GEOTEST
ENGINEERING, INC.

Geotechnical Engineers

GEOTECHNICAL INVESTIGATION
NEW WATER MAIN PROJECT ALONG
COURT, FONDREN AND HILLCROFT ROADS
CITY OF HOUSTON WATER PROJECT NO. 10447
G.F.S NO. S-1002-02-2

REPORT NO. 1140099601

Reported to:

ALEXANDER ENGINEERING, INC.

Spring, Texas

Submitted by:

GEOTEST ENGINEERING, INC.

Houston, Texas

Key Map Nos. 570 Y, Z & 610 D

GEOTEST ENGINEERING, INC.

Geotechnical Engineers & Materials Testing

5600 Bintliff Drive Houston, Texas 77036 Telephone: (713) 266-0588
Fax: (713) 266-2977

Report No. 1140099601
August 11, 1997

Alexander Engineering, Inc.
400 Randal Way, Suite 200
Spring, Texas 77388

Attention: Mr. John Gerdes, P.E.

Reference: Geotechnical Investigation
New Water Main Project along
Court, Fondren and Hillcroft Roads
City of Houston Water Project No. 10447
G.F.S No. S-1002-02-2

Gentlemen:

Presented herein is the geotechnical investigation report for the above referenced project. This study was authorized by accepting our Proposal No. 1140097299 on April 11, 1997.

We appreciate this opportunity to be of service to you. Please call on us when we can be of further assistance to you.

Very truly yours,
GEOTEST ENGINEERING, INC.

Hasnain Jaffri

Hasnain S. Jaffri
Sr. Staff Engineer

8-11-97

Kuo-Chiang "Frank" Lin, P.E.
Sr. Vice President

STATE OF TEXAS
KUO CHIANG LIN
58301
REGISTERED PROFESSIONAL ENGINEER

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EXECUTIVE SUMMARY

A geotechnical Investigation was conducted in connection with the design and construction of New water Main Project along Court, Fondren and Hillcroft Roads in Houston, Texas.

The project consists of installing 24-inch diameter water main. This investigation included drilling sixteen borings to depths ranging from 15 to 60 feet, performing laboratory tests on soil samples recovered from the borings and engineering analyses.

The principal findings and conclusions developed from this investigation are summarized below:

- Subsidence in the Houston area has substantially decreased in recent years. During 1906 through 1978 subsidence in the project area appears to have been between 1 and 3 feet. During 1978 through 1987 subsidence in the project area appears to have been between 0.5 and 1.5 feet. During 1987 through 1995 subsidence in the project area appears to have been between 0 and 0.5 feet.

- Based on the review of published and unpublished literature, aerial photographs and topographic maps of the project site, no geologic faults were identified which would impact this project.

- The subsurface soils along the water main alignment consist of stiff to hard clay, sandy clay and silty clay at least to a depth of 15 feet below the existing ground surface. Silty sand was encountered from 11 to 15 feet near north end of the project alignment. No groundwater was encountered in borings drilled for this alignment other than borings across two ditches.

- At the location of ditch crossing at future Fondren, the subsurface soils consist of stiff to hard clay and silty clay to a depth of 30 feet below the existing ground surface. Sandy silt was encountered between 15 and 18 feet on north side of the ditch. The groundwater was encountered at depths between 22 and 28 feet below the existing ground surface.

- At the location of ditch crossing at Hillcroft, the subsurface soils consist of cohesive fill from surface to about 4 feet depth. Below the fill, sandy clay and clay were encountered to a depth of 60 feet. Sand was encountered between 15 and 20 feet on south side of the ditch. The groundwater was encountered at depths between 13 and 15 feet below the existing ground surface.

- No specific problems are anticipated with placement of the water main by pipe and casing augering at the intersection of Hillcroft and West Fuqua.

- Restrained joints should be used to resist the unbalanced hydrostatic forces. Geotechnical parameters for design of these restraints are provided in this report.

- The pipe bridge across the ditch at Hillcroft can be supported on driven prestressed precast concrete piles. Pile capacity curves were developed and are presented in this report.

- All excavations and trenching operations should be in accordance with OSHA standards.

- Bedding and backfill for the water main installation should be in accordance with the most recent City of Houston Specifications.

2.0 INTRODUCTION

Alexander Engineering, Inc. was selected by the City of Houston for the design and construction of this project. Alexander Engineering, Inc. selected Geotest Engineering, Inc. to provide geotechnical engineering services related to the design and construction of the project.

2.1 Location and Description of the Project

The south end of the proposed alignment is near the existing water facility at Court and Hillcroft Roads. The proposed route will follow east along Court, north along Fondren Road and north along Hillcroft Road. The north end of the proposed alignment is near the intersection of Hillcroft Road and Chasewood Drive. This project consists of installing 24-inch water main along Court, Fondren and Hