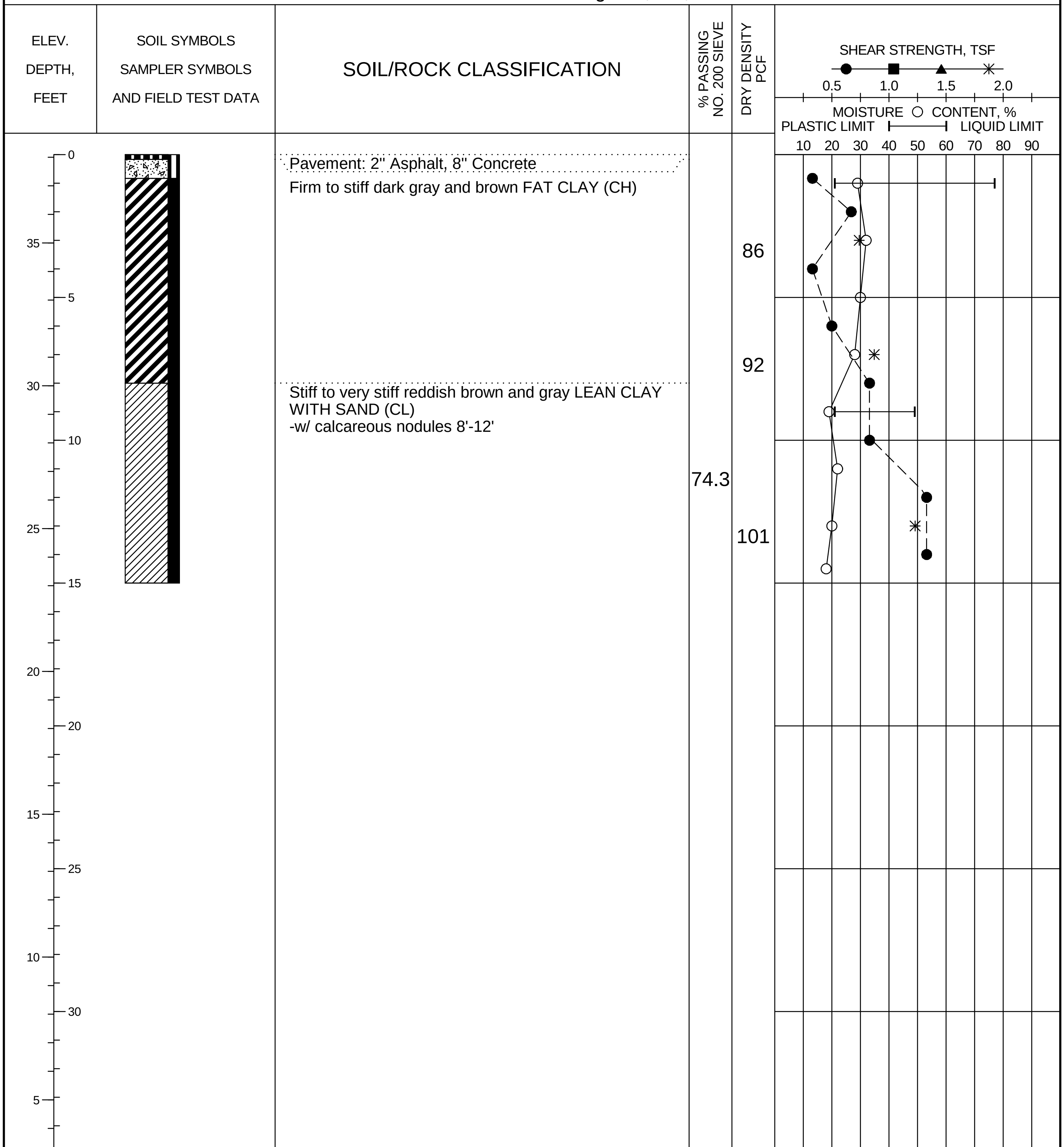
Key to Abbreviations:
- N - SPT Data (Blows/Ft)
- P - Pocket Penetrometer (tsf)
- T - Torvane (psf)
- C_u - Undrained Cohesion (tsf)
- SS - Shear Strength (P/2, tsf)

Notes:

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-12 | Date: 8/16/2011 | Elevation: 38.09 feet
Groundwater during drilling: --- | Northing: 3,131,930.0 | Station: 126+26.13
Groundwater after 24 hrs: --- | Easting: 13,811,960.0 | Offset: 41.12 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 8" Concrete		
		Firm to stiff dark gray and brown FAT CLAY (CH)		86
				92
8		Stiff to very stiff reddish brown and gray LEAN CLAY WITH SAND (CL) -w/ calcareous nodules 8'-12'		
			74.3	
				101



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-12

HVJ ASSOCIATES

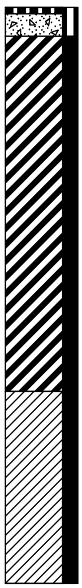
LOG OF SOIL BORING HG-10-18380.GPJ HVJ.GDT 6/3/13

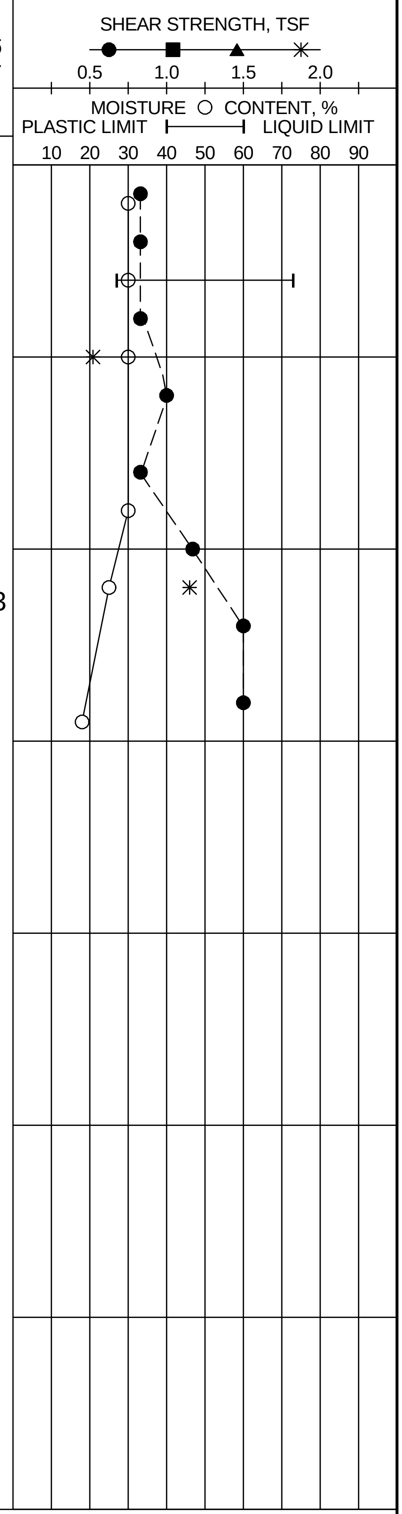
LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-13 | Date: 8/16/2011 | Elevation: 38.07 feet
Groundwater during drilling: --- | Northing: 3,131,889.0 | Station: 121+71.11
Groundwater after 24 hrs: --- | Easting: 13,811,503.6 | Offset: 41.06 RT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 7" Concrete		
		Stiff dark gray and brown FAT CLAY WITH SAND (CH)		
		-w/ calcareous nodules 4'-10'		
5				94
			81.2	
10		Very stiff reddish brown LEAN CLAY (CL)		
				103
			89.6	

Elevation scale: 35, 30, 25, 20, 15, 10, 5; Depth scale: 0, 5, 10, 15, 20, 25, 30, 35





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

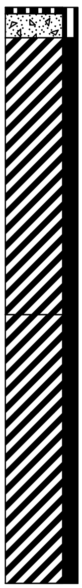
See Plate 2 for boring location.

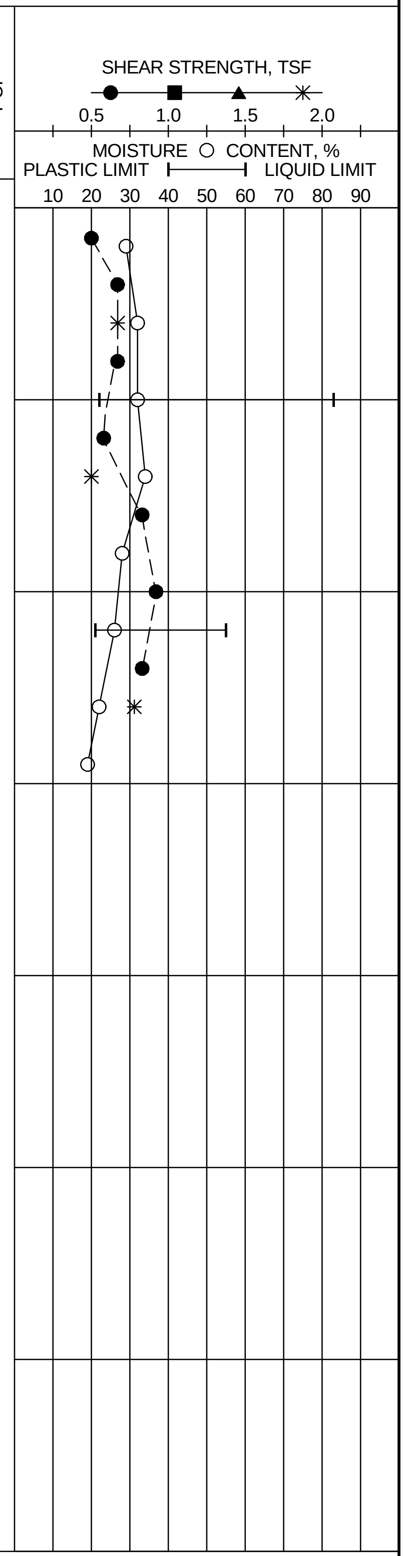
PLATE A-13

HVJ ASSOCIATES

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort Project No.: HG1018380 WBS No.: N-000801-0001-3
Boring No.: B-14 Date: 8/16/2011 Elevation: 37.66 feet
Groundwater during drilling: --- Northing: 3,131,758.0 Station: 117+27.71
Groundwater after 24 hrs: --- Easting: 13,811,072.6 Offset: 42.01 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 7.5" Concrete		
		Stiff dark gray and brown FAT CLAY (CH)	86.2	
35				89
		-w/ calcareous nodules 4'-12'		
5				
30				87
		Stiff dark gray and brown FAT CLAY WITH SAND (CH)	78.7	
10				
25				93
15				
20				
20				
15				
25				
10				
30				
5				
35				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-14

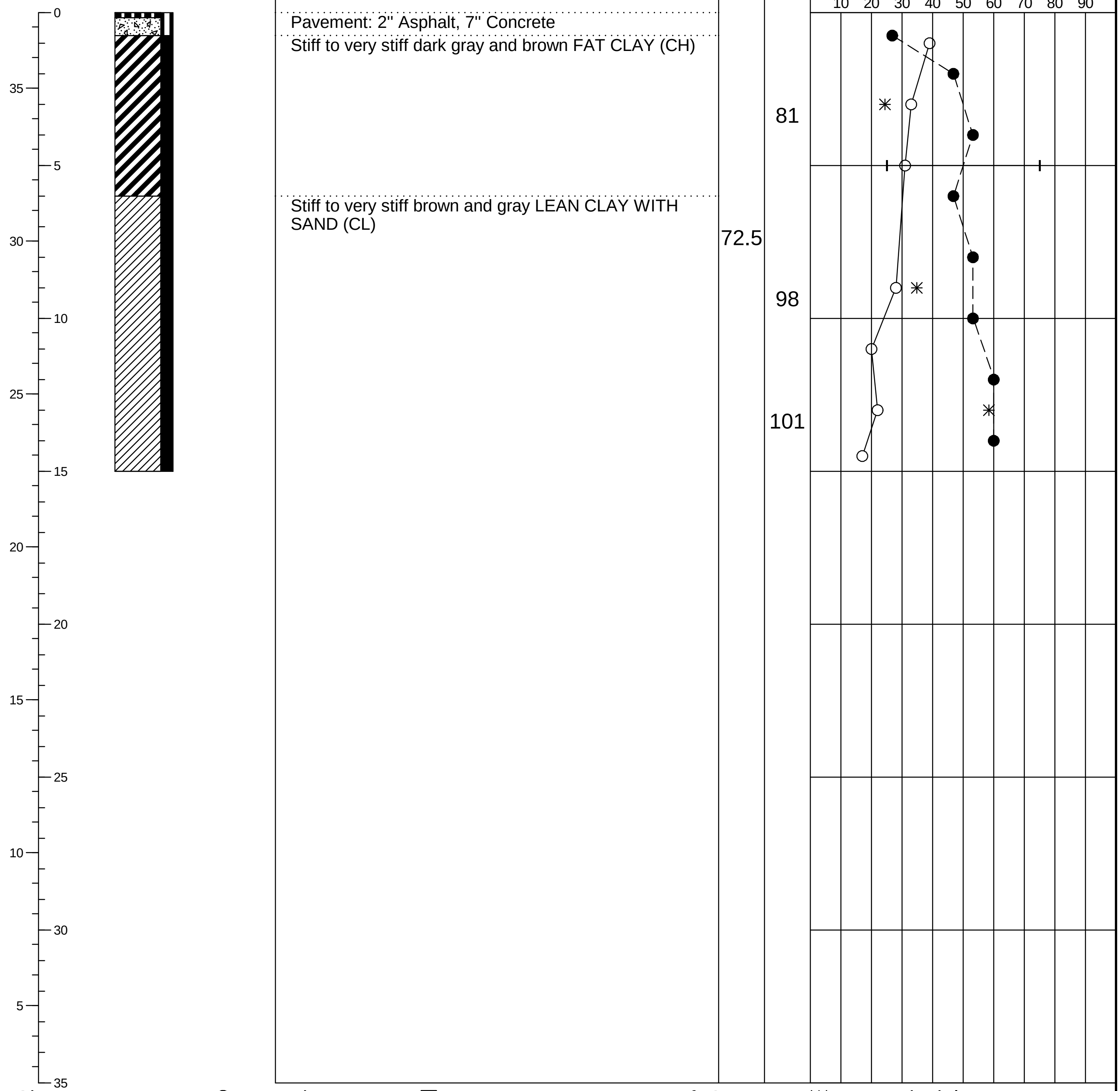
HVJ ASSOCIATES

LOG OF SOIL BORING HG-10-18380.GPJ HVJ.GDT 6/3/13

LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort Project No.: HG1018380 WBS No.: N-000801-0001-3
Boring No.: B-15 Date: 8/16/2011 Elevation: 37.47 feet
Groundwater during drilling: --- Northing: 3,131,862.1 Station: 112+74.38
Groundwater after 24 hrs: --- Easting: 13,810,621.5 Offset: 42.64 RT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF / MOISTURE CONTENT, %
0		Pavement: 2" Asphalt, 7" Concrete			
		Stiff to very stiff dark gray and brown FAT CLAY (CH)		81	
6		Stiff to very stiff brown and gray LEAN CLAY WITH SAND (CL)	72.5	98	
				101	



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-15

HVJ ASSOCIATES

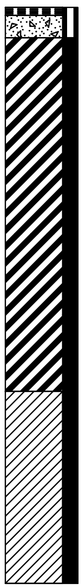
LOG OF SOIL BORING HG-10-18380.GPJ HVJ.GDT 6/3/13

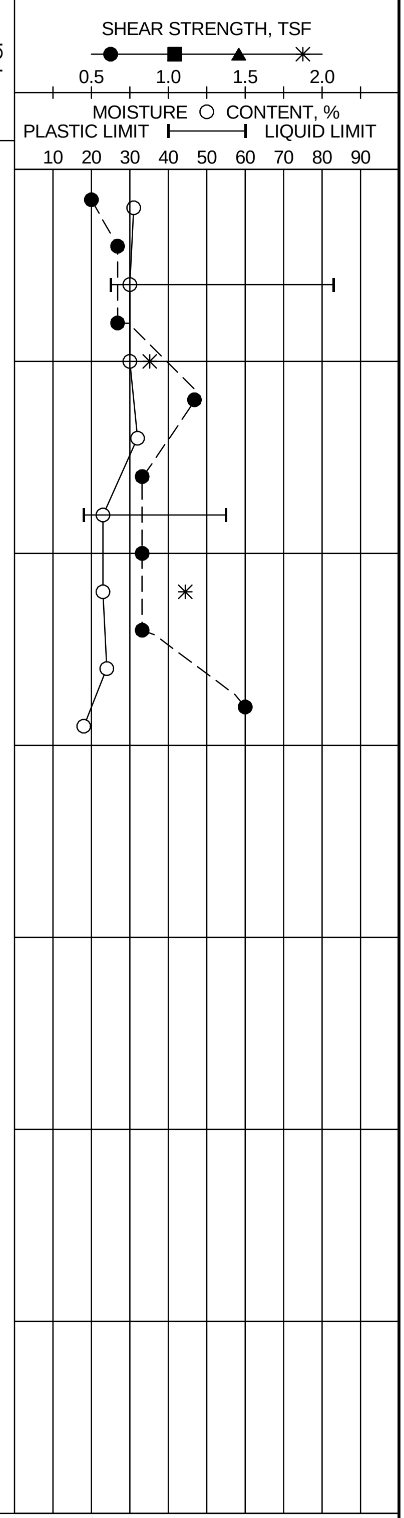
LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3
Boring No.: B-16 | Date: 8/16/2011 | Elevation: 37.7 feet
Groundwater during drilling: --- | Northing: 3,131,802.4 | Station: 108+34.72
Groundwater after 24 hrs: --- | Easting: 13,810,177.7 | Offset: 42.59 LT

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2.5" Asphalt, 7" Concrete		
		Stiff to very stiff dark gray and brown FAT CLAY WITH SAND (CH)		
				83
		-w/ calcareous nodules 6'-8'	79.5	
10		Stiff to very stiff brown and gray LEAN CLAY WITH SAND (CL)		94
			71.0	

Elevation scale: 35, 30, 25, 20, 15, 10, 5. Depth scale: 0, 5, 10, 15, 20, 25, 30, 35.





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

PLATE A-16

HVJ ASSOCIATES

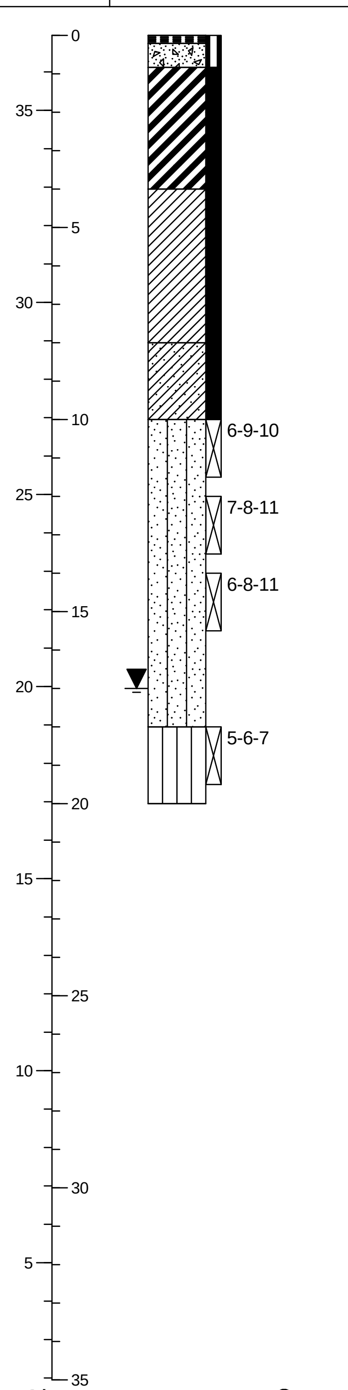
LOG OF BORING

Project: MLK BLVD Reconstruction: IH610S to Bellfort | Project No.: HG1018380 | WBS No.: N-000801-0001-3

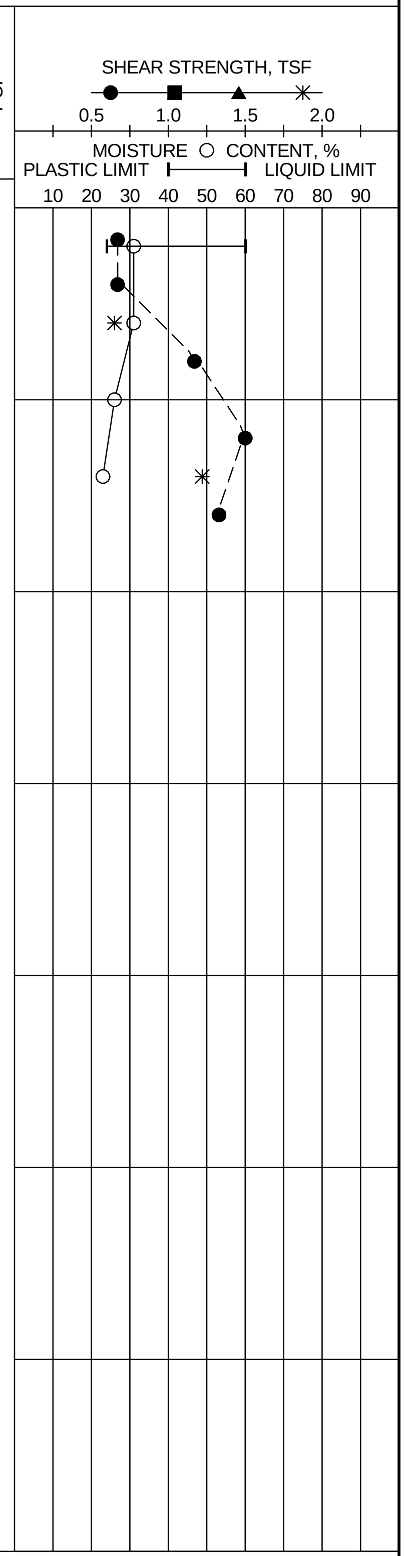
Boring No.: B-17 | Date: 8/16/2011 | Elevation: 36.95 feet

Groundwater during drilling: 17 feet | Northing: 3,131,913.1 | Station: 103.82.61

Groundwater after 24 hrs: --- | Easting: 13,809,731.2 | Offset: 42.02 RT



Field Test Data	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
	Pavement: 2.5" Asphalt, 7.5" Concrete		
	Stiff gray FAT CLAY (CH)		94
	Very stiff brown and gray LEAN CLAY (CL)		97
	Very stiff reddish brown SANDY LEAN CLAY (CL)	57.6	
6-9-10	Medium dense light brown SILTY SAND (SM)	12.5	
7-8-11			
6-8-11		26.7	
5-6-7	Medium dense reddish brown SILT (ML)	90.6	



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

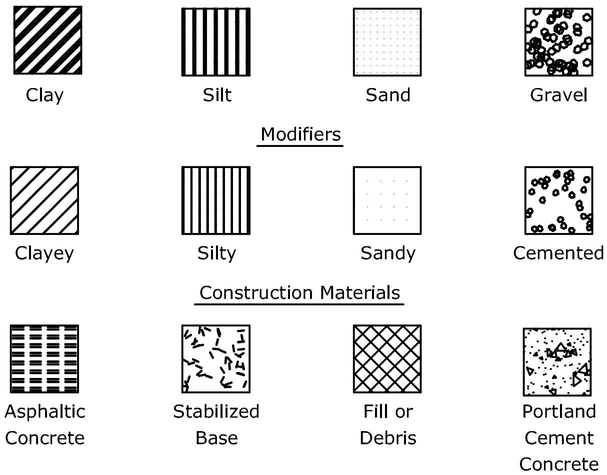
See Plate 2 for boring location.

PLATE A-17

HVJ ASSOCIATES

SOIL SYMBOLS

Soil Types



SAMPLER TYPES

- Thin Walled Shelby Tube
- No Recovery
- Split Barrel
- Core
- Liner Tube
- Jar Sample

WATER LEVEL SYMBOLS

- Groundwater level after drilling in open borehole or piezometer
- Groundwater level determined during drilling operations

SOIL GRAIN SIZE

Classification	Particle Size	Particle Size or Sieve No. (U.S. Standard)
Clay	< 0.002 mm	< 0.002 mm
Silt	0.002 - 0.075 mm	0.002 mm - #200 sieve
Sand	0.075 - 4.75 mm	#200 sieve - #4 sieve
Gravel	4.75 - 75 mm	#4 sieve - 3 in.
Cobble	75 - 200 mm	3 in. - 8 in.
Boulder	> 200 mm	> 8 in.

DENSITY OF COHESIONLESS SOILS

Descriptive Term	Penetration Resistance "N" * Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

CONSISTENCY OF COHESIVE SOILS

Consistency	Undrained Shear Strength (tsf)	Penetration Resistance "N" * Blows/Foot
Very Soft	0 - 0.125	0 - 2
Soft	0.125 - 0.25	2 - 4
Firm	0.25 - 0.5	4 - 8
Stiff	0.5 - 1.0	8 - 16
Very Stiff	1.0 - 2.0	16 - 32
Hard	> 2.0	> 32

PENETRATION RESISTANCE

3/6	Blows required to penetrate each of three consecutive 6-inch increments per ASTM D-1586 *
50/4"	If more than 50 blows are required, driving is discontinued and penetration at 50 blows is noted
0/18"	Sampler penetrated full depth under weight of drill rods and hammer

* The N value is taken as the blows required to penetrate the final 12 inches

TERMS DESCRIBING SOIL STRUCTURE

Slickensided	Fracture planes appear polished or glossy, sometimes striated
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Inclusion	Small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Parting	Inclusion less than 1/4 inch thick extending through the sample
Seam	Inclusion 1/4 inch to 3 inches thick extending through the sample
Layer	Inclusion greater than 3 inches thick extending through the sample
Laminated	Soil sample composed of alternating partings of different soil type
Stratified	Soil sample composed of alternating seams or layers of different soil type
Intermixed	Soil sample composed of pockets of different soil type and laminated or stratified structure is not evident
Calcareous	Having appreciable quantities of calcium carbonate
Ferrous	Having appreciable quantities of iron
Nodule	A small mass of irregular shape

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KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

PROJECT NO.:	DRAWING NO.:
HG1018380	PLATE A-18

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-1	2								0.83
B-1	3	60	26	34	95	29.3			
B-1	4								0.67
B-1	6								0.83
B-1	7					27	123.2	0.86	
B-1	8								0.83
B-1	9					26.8			
B-1	10								1
B-1	11	64	25	39		26.3			
B-1	12								0.83
B-1	13					29.6	111.9	0.58	
B-1	14								1
B-1	14.5					30			
B-2	0.8								0.5
B-2	1	63	25	38		32.4			
B-2	2								0.5
B-2	3					29.5	109.1	0.76	
B-2	4								0.42
B-2	5				85	29.2			
B-2	6								0.83
B-2	7	57	22	35		25.7			
B-2	8								0.67
B-2	9					31.4	129	0.76	
B-2	10								0.67
B-2	11					28.5			
B-2	12								0.75
B-2	13				88	30.5			
B-2	14								0.75
B-2	14.5					30.4			
B-3	0.9								0.83
B-3	1					27.8			
B-3	2								0.67
B-3	3	58	22	36		25.2			
B-3	4								1
B-3	5					20.5	116.8	0.98	
B-3	6								1.5
B-3	7				84				
B-3	8								1
B-3	9	37	18	19		18.3			
B-3	10								1.5
B-3	11					21.5	121.9	1.18	

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-3	12								1.33
B-3	13					20.5			
B-3	14								1.5
B-3	14.5				95				
B-4	0.8								0.5
B-4	1					27.9			
B-4	2								0.67
B-4	3					24.9	125.3	0.72	
B-4	4								0.83
B-4	5	51	21	30		23.3			
B-4	6								1.33
B-4	7					17.4			
B-4	8								0.67
B-4	9					18	135.4	1.28	
B-4	11				23	15.1			
B-4	13					16.2			
B-4	15				13	21.8			
B-4	17					22.8			
B-4	19				71	25.4			
B-5	0.8								0.67
B-5	1	75	29	46		34.3			
B-5	2								0.83
B-5	3					28.5	110.3	0.59	
B-5	4								0.83
B-5	5					27.7			
B-5	6								0.67
B-5	7				86				
B-5	8								1.5
B-5	9	40	18	22		13			
B-5	10								1
B-5	11					26.1	115.3	0.87	
B-5	12								1
B-5	13					26.1			
B-5	14								1.33
B-5	14.5				94				
B-6	0.8								0.33
B-6	1	67	27	40		32.8			
B-6	2								0.67
B-6	3					31.2			
B-6	4								0.75
B-6	5					29.8	124.7	0.63	

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-6	6								0.75
B-6	7	57	17	40		26.5			
B-6	8								0.83
B-6	9					20.7			
B-6	10								1.33
B-6	11					18	133.9	1.65	
B-6	12								1.5
B-6	13				95	22.8			
B-6	14								0.83
B-6	14.5					27.4			
B-7	0.8								0.5
B-7	1	70	28	42		33			
B-7	2								0.67
B-7	3					31.3	107.9	0.55	
B-7	4								0.83
B-7	5					31.1			
B-7	6								1
B-7	7				90				
B-7	8								1
B-7	9					28.9	111.4	0.51	
B-7	10								1.5
B-7	11					18.9			
B-7	12								1.5
B-7	13				96				
B-7	14								1.5
B-7	14.5					28.8			
B-8	0.8								0.83
B-8	1	53	18	35		24.3			
B-8	2								0.67
B-8	3					27.8	111	0.88	
B-8	4								0.67
B-8	5				95	27.9			
B-8	6								0.83
B-8	7					26.2			
B-8	8								0.83
B-8	9					24.3	129.3	1.07	
B-8	10								0.67
B-8	11	38	16	22		21.8			
B-8	12								0.83
B-8	13					19.8	129.6	1.49	
B-8	14								0.67

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-8	14.5				91	29.7			
B-9	0.9								0.83
B-9	1	64	25	39		30.4			
B-9	2								0.83
B-9	3					34.1	119.5	0.67	
B-9	4								0.83
B-9	5				93				
B-9	6								0.67
B-9	7					28.6			
B-9	8								1
B-9	9					20.7	120.1	0.93	
B-9	10								1.5
B-9	11	50	22	28		26.6			
B-9	12								1.17
B-9	13					27.1	125.3	0.96	
B-9	14								1.17
B-9	14.5					38.6			
B-10	0.8								0.33
B-10	1	80	25	55		33.7			
B-10	2								0.33
B-10	3					34.1	113.7	0.48	
B-10	4								0.33
B-10	5				98	33.7			
B-10	6								0.83
B-10	7	76	25	51		33.6			
B-10	8								0.83
B-10	9					21.4	123.9	0.55	
B-10	10								0.83
B-10	11					24.4			
B-10	12								0.67
B-10	13				83	25.1			
B-10	14								0.83
B-10	14.5					25.8	125.5	0.79	
B-11	0.9								1.5
B-11	1					13.6			
B-11	2								1.5
B-11	3					21	109.3	3.48	
B-11	4								1.5
B-11	5	74	23	51		22.6			
B-11	6								1.5
B-11	7				83				

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-11	8								1.17
B-11	9					26.1	114	0.66	
B-11	10								1.17
B-11	11	68	28	40		29.2			
B-11	12								1.17
B-11	13					33.5	111.5	0.74	
B-11	14								1
B-11	14.5					37.7			
B-12	0.8								0.33
B-12	1	77	21	56		29.3			
B-12	2								0.67
B-12	3					31.5	112.7	0.74	
B-12	4								0.33
B-12	5					30.1			
B-12	6								0.5
B-12	7					27.9	117.8	0.87	
B-12	8								0.83
B-12	9	49	21	28		19.1			
B-12	10								0.83
B-12	11				74	21.6			
B-12	12								1.33
B-12	13					19.9	120.9	1.23	
B-12	14								1.33
B-12	14.5					18.4			
B-13	0.8								0.83
B-13	1					30.1			
B-13	2								0.83
B-13	3	73	27	46		29.8			
B-13	4								0.83
B-13	5					29.7	122.3	0.52	
B-13	6								1
B-13	7				81				
B-13	8								0.83
B-13	9					29.6			
B-13	10								1.17
B-13	11					24.8	128.5	1.15	
B-13	12								1.5
B-13	13				90				
B-13	14								1.5
B-13	14.5					17.8			
B-14	0.8								0.5

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

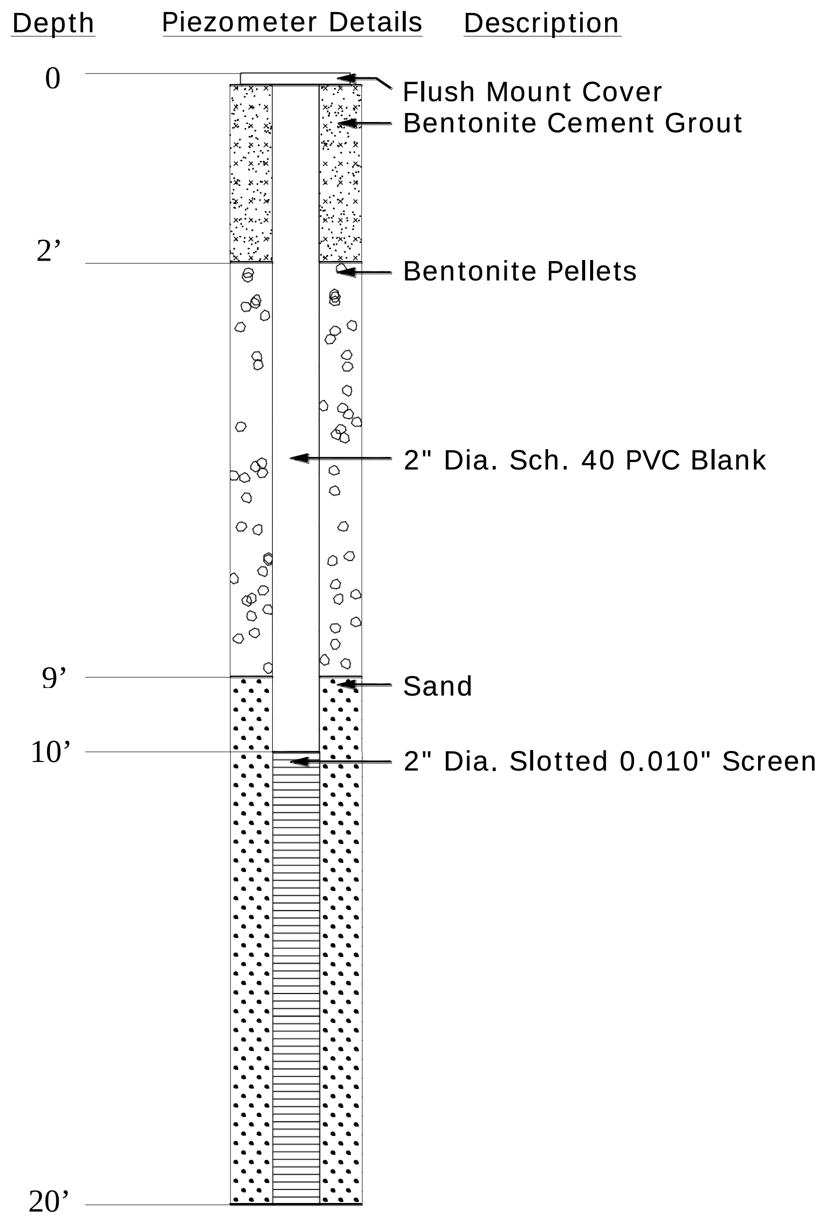
Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-14	1				86	29.4			
B-14	2								0.67
B-14	3					32.1	117.2	0.67	
B-14	4								0.67
B-14	5	83	22	61		31.6			
B-14	6								0.58
B-14	7					34.1	116.4	0.5	
B-14	8								0.83
B-14	9				79	27.8			
B-14	10								0.92
B-14	11	55	21	34		25.7			
B-14	12								0.83
B-14	13					21.5	113.1	0.78	
B-14	14.5					19.4			
B-15	0.8								0.67
B-15	1					39.1			
B-15	2								1.17
B-15	3					32.8	106.9	0.61	
B-15	4								1.33
B-15	5	75	25	50		30.9			
B-15	6								1.17
B-15	7				73				
B-15	8								1.33
B-15	9					28.2	125.7	0.87	
B-15	10								1.33
B-15	11					20.2			
B-15	12								1.5
B-15	13					21.9	123.1	1.46	
B-15	14								1.5
B-15	14.5					16.5			
B-16	0.8								0.5
B-16	1					31.2			
B-16	2								0.67
B-16	3	83	25	58		29.6			
B-16	4								0.67
B-16	5					30.4	108	0.88	
B-16	6								1.17
B-16	7				80	31.7			
B-16	8								0.83
B-16	9	55	18	37		23.4			
B-16	10								0.83

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort
Location: Houston, Texas
Number: HG1018380

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-16	11					22.9	116.1	1.11	
B-16	12								0.83
B-16	13				71	23.7			
B-16	14								1.5
B-16	14.5					17.6			
B-17	0.8								0.67
B-17	1	60	24	36		31.1			
B-17	2								0.67
B-17	3					30.9	123	0.65	
B-17	4								1.17
B-17	5					26.1			
B-17	6								1.5
B-17	7					22.9	119.2	1.22	
B-17	8								1.33
B-17	9				58				
B-17	11				13				
B-17	14.5				27				
B-17	19				91				
Total		**29**	**29**	**29**	**31**	**121**	**41**	**41**	**128**

APPENDIX C

PIEZOMETER INSTALLATION RECORDS



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
8/17/11	8.0	29.45
9/15/11	12.5	24.95

NOTES:

- Piezometer was installed on 8/16/11. Diameter of Piezometer is 2 inches.
- See Plate 2 for boring location; see Plate A-4 for boring log.

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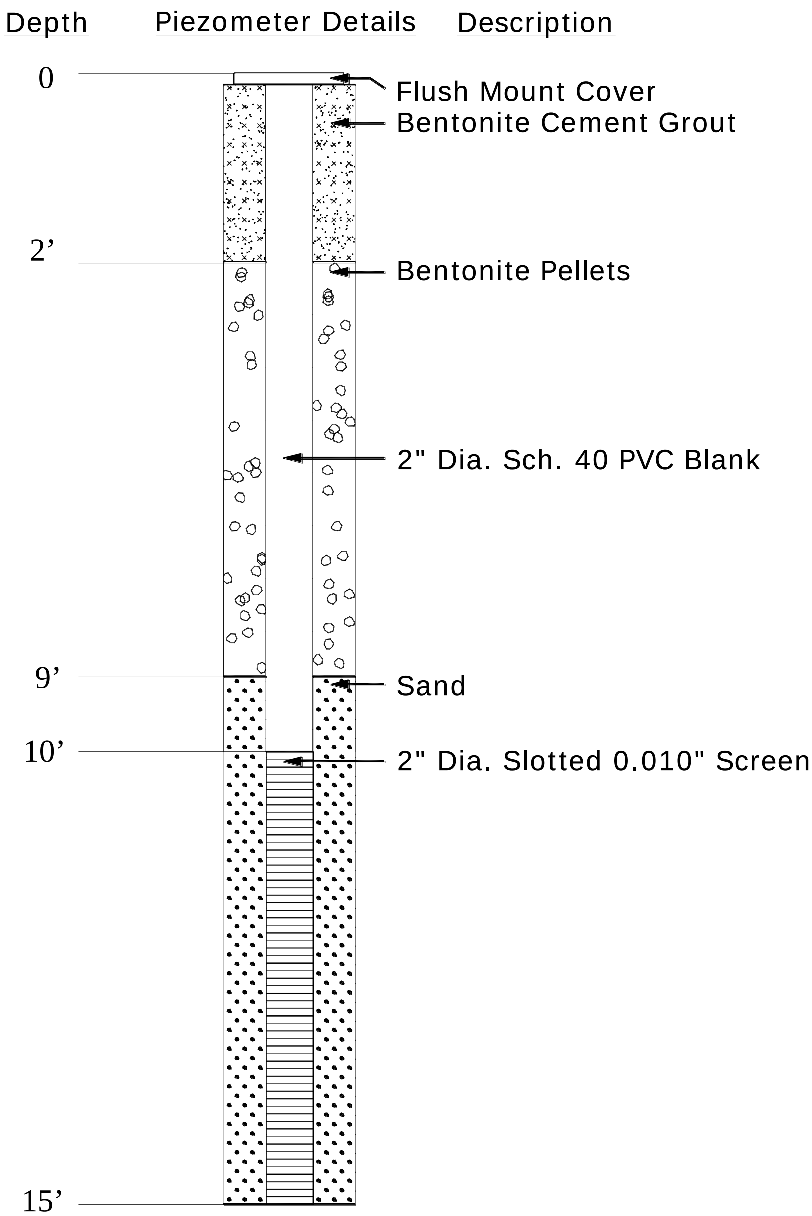
PIEZOMETER INSTALLATION REPORT
PIEZOMETER NO. PZ-1 (B-4)

PROJECT NO.:	DRAWING NO.:
HG1018380	PLATE C-1



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
8/17/11	Dry	Dry
9/15/11	8	30.02

NOTES:

- Piezometer was installed on 8/16/11. Diameter of Piezometer is 2 inches.
- See Plate 2 for boring location; see Plate A-7 for boring log.

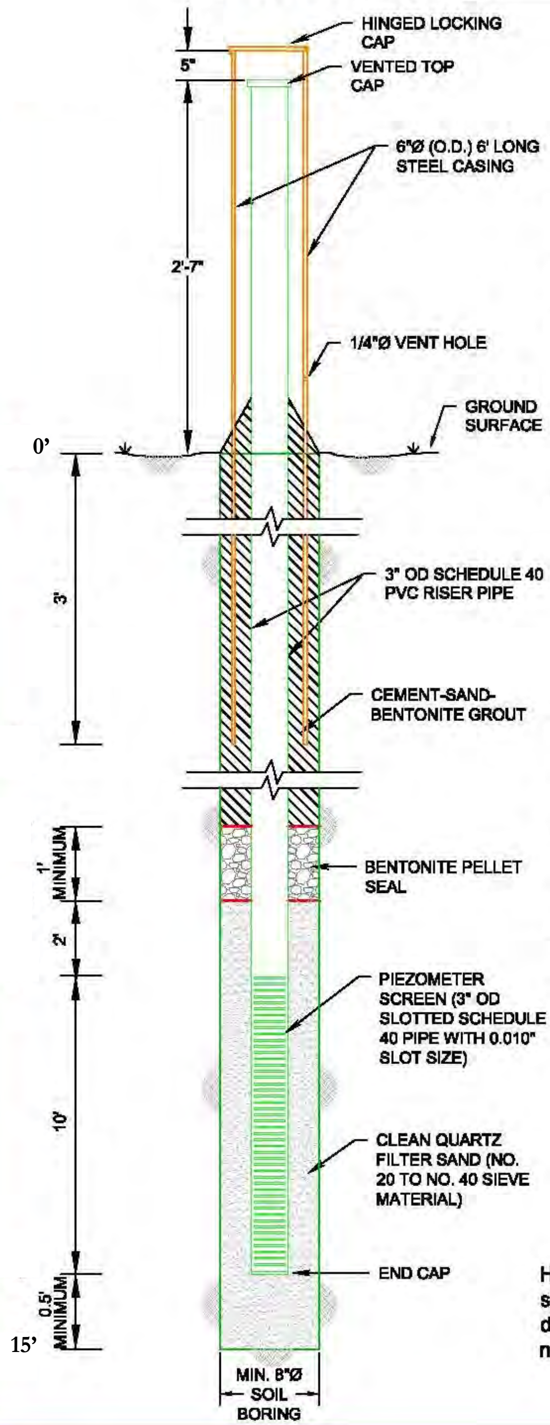
HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

PIEZOMETER INSTALLATION REPORT
PIEZOMETER NO. PZ-2 (B-7)

PROJECT NO.:	DRAWING NO.:
HG1018380	PLATE C-2

PIEZOMETER INSTALLATION DIAGRAM

HCFCD ID#________________



Installation and Development Details

Piezometer No.: PZ-3

Location: B-11

Installation Date: 8/16/10

Drilling Method:
- Dry Auger [X]
- Wet Rotary [ ]

Development Date: 8/16/11

Development Method: Surge Block

Water Level Data	Depth below grade, ft.	Elevation
During Drilling	Dry	Dry
After Installation (24 hrs)	10	27.93
Before Development	N/A	N/A
After Development (15 days)	10.5	27.03
Before Development	N/A	N/A
After Development (30 days)	N/A	25.03
	12.5	

Height above the ground surface is shown as a positive number (+) and depth below ground is shown a negative number (-).

Harris County Flood Control District

Date: January 5, 2007

HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 9/9/2011	APPROVED BY: SV	PREPARED BY: NL

PIEZOMETER INSTALLATION REPORT
PIEZOMETER NO. PZ-3 (B-11)

PROJECT NO.: HG1018380	DRAWING NO.: PLATE C-3

Attention Owner: Confidentiality Privilege Notice on reverse side of owner's copy.

Texas Department of Licensing and Regulation

Water Well Driller/Pump Installer Program
P.O. Box 12157 Austin, Texas 78711 (512) 463-7880 FAX (512) 463-8616
Toll free (800) 803-9202
Email address: water.well@license.state.tx.us

This form must be completed and filed with the department and owner **within 60 days** upon completion of the well.

WELL REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
City of Houston Geotechnical Dept	611 Walker Floor 14	Houston	Tx	77002

2) WELL LOCATION

County	Physical Address	City	State	Zip
Harris	MLK @ Rapido (pz-1)	Houston	Tx	77033

3) Type of Work
☒ New Well ☐ Reconditioning ☐ Replacement ☐ Deepening

Lat. ° ' " Long. ° ' " Grid # 65-22-5

4) Proposed Use (check) ☒ Monitor ☐ Environmental Soil Boring ☐ Domestic ☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☐ Testwell ☐ Rig Supply ☐ Stock or Livestock
If Public Supply, were plans approved? ☐ Yes ☐ No

5) N↑

6) Drilling Date
Started 8/16/2011
Completed 8/16/2011

Diameter of Hole

Dia. (in)	From (ft)	To (ft)
	Surface	
4	0	20

7) Drilling Method (check) ☐ Driven ☐ Air Rotary ☒ Mud Rotary ☐ Bored ☐ Air Hammer ☐ Cable Tool ☐ Jetted ☐ Hollow Stem Auger ☐ Reverse Circulation ☐ Other

From (ft)	To (ft)	Description and color of formation material
0	4	Dk Gr SaCl
4	10	Y G SaCl
10	14	T Br G ClSa
14	20	Br SaSi (Sa@16')

(Use reverse side of Well Owner's copy, If necessary)

8) Borehole Completion ☐ Open Hole ☐ Straight Wall ☐ Under-reamed ☐ Gravel Packed ☒ Other 9 & 12
Gravel Packed interval from ft. to ft. Size:

Casing, Blank Pipe, and Well Screen Data

Dia. (in.)	New Or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft) From	To	Gage Casing Screen
2	n	Sch 40 PVC Riser	0	10	
2	n	Sch 40 PVC Screen	10	15	.010

9) Annular Seal Data: i.e. *(from 0 ft to 100 ft #sacks & material 13 cement)*
from 0 ft. to 8 ft. #sacks & material 1 holeplug
from ft. to ft. #sacks & material
from ft. to ft. #sacks & material
Method Used manually done
Distance to septic field or other concentrated contamination ft.
Distance to Property Line ft Method
Verified:

13) Plugged ☐ Well plugged within 48 hours
Casing left in well: na Cement/Bentonite placed in well:

From (ft)	To (ft)	From (ft)	To (ft)	Material used & # Sacks

10) Surface Completion (If steel cased, leave blank)
☐ Surface Slab Installed ☒ Surface Sleeve Installed ☐ Pitless Adapter Used ☐ Alternative Procedure Used

14) Type Pump
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder ☐ Other na
Depth to pump bowls, cylinder, jet, etc., ft.

11) Water Level
Static level dry ft. Date 08/16/2011
Artesian Flow gpm

15) Water Test
Type test ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: na gpm with ft. drawdown after hrs.

12) Packers

Type	Depth	Type	Depth
20/40	8		
	20		

16) Water Quality
Type of water: Depth of Strata: Was a chemical analysis made? ☐ Yes ☒ No
Did you knowingly penetrate a strata which contains undesirable constituents? ☐ Yes ☒ No If yes, Continue:
Check One: ☐ Naturally poor-quality groundwater – type ☐ Hydrocarbons (i.e. gas, oil, etc.) ☐ Hazardous material/waste contamination encountered ☐ Other (describe)

☐ *I certify that while drilling, deepening, or otherwise altering the above described well, undesirable water or constituents was encountered and the landowner was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.*

Company or Individual's Name (type or print) Van and Sons Drilling Service, Inc Lic. No. 3286M
Address 319 John Alber City Houston State Tx Zip 77076

Signature	Date	Signature	Date
[signature]	9/26/2011		/ /
Licensed Driller/Pump Installer	Date	Apprentice	Date

Attention Owner: Confidentiality Privilege Notice on reverse side of owner's copy.

Texas Department of Licensing and Regulation

Water Well Driller/Pump Installer Program
P.O. Box 12157 Austin, Texas 78711 (512) 463-7880 FAX (512) 463-8616
Toll free (800) 803-9202
Email address: water.well@license.state.tx.us

This form must be completed and filed with the department and owner **within 60 days** upon completion of the well.

WELL REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
City of Houston Geotechnical Dept	611 Walker Floor 14	Houston	Tx	77002

2) WELL LOCATION

County	Physical Address	City	State	Zip
Harris	MLK @ Crestridge (pz-2)	Houston	Tx	77033

Lat. ° ' " Long. ° ' " Grid # 65-22-5

3) Type of Work
☒ New Well ☐ Reconditioning
☐ Replacement ☐ Deepening

4) Proposed Use (check) ☒ Monitor ☐ Environmental Soil Boring ☐ Domestic ☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☐ Testwell ☐ Rig Supply ☐ Stock or Livestock
If Public Supply, were plans approved? ☐ Yes ☐ No

5) N↑

6) Drilling Date
Started 8/16/2011
Completed 8/16/2011

Diameter of Hole

Dia. (in)	From (ft)	To (ft)
4	Surface 0	15

7) Drilling Method (check)
☐ Driven ☐ Air Rotary ☒ Mud Rotary
☐ Bored ☐ Air Hammer ☐ Cable Tool
☐ Jetted ☐ Hollow Stem Auger
☐ Reverse Circulation
☐ Other

From (ft)	To (ft)	Description and color of formation material
0	6	G Cl
6	10	G T Cl
10	12	G T SaCl
12	15	R Cl

(Use reverse side of Well Owner's copy, if necessary)

8) Borehole Completion ☐ Open Hole ☐ Straight Wall ☐ Under-reamed ☐ Gravel Packed ☒ Other 9 & 12
Gravel Packed interval from ft. to ft. Size:

Casing, Blank Pipe, and Well Screen Data

Dia. (in.)	New Or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft) From	Setting (ft) To	Gage Casing Screen
2	n	Sch 40 PVC Riser	0	10	
2	n	Sch 40 PVC Screen	10	15	.010

9) Annular Seal Data: i.e. *(from 0 ft to 100 ft #sacks & material 13 cement)*
from 0 ft. to 8 ft. #sacks & material 1 holeplug
from ___ ft. to ___ ft. #sacks & material ___
from ___ ft. to ___ ft. #sacks & material ___
Method Used manually done
Distance to septic field or other concentrated contamination ___ ft.
Distance to Property Line ___ ft Method ___
Verified:

13) Plugged ☐ Well plugged within 48 hours
Casing left in well: na Cement/Bentonite placed in well:

From (ft)	To (ft)	From (ft)	To (ft)	Material used & # Sacks

10) Surface Completion (If steel cased, leave blank)
☐ Surface Slab Installed ☒ Surface Sleeve Installed
☐ Pitless Adapter Used ☐ Alternative Procedure Used

14) Type Pump
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other na
Depth to pump bowls, cylinder, jet, etc., ft.

11) Water Level
Static level dry ft. Date 08/16/2011
Artesian Flow ___ gpm

15) Water Test
Type test ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: na gpm with ___ ft. drawdown after ___ hrs.

12) Packers

Type	Depth	Type	Depth
20/40	8		
	15		

16) Water Quality
Type of water: ___ Depth of Strata: ___ Was a chemical analysis made? ☐ Yes ☒ No
Did you knowingly penetrate a strata which contains undesirable constituents? ☐ Yes ☒ No If yes, Continue:
Check One: ☐ Naturally poor-quality groundwater – type ___ ☐ Hydrocarbons (i.e. gas, oil, etc.)
☐ Hazardous material/waste contamination encountered ☐ Other (describe) ___

☐ *I certify that while drilling, deepening, or otherwise altering the above described well, undesirable water or constituents was encountered and the landowner was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.*

Company or Individual's Name (type or print) Van and Sons Drilling Service, Inc Lic. No. 3286M
Address 319 John Alber City Houston State Tx Zip 77076

Signature	Date	Signature	Date
[signature]	9/26/2011		/ /
Licensed Driller/Pump Installer	Date	Apprentice	Date

Attention Owner: Confidentiality Privilege Notice on reverse side of owner's copy.

Texas Department of Licensing and Regulation

Water Well Driller/Pump Installer Program
P.O. Box 12157 Austin, Texas 78711 (512) 463-7880 FAX (512) 463-8616
Toll free (800) 803-9202
Email address: water.well@license.state.tx.us

This form must be completed and filed with the department and owner **within 60 days** upon completion of the well.

WELL REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
City of Houston Geotechnical Dept	611 Walker Floor 14	Houston	Tx	77002

2) WELL LOCATION

County	Physical Address	City	State	Zip
Harris	MLK @ Doulton (pz-3)	Houston	Tx	77033

Lat. ° ' " Long. ° ' " Grid # 65-22-5

3) Type of Work
☒ New Well ☐ Reconditioning ☐ Replacement ☐ Deepening

4) Proposed Use (check) ☒ Monitor ☐ Environmental Soil Boring ☐ Domestic ☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☐ Testwell ☐ Rig Supply ☐ Stock or Livestock If Public Supply, were plans approved? ☐ Yes ☐ No

5) N↑

6) Drilling Date
Started 8/16/2011
Completed 8/16/2011

Diameter of Hole

Dia. (in)	From (ft)	To (ft)
6	Surface 0	15

7) Drilling Method (check) ☐ Driven ☐ Air Rotary ☒ Mud Rotary ☐ Bored ☐ Air Hammer ☐ Cable Tool ☐ Jetted ☐ Hollow Stem Auger ☐ Reverse Circulation ☐ Other

From (ft)	To (ft)	Description and color of formation material
0	4	Dk G Cl
4	6	Dk G T Cl
6	10	G T Cl
10	15	R Cl

(Use reverse side of Well Owner's copy, if necessary)

8) Borehole Completion ☐ Open Hole ☐ Straight Wall ☐ Under-reamed ☐ Gravel Packed ☒ Other 9 & 12
Gravel Packed interval from ft. to ft. Size:

Casing, Blank Pipe, and Well Screen Data

Dia. (in.)	New Or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft) From	Setting (ft) To	Gage Casing Screen
3	n	Sch 40 PVC Riser	0	10	
3	n	Sch 40 PVC Screen	10	15	.010

9) Annular Seal Data: i.e. *(from 0 ft to 100 ft #sacks & material 13 cement)*
from 0 ft. to 8 ft. #sacks & material 1 holeplug
from ft. to ft. #sacks & material
from ft. to ft. #sacks & material
Method Used manually done
Distance to septic field or other concentrated contamination ft.
Distance to Property Line ft Method
Verified:

13) Plugged ☐ Well plugged within 48 hours
Casing left in well: na Cement/Bentonite placed in well:

From (ft)	To (ft)	From (ft)	To (ft)	Material used & # Sacks

10) Surface Completion (If steel cased, leave blank)
☐ Surface Slab Installed ☒ Surface Sleeve Installed ☐ Pitless Adapter Used ☐ Alternative Procedure Used

14) Type Pump
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder ☐ Other na
Depth to pump bowls, cylinder, jet, etc., ft.

11) Water Level
Static level dry ft. Date 08/16/2011
Artesian Flow gpm

15) Water Test
Type test ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: na gpm with ft. drawdown after hrs.

12) Packers

Type	Depth	Type	Depth
20/40	8		
	15		

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Type of water: Depth of Strata: Was a chemical analysis made? ☐ Yes ☒ No
Did you knowingly penetrate a strata which contains undesirable constituents? ☐ Yes ☒ No If yes, Continue:
Check One: ☐ Naturally poor-quality groundwater – type ☐ Hydrocarbons (i.e. gas, oil, etc.) ☐ Hazardous material/waste contamination encountered ☐ Other (describe)

☐ *I certify that while drilling, deepening, or otherwise altering the above described well, undesirable water or constituents was encountered and the landowner was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.*

Company or Individual's Name (type or print) Van and Sons Drilling Service, Inc Lic. No. 3286M
Address 319 John Alber City Houston State Tx Zip 77076

Signature Licensed Driller/Pump Installer	Date	Signature Apprentice	Date
[signature]	9/26/2011		/ /

Texas Department of License and Regulation

Water Well Driller/Pump Installer Program

P.O. Box 12157 Austin, Texas 78711 (512)463-7880 FAX (512)463-8616

Email address: water.well@license.state.tx.us

This form must be completed and filed with the department within 30 days following the plugging of the well.

PLUGGING REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
City of Houston Geo Dept	611 Walker Floor 14	Houston	TX	77002

2) WELL LOCATION

County	Physical Address	City	State	Zip
Harris	MLK @ Rapido	Houston	Tx	77033

3) Owner's Well No. 1 **Long.** ° ' " **Lat.** ° ' " **Grid #** 65-22-5

4) Type of Well ☐ Water ☒ Monitor ☐ Injection ☐ De-Watering

5) N↑

Drill, Pump Installer, or Landowner performing the plugging operations must locate and identify the location of the well within a specific grid on a full scale gridded map available from Texas Natural Resource Information Service. The location of the well should be denoted within the grid by placing a corresponding dot in the square to the right. The legal description is optional.

B) HISTORICAL DATA ON WELL TO BE PLUGGED (if available)

6) Driller **Mark Thornton** License No. **3286M**

7) Drilled **08/16/2011** 8) Diameter of hole **4** inches 9) Total depth of well **15** feet.

C. CURRENT PLUGGING DATA

10) Date well plugged **9/16/2011**

12) Name of Driller/Pump Installer or Well Owner performing the plugging **Mark Thornton**

License No. **3286M**

13) CASING AND CEMENTING DATA RELATIVE TO THE PLUGGING OPERATIONS.

CASING LEFT IN WELL

DIAMETER (inches)	FROM (feet)	TO (feet)
2	0	15

CEMENT/BENTONITE PLUG(S) PLACED IN WELL

FROM (feet)	TO (feet)	SACKS
0	15	2

11) REMOVE ALL REMOVEABLE CASING

Please check box beside the method of plugging used

☐ Tremmie pipe cement from bottom to top.

☐ Tremmie pipe bentonite from bottom to 2 feet from surface, cement top 2 feet.

☒ Pour in 3/8 bentonite chips when standing water in well is less than 100 feet in depth, cement top 2 feet.

☐ Large diameter well filled with clay material from top to bottom.

COMMENTS

1) Tried to pull well casing casing

2) Grouted well in place

D. VALIDATION OF INFORMATION INCLUDED IN FORM

I certify that I plugged this well (or the well was plugged under my supervision) and that all of the statements herein are true and correct. I understand that failure to complete items 1 through 13 will result in the report(s) being returned for completion and resubmitted.

Company or Individual's Name (type or print) **Van and Sons Drilling Service, Inc**

Address **319 John Alber** City **Houston** State **Tx** Zip **77076**

Signature [signature]	9/26/2011	Signature	/ /
Licensed Driller/Pump Installer	Date	Apprentice	Date

Texas Department of License and Regulation

Water Well Driller/Pump Installer Program
P.O. Box 12157 Austin, Texas 78711 (512)463-7880 FAX (512)463-8616
Email address: water.well@license.state.tx.us

This form must be completed and filed with the department within 30 days following the plugging of the well.

PLUGGING REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
City of Houston Geo Dept	611 Walker Floor 14	Houston	TX	77002

2) WELL LOCATION

County	Physical Address	City	State	Zip
Harris	MLK @ Crestridge	Houston	Tx	77033

3) Owner's Well No. 2 Long. ° ' " Lat. ° ' " Grid # 65-22-5

4) Type of Well ☐ Water ☒ Monitor ☐ Injection ☐ De-Watering

5) N↑

Drill, Pump Installer, or Landowner performing the plugging operations must locate and identify the location of the well within a specific grid on a full scale gridded map available from Texas Natural Resource Information Service. The location of the well should be denoted within the grid by placing a corresponding dot in the square to the right. The legal description is optional.

B) HISTORICAL DATA ON WELL TO BE PLUGGED (if available)

6) Driller: Mark Thornton

License No.: 3286M

7) Drilled 08/16/2011 8) Diameter of hole 4 inches 9) Total depth of well 15 feet.

C. CURRENT PLUGGING DATA

10) Date well plugged: 9/16/2011

12) Name of Driller/Pump Installer or Well Owner performing the plugging: Mark Thornton

License No. 3286M

13) CASING AND CEMENTING DATA RELATIVE TO THE PLUGGING OPERATIONS.

CASING LEFT IN WELL

DIAMETER (inches)	FROM (feet)	TO (feet)
2	0	15

11) REMOVE ALL REMOVEABLE CASING

Please check box beside the method of plugging used

☐ Tremmie pipe cement from bottom to top.

☐ Tremmie pipe bentonite from bottom to 2 feet from surface, cement top 2 feet.

☒ Pour in 3/8 bentonite chips when standing water in well is less than 100 feet in depth, cement top 2 feet.

☐ Large diameter well filled with clay material from top to bottom.

CEMENT/BENTONITE PLUG(S) PLACED IN WELL

FROM (feet)	TO (feet)	SACKS
0	15	2

COMMENTS

1) Tried to pull well casing casing
2) Grouted well in place

D. VALIDATION OF INFORMATION INCLUDED IN FORM

I certify that I plugged this well (or the well was plugged under my supervision) and that all of the statements herein are true and correct. I understand that failure to complete items 1 through 13 will result in the report(s) being returned for completion and resubmitted.

Company or Individual's Name (type or print): Van and Sons Drilling Service, Inc

Address: 319 John Alber City: Houston State: Tx Zip: 77076

Signature	Date	Signature	Date
[signature]	9/26/2011		/ /
Licensed Driller/Pump Installer	Date	Apprentice	Date

Texas Department of License and Regulation

Water Well Driller/Pump Installer Program
P.O. Box 12157 Austin, Texas 78711 (512)463-7880 FAX (512)463-8616
Email address: water.well@license.state.tx.us

This form must be completed and filed with the department within 30 days following the plugging of the well.

PLUGGING REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
City of Houston Geo Dept	611 Walker Floor 14	Houston	TX	77002

2) WELL LOCATION

County	Physical Address	City	State	Zip
Harris	MLK @ Doulton	Houston	Tx	77033

3) Owner's Well No. 3 | **Long.** ° ' " | **Lat.** ° ' " | **Grid #** 65-22-5

4) Type of Well ☐ Water ☒ Monitor ☐ Injection ☐ De-Watering

5) N↑

Drill, Pump Installer, or Landowner performing the plugging operations must locate and identify the location of the well within a specific grid on a full scale gridded map available from Texas Natural Resource Information Service. The location of the well should be denoted within the grid by placing a corresponding dot in the square to the right. The legal description is optional.

B) HISTORICAL DATA ON WELL TO BE PLUGGED (if available)

6) Driller Mark Thornton — **License No.** 3286M

7) Drilled 08/16/2011 **8) Diameter of hole** 4 inches **9) Total depth of well** 15 feet.

C. CURRENT PLUGGING DATA

10) Date well plugged 9/16/2011

12) Name of Driller/Pump Installer or Well Owner performing the plugging Mark Thornton

License No. 3286M

11) REMOVE ALL REMOVEABLE CASING
Please check box beside the method of plugging used

- ☐ Tremmie pipe cement from bottom to top.
- ☐ Tremmie pipe bentonite from bottom to 2 feet from surface, cement top 2 feet.
- ☒ Pour in 3/8 bentonite chips when standing water in well is less than 100 feet in depth, cement top 2 feet.
- ☐ Large diameter well filled with clay material from top to bottom.

13) CASING AND CEMENTING DATA RELATIVE TO THE PLUGGING OPERATIONS.

CASING LEFT IN WELL

DIAMETER (inches)	FROM (feet)	TO (feet)
2	0	15

CEMENT/BENTONITE PLUG(S) PLACED IN WELL

FROM (feet)	TO (feet)	SACKS
0	15	2

COMMENTS

1) Tried to pull well casing casing
2) Grouted well in place

D. VALIDATION OF INFORMATION INCLUDED IN FORM

I certify that I plugged this well (or the well was plugged under my supervision) and that all of the statements herein are true and correct. I understand that failure to complete items 1 through 13 will result in the report(s) being returned for completion and resubmitted.

Company or Individual's Name (type or print) **Van and Sons Drilling Service, Inc**

Address **319 John Alber** City **Houston** State **Tx** Zip **77076**

Signature [signature]	9/26/2011	Signature	/ /
Licensed Driller/Pump Installer	Date	Apprentice	Date

Type or print on this form a list of wells for which you are submitting "Well Report" forms.

State of Texas

State Well Report Submission Form

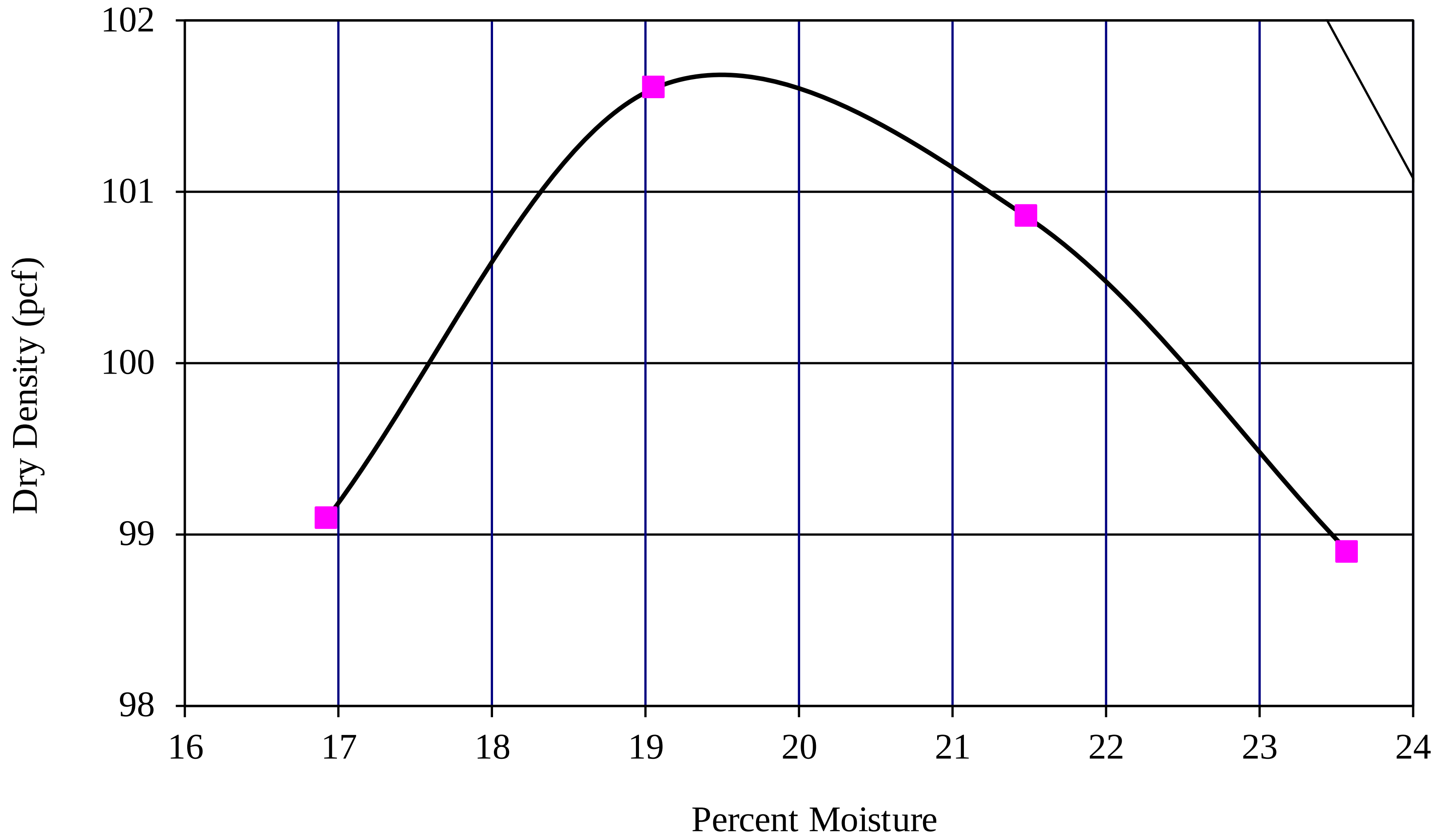
Send original copy, along with original copies of your State Well Reports, by certified mail to:
TDLR
P.O. Box 12157
Austin, Texas 78711

DATE DRILLED	WELL OWNER	COUNTY
PZ1-3 Drilled 08/16/2011	City of Houston	Harris
PZ1-3 Plugged 09/16/2011	Geotechnical Dept	
	611Walker Floor 14	
	Houston, TX 77002	

Mark Thornton	3286M	09/26/2011
LICENSED DRILLER/PUMP INSTALLER (Please type or print)	LICENSE NUMBER	DATE

APPENDIX D

STANDARD PROCTOR AND CBR TEST RESULTS



TEST DATA

TYPE OF MATERIAL	Gray Fat Clay with Sand	SAMPLE LOCATION	Composite
MAXIMUM DRY DENSITY	101.7 pcf	LIQUID LIMIT	67
OPT. MOISTURE CONTENT	19.5 %	PLASTICITY INDEX	44
METHOD OF TEST	Standard ASTM D-698 Method A		

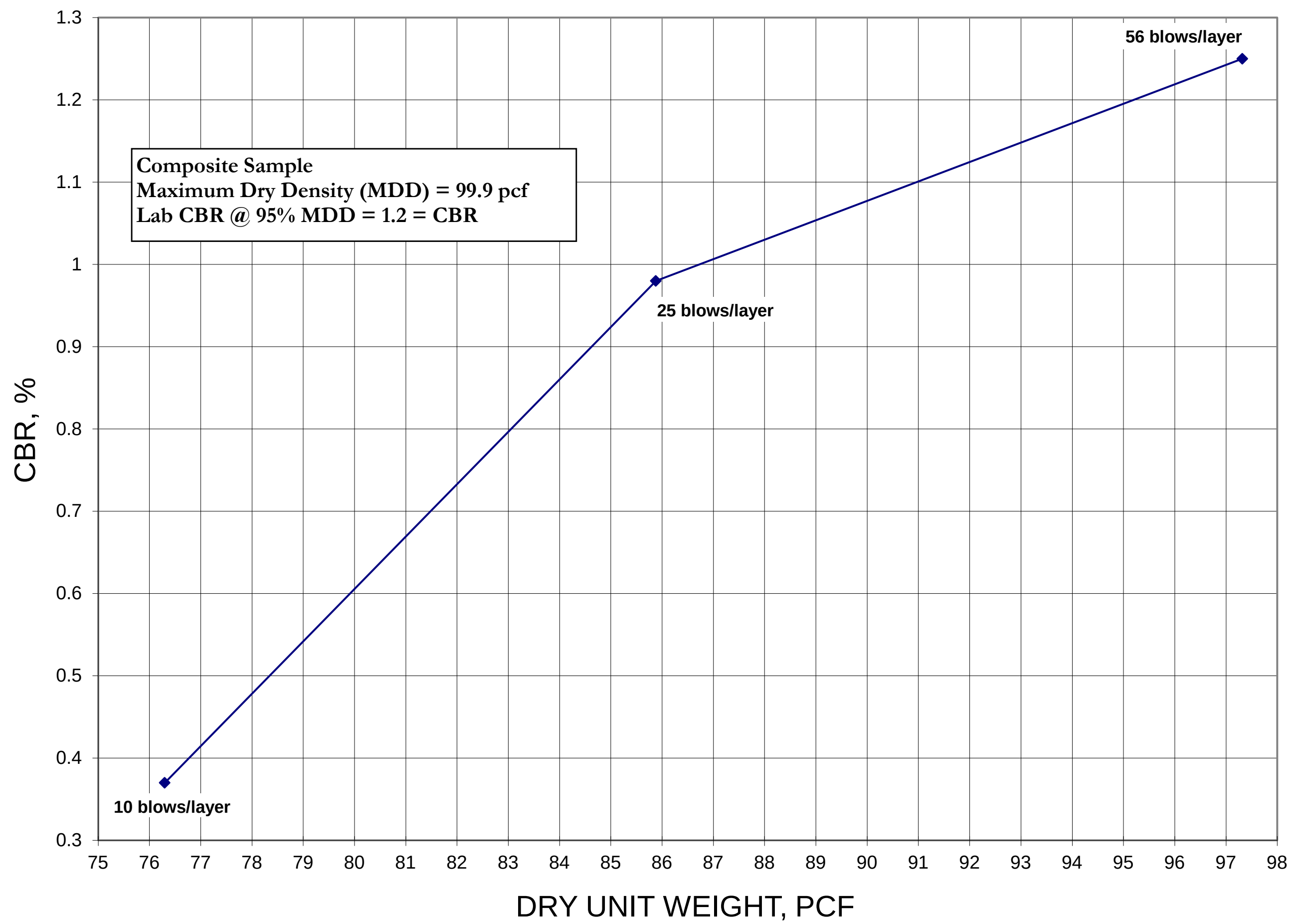
HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 9/9/2011	APPROVED BY: SV	PREPARED BY: NL

PROCTOR TEST RESULTS
MLK BOULEVAR RECONSTRUCTION:
IH 610 SOUTH TO BELLFORT

PROJECT NO.: HG1018380	DRAWING NO.: PLATE D-1

CALIFORNIA BEARING RATIO TEST RESULT



HVJ ASSOCIATES
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Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 9/9/2011	APPROVED BY: SV	PREPARED BY: NL

CBR TEST RESULTS
MLK BOULEVARD RECONSTRUCTION:
IH 610 SOUTH TO BELLFORT

PROJECT NO.: HG1018380	DRAWING NO.: PLATE D-2

CBR (CALIFORNIA BEARING RATIO) OF LABORATORY COMPACTED SOILS ASTM D1883

Project: MLK Boulevard Reconstruction: IH 610 South to Bellfort

Sample Location: Composite

Liquid Limit: 67 **Plastic Limit:** 23 **Plasticity Index:** 44

Method of Compaction:
☒ ASTM D698
☐ ASTM D1557

Sample Condition: ☒ soaked ☐ unsoaked

No. of Blows:	**10**	**25**	**56**
Dry Density Before Soaking (pcf):	76.3	85.9	97.3
Dry Density After Soaking (pcf):	74.8	84.0	89.7
Moisture Content:			
Before Compaction (%):	19.8	20.7	19.1
Top 1-inch Layer After Soaking (%):	47.2	40.4	37.2
Swell (%):	6.76	8.56	7.00
Bearing Ratio (%): (☒ soaked ☐ unsoaked)	0.37	0.98	1.25

Surcharge: 10 lbs.

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

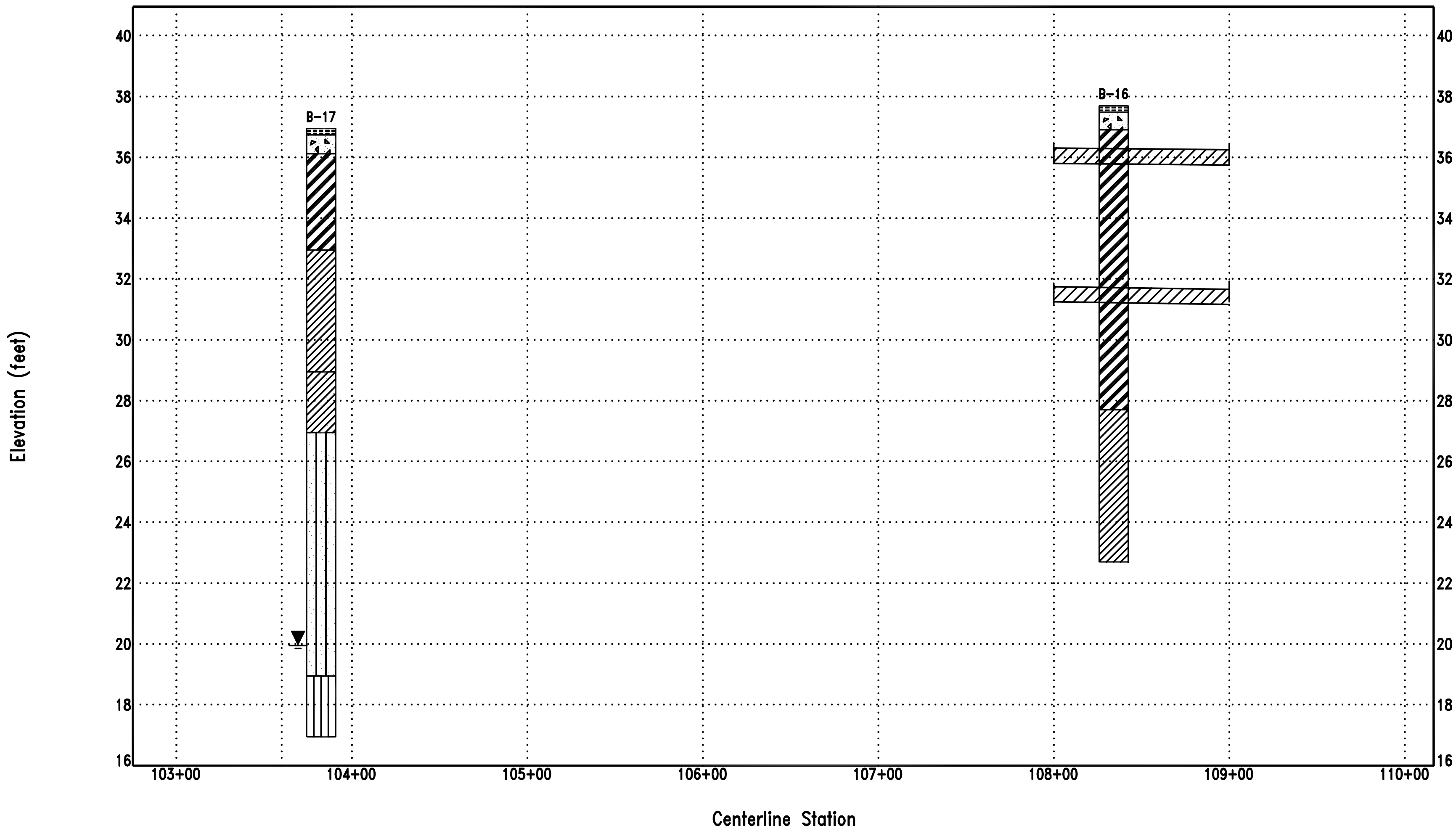
DATE: 9/9/2011	APPROVED BY: SV	PREPARED BY: NL

CBR TEST SUMMARY RESULTS
MLK BOULEVARD RECONSTRUCTION:
IH 610 SOUTH TO BELLFORT

PROJECT NO.: HG1018380	DRAWING NO.: PLATE D-3

APPENDIX E

BORING LOG PROFILE

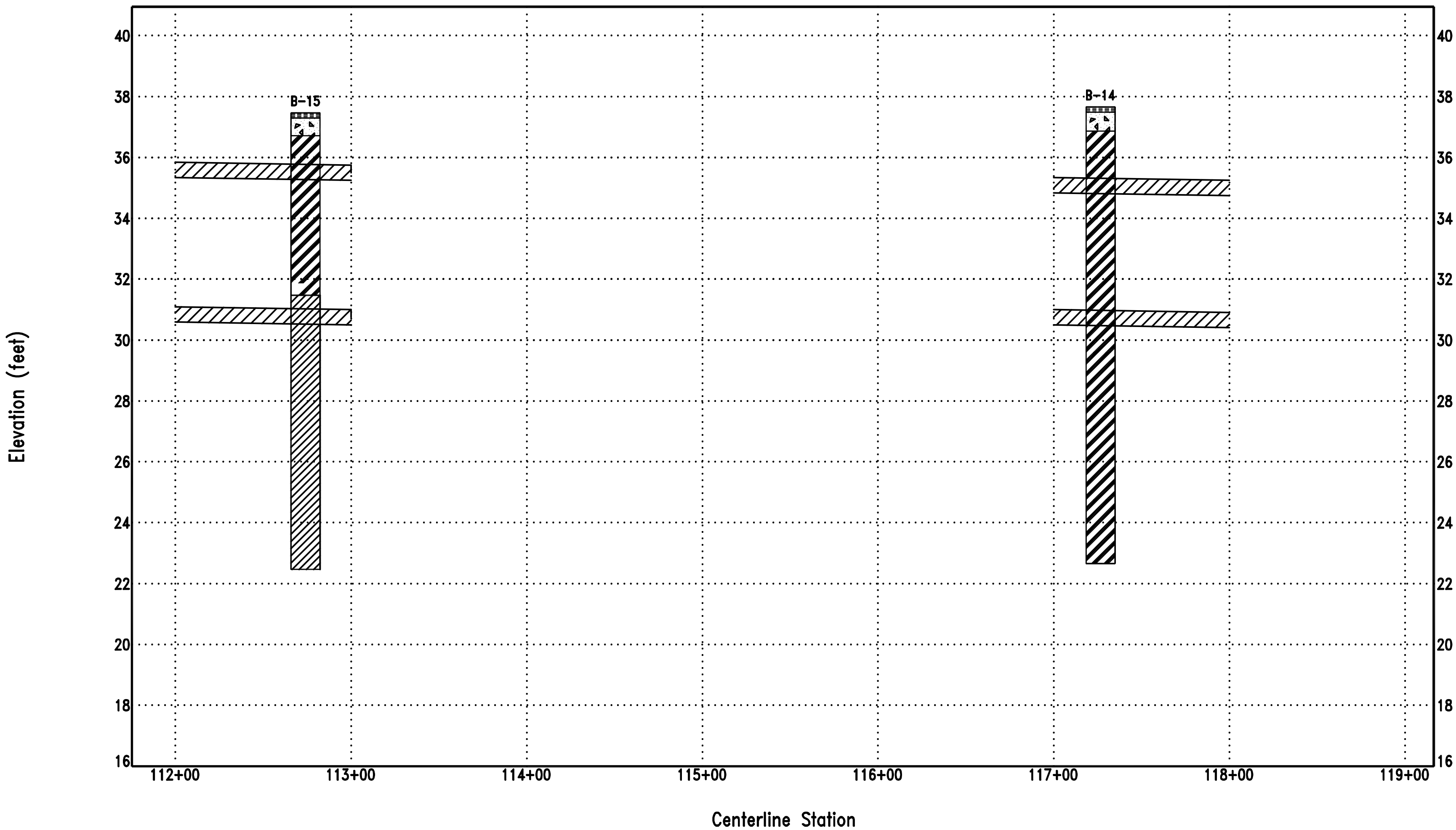


LEGEND:

- Concrete
- Fill (made ground)
- Sandy Clay
- Silt
- Asphaltic Concrete
- Fat Clay
- Base
- Clayey Sand
- Sand

Note:
Data concerning subsurface conditions obtained at boring locations only.

HVJ ASSOCIATES	2/13/2012	
	APPROVED BY: SV	PREPARED BY: GE
SOIL PROFILE MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT		
PROJECT NO.: HG1018380	DRAWING NO.: PLATE E	



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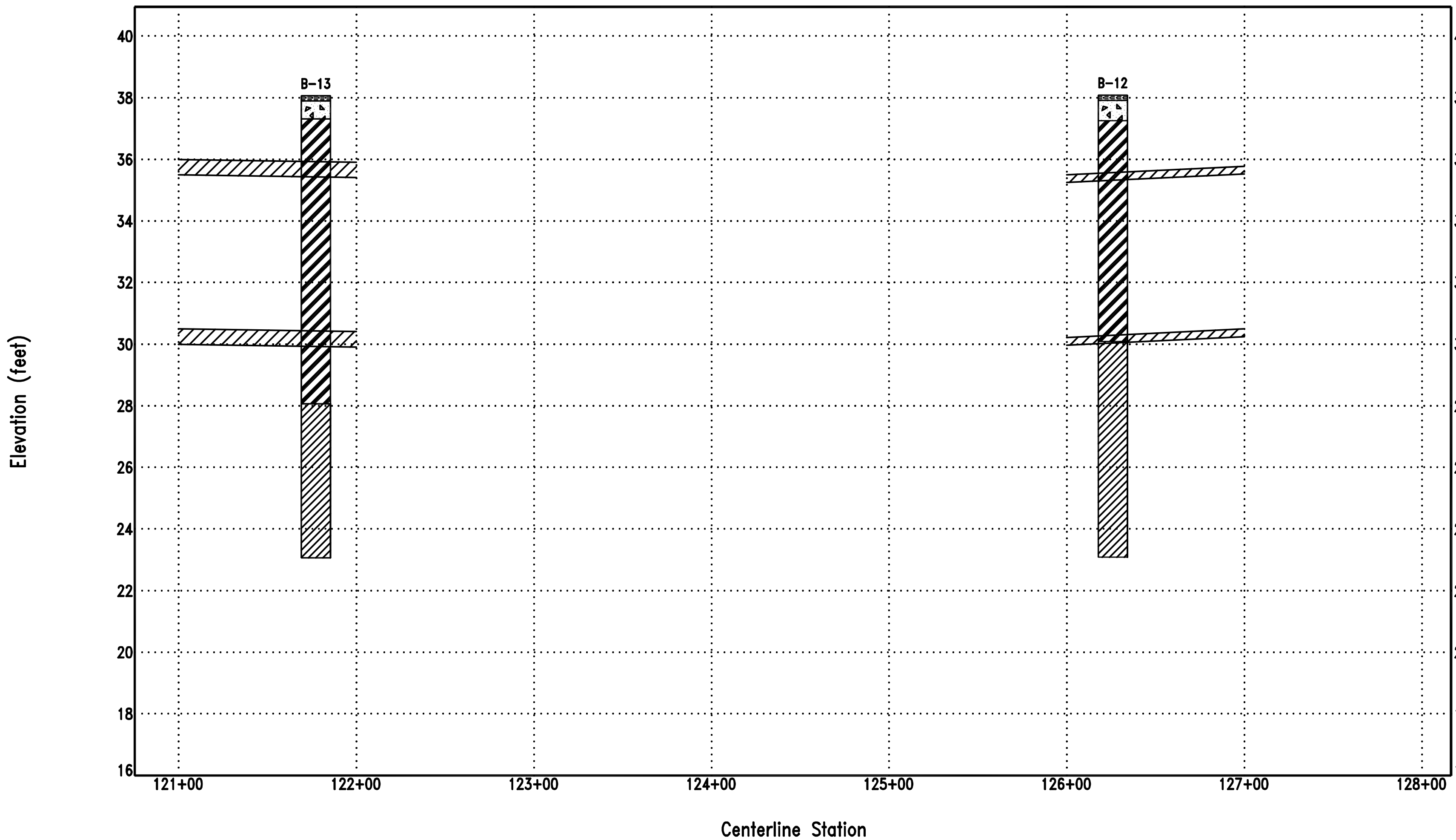
SOIL PROFILE MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT		
PROJECT NO.: HG1018380	DRAWING NO.: PLATE E	



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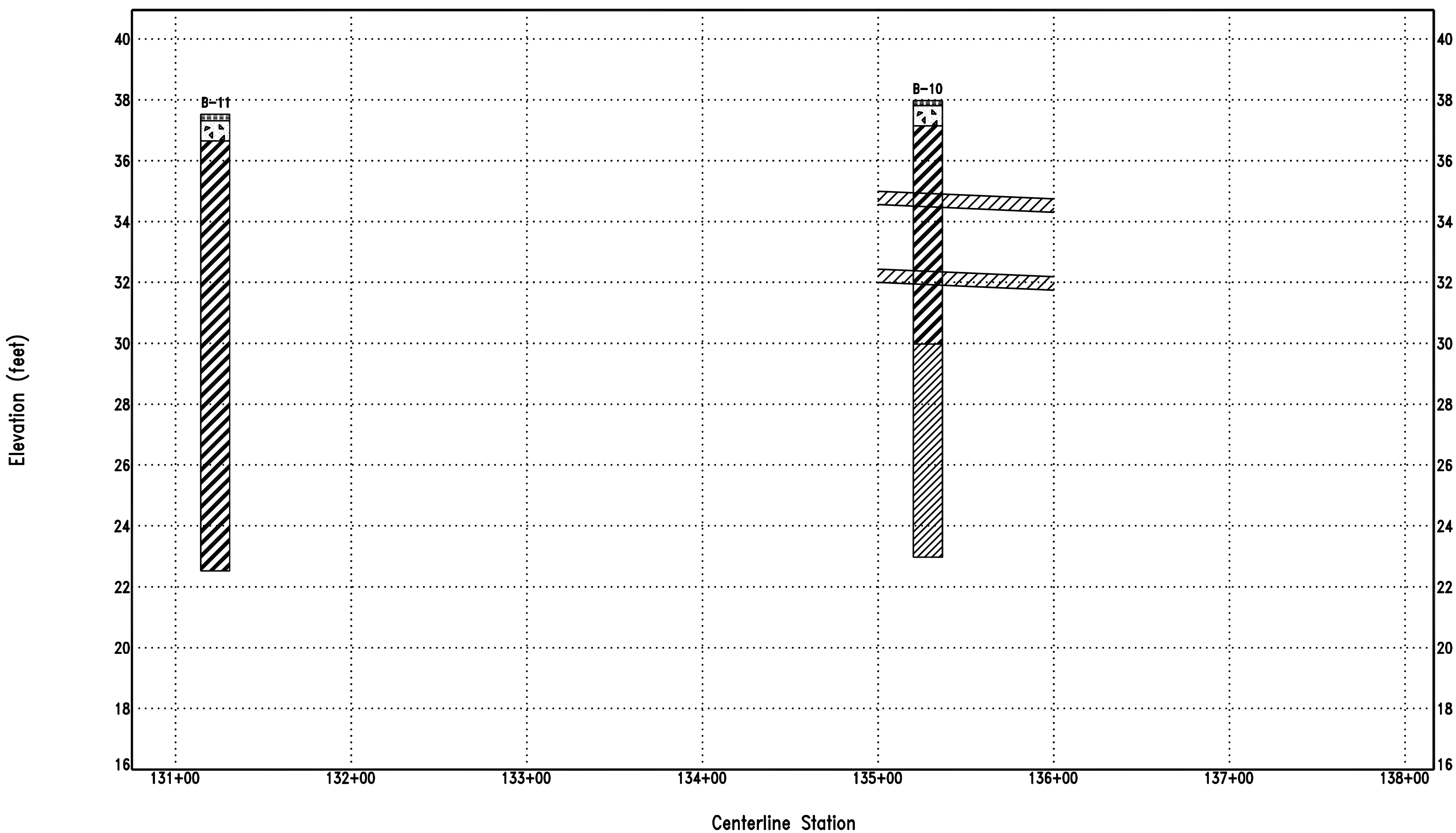
	2/13/2012	
	APPROVED BY: SV	PREPARED BY: GE

SOIL PROFILE
MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT

PROJECT NO.:	DRAWING NO.:
HG1018380	PLATE E



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HVJ ASSOCIATES

2/13/2012

APPROVED BY: SV

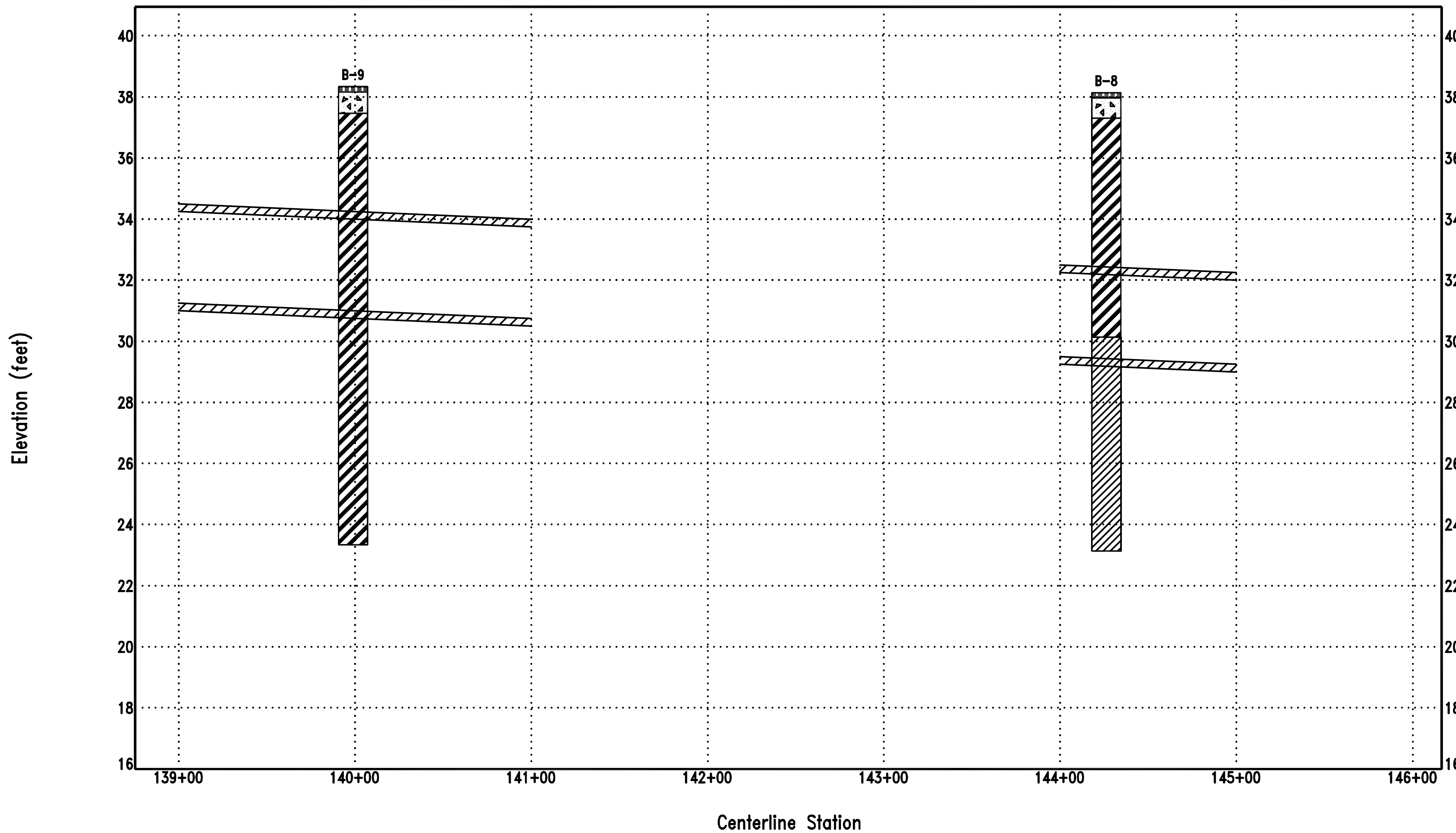
PREPARED BY: GE

SOIL PROFILE

MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT

PROJECT NO.: HG1018380

DRAWING NO.: PLATE E



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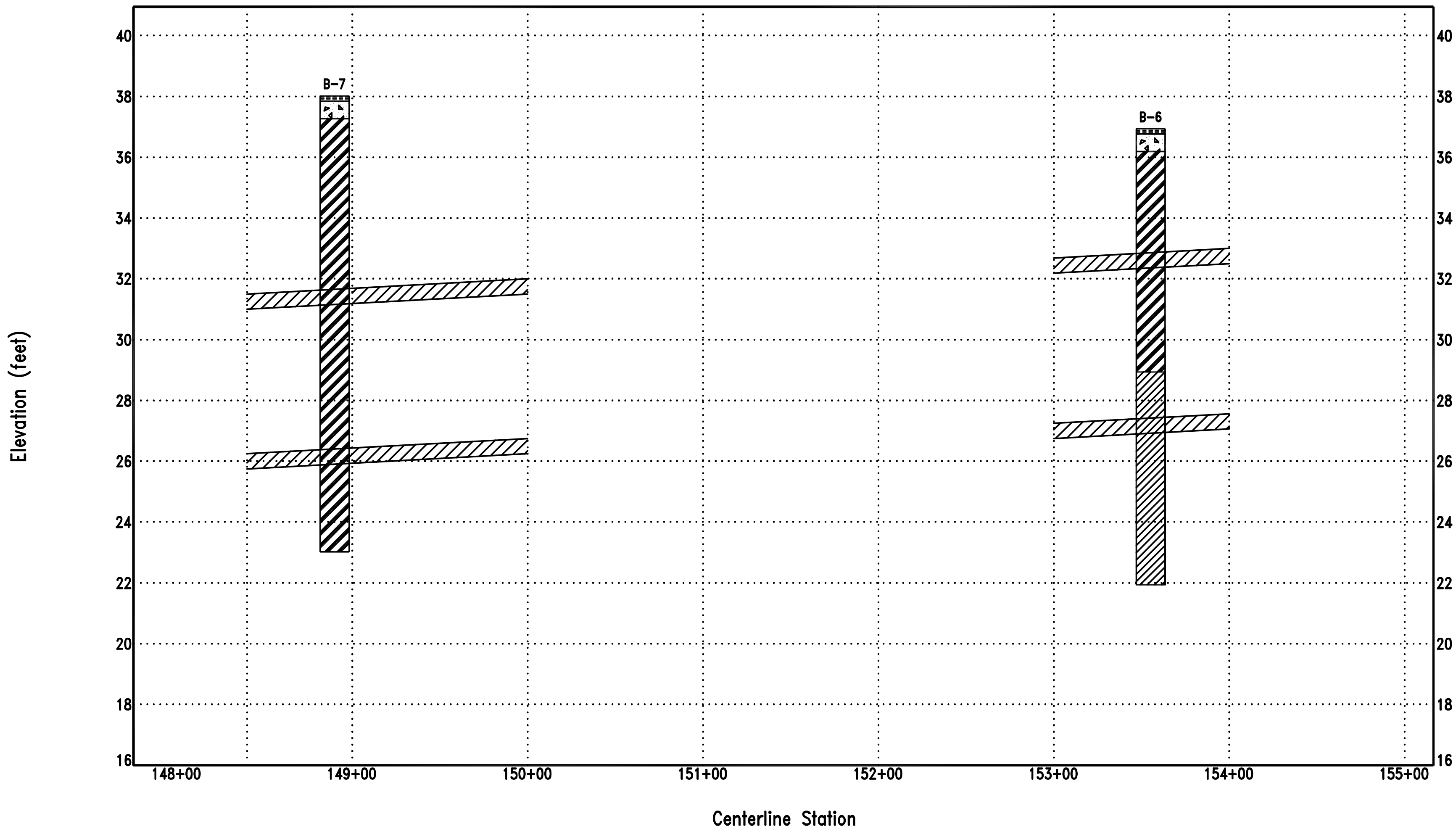
SOIL PROFILE MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT		
PROJECT NO.: HG1018380	DRAWING NO.: PLATE E	



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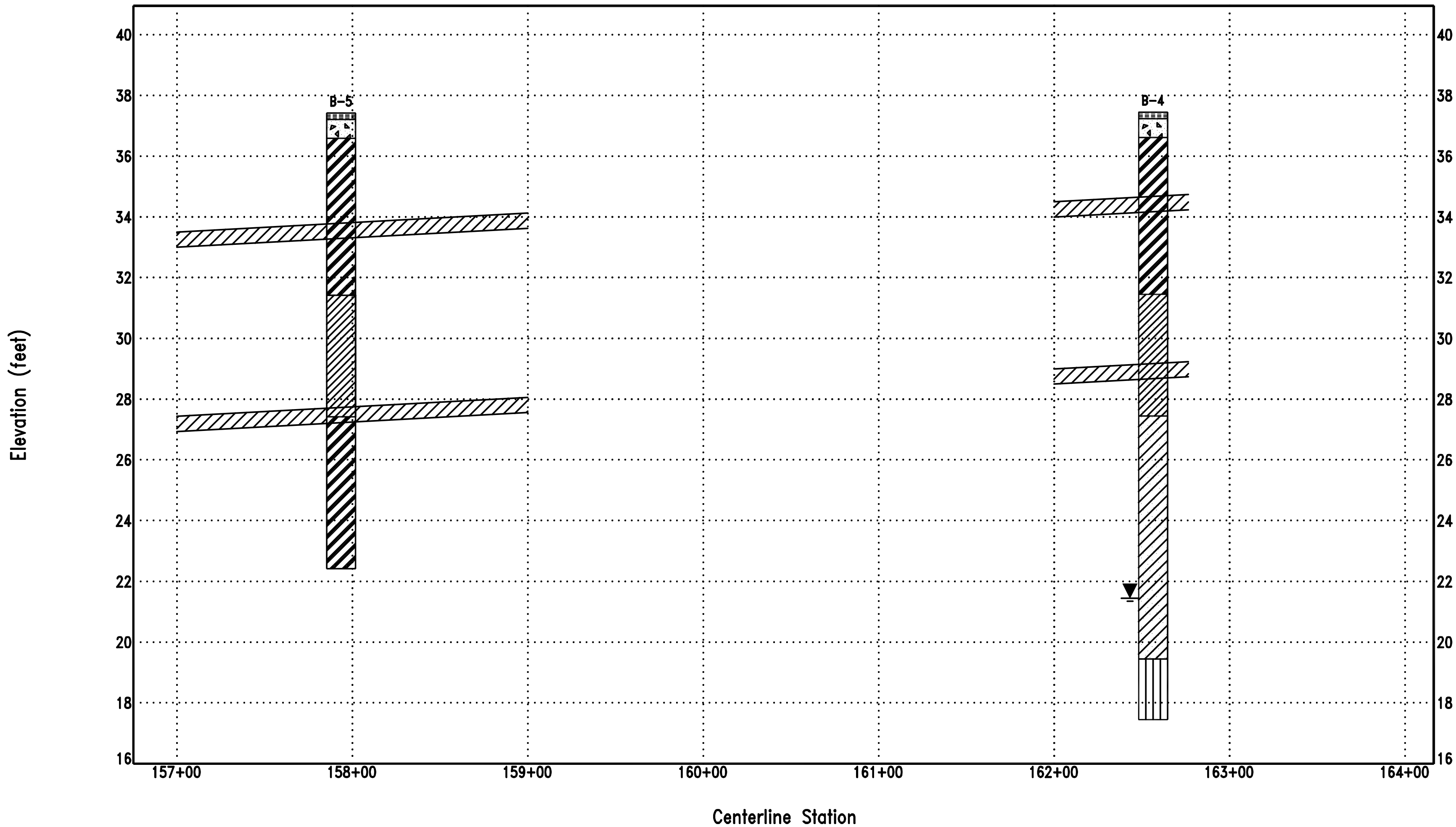
PROJECT NO.: HG1018380	DRAWING NO.: PLATE E	



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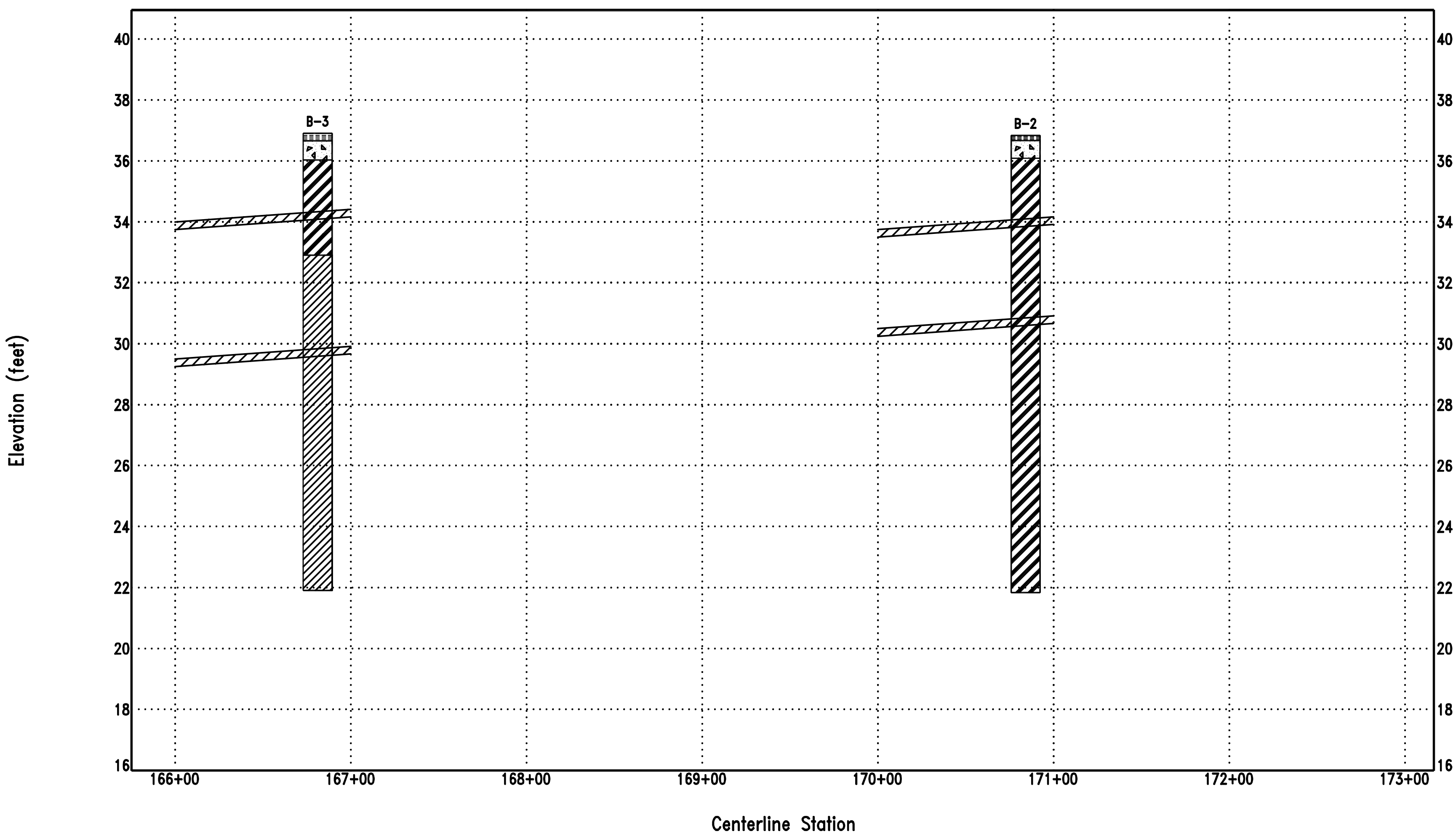
2/13/2012	APPROVED BY: SV	PREPARED BY: GE

SOIL PROFILE
MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT

PROJECT NO.:	DRAWING NO.:
HG1018380	PLATE E



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2/13/2012

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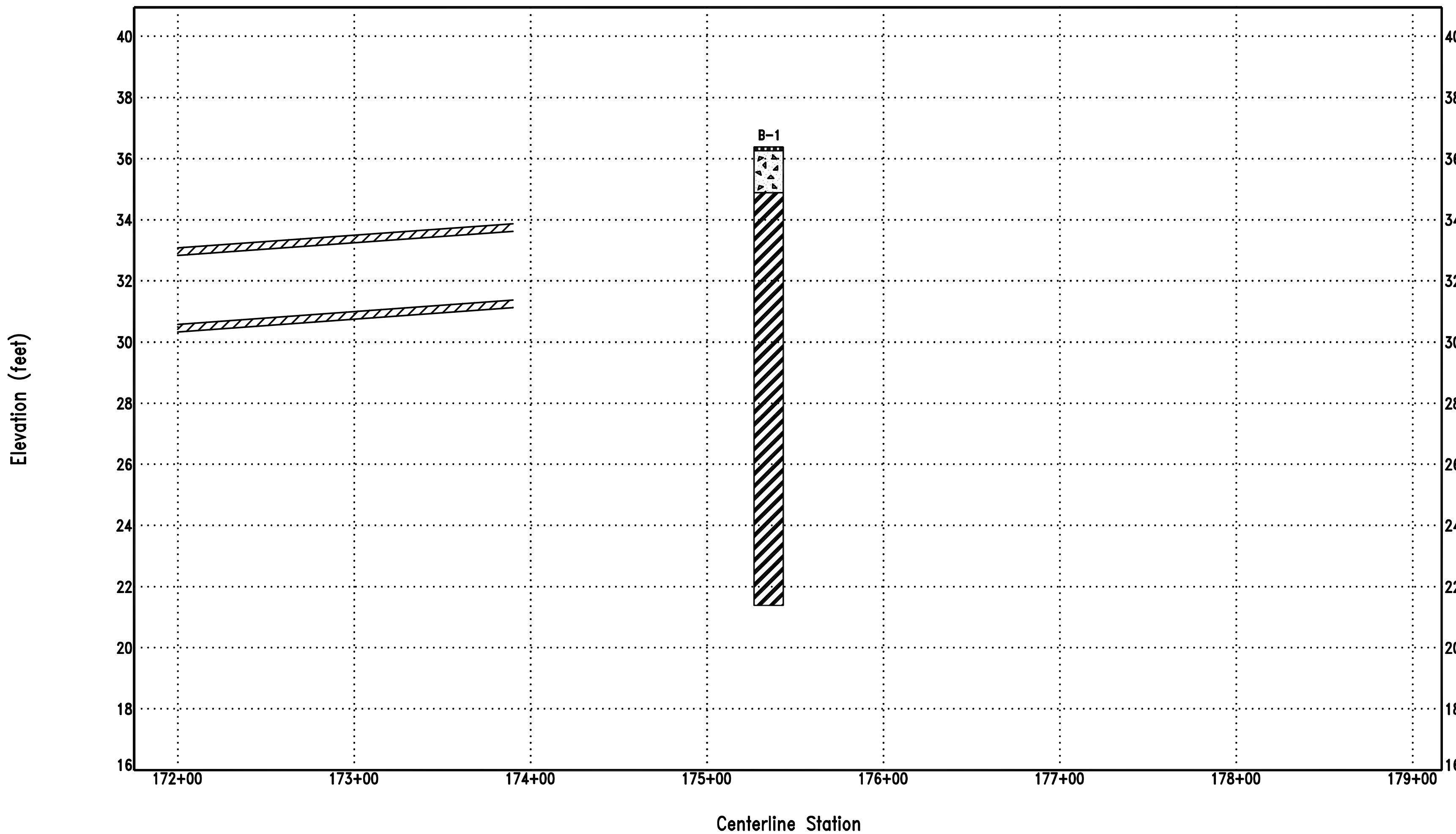
PROJECT NO.: HG1018380

DRAWING NO.: PLATE E



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SOIL PROFILE MLK BOULEVARD RECONSTRUCTION: IH 610 SOUTH TO BELLFORT		
PROJECT NO.: HG1018380	DRAWING NO.: PLATE E	

APPENDIX F

TRAFFIC COUNT AND DRAWIN OUTPUT

Exhibit 2.6
City of Houston - Traffic Counts March 2009
Martin Luther King Blvd - IH 610 S to S. Bellfort

Data File: 'ADTMARTINLUTHERKING04NB.rdf'
Site Code: 'ADT T-225'
Start Date: 3/24/2009
Start Time: 1:04 PM
Sensor Lay '11'

'REQUEST '6917 M.L.K.'
'CROSS S 'S. LOOP'
'CROSS S 'BELLFORT'

Date	Time	NORTH BOUND	
3/24/2009	1:04 PM	521	
3/24/2009	2:00 PM	578	
3/24/2009	3:00 PM	623	
3/24/2009	4:00 PM	639	
3/24/2009	5:00 PM	664	
3/24/2009	6:00 PM	619	
3/24/2009	7:00 PM	591	
3/24/2009	8:00 PM	439	
3/24/2009	9:00 PM	351	
3/24/2009	10:00 PM	264	
3/24/2009	11:00 PM	162	
3/25/2009	12:00 AM	120	120
3/25/2009	1:00 AM	44	44
3/25/2009	2:00 AM	43	43
3/25/2009	3:00 AM	47	47
3/25/2009	4:00 AM	77	77
3/25/2009	5:00 AM	204	204
3/25/2009	6:00 AM	462	462
3/25/2009	7:00 AM	898	898
3/25/2009	8:00 AM	721	721
3/25/2009	9:00 AM	468	468
3/25/2009	10:00 AM	512	512
3/25/2009	11:00 AM	445	445
3/25/2009	12:00 PM	533	533
3/25/2009	1:00 PM	584	584
3/25/2009	2:00 PM	662	662
3/25/2009	3:00 PM	624	624
3/25/2009	4:00 PM	642	642
3/25/2009	5:00 PM	639	639
3/25/2009	6:00 PM	654	654
3/25/2009	7:00 PM	556	556
3/25/2009	8:00 PM	434	434
3/25/2009	9:00 PM	365	365
3/25/2009	10:00 PM	266	266
3/25/2009	11:00 PM	179	179
3/26/2009	12:00 AM	98	
3/26/2009	1:00 AM	53	10179
3/26/2009	2:00 AM	37	
3/26/2009	3:00 AM	47	
3/26/2009	4:00 AM	73	

Exhibit 2.6
City of Houston - Traffic Counts March 2009
Martin Luther King Blvd - IH 610 S to S. Bellfort

3/26/2009	5:00 AM	197
3/26/2009	6:00 AM	505
3/26/2009	7:00 AM	910
3/26/2009	8:00 AM	723
3/26/2009	9:00 AM	487
3/26/2009	10:00 AM	494
3/26/2009	11:00 AM	552
3/26/2009	12:00 PM	360

Exhibit 2.6
City of Houston - Traffic Counts March 2009
Martin Luther King Blvd - IH 610 S to S. Bellfort

Data File: 'ADTMARTINLUTHERKING04SB.rdf'
Site Code: 'ADT T-206'
Start Date: 3/24/2009
Start Time: 1:06 PM
Sensor Lay '11'

'REQUEST '6917 M.L.K.'
'CROSS S 'S. LOOP'
'CROSS S 'BELLFORT'

Date	Time	SOUTH BOUND	
3/24/2009	1:06 PM	417	
3/24/2009	2:00 PM	506	
3/24/2009	3:00 PM	589	
3/24/2009	4:00 PM	744	
3/24/2009	5:00 PM	1103	
3/24/2009	6:00 PM	697	
3/24/2009	7:00 PM	525	
3/24/2009	8:00 PM	391	
3/24/2009	9:00 PM	302	
3/24/2009	10:00 PM	213	
3/24/2009	11:00 PM	154	
3/25/2009	12:00 AM	91	91
3/25/2009	1:00 AM	36	36
3/25/2009	2:00 AM	42	42
3/25/2009	3:00 AM	28	28
3/25/2009	4:00 AM	34	34
3/25/2009	5:00 AM	56	56
3/25/2009	6:00 AM	148	148
3/25/2009	7:00 AM	268	268
3/25/2009	8:00 AM	361	361
3/25/2009	9:00 AM	326	326
3/25/2009	10:00 AM	385	385
3/25/2009	11:00 AM	426	426
3/25/2009	12:00 PM	472	472
3/25/2009	1:00 PM	560	560
3/25/2009	2:00 PM	536	536
3/25/2009	3:00 PM	629	629
3/25/2009	4:00 PM	773	773
3/25/2009	5:00 PM	1010	1010
3/25/2009	6:00 PM	756	756
3/25/2009	7:00 PM	516	516
3/25/2009	8:00 PM	405	405
3/25/2009	9:00 PM	290	290
3/25/2009	10:00 PM	210	210
3/25/2009	11:00 PM	132	132
3/26/2009	12:00 AM	90	
3/26/2009	1:00 AM	49	8490
3/26/2009	2:00 AM	39	
3/26/2009	3:00 AM	18	
3/26/2009	4:00 AM	27	

Exhibit 2.6
City of Houston - Traffic Counts March 2009
Martin Luther King Blvd - IH 610 S to S. Bellfort

3/26/2009	5:00 AM	68
3/26/2009	6:00 AM	134
3/26/2009	7:00 AM	272
3/26/2009	8:00 AM	388
3/26/2009	9:00 AM	328
3/26/2009	10:00 AM	372
3/26/2009	11:00 AM	380
3/26/2009	12:00 PM	287

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Rigid Structural Design Module

Rigid Pavement Design - MLK Boulevard

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	5,817,040
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	600 psi
28-day Mean Elastic Modulus of Slab	3,120,000 psi
Mean Effective k-value	53 psi/in
Reliability Level	95 %
Overall Standard Deviation	0.35
Load Transfer Coefficient, J	3.2
Overall Drainage Coefficient, Cd	1.2
Calculated Design Thickness	9.45 in

Effective Modulus of Subgrade Reaction

Period	Description	Roadbed Soil Resilient Modulus (psi)	Base Elastic Modulus (psi)
1	-	1,800	30,000

Base Type	Lime Stabilized Subgrade
Base Thickness	8 in
Depth to Bedrock	100 ft
Projected Slab Thickness	9 in
Loss of Support Category	1
Effective Modulus of Subgrade Reaction	53 psi/in

Rigorous ESAL Calculation

Performance Period (years)	23
Two-Way Traffic (ADT)	18,669
Number of Lanes in Design Direction	2
Percent of All Trucks in Design Lane	90 %
Percent Trucks in Design Direction	50 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	85	2	0.0002	2	18,069
2	10	2	0.02	2	212,572
3	3	2	0.472	2	1,505,012
4	2	2	1.92	2	4,081,387
Total	100	-	-	-	5,817,040

Growth	Simple
Total Calculated Cumulative ESALs	5,817,040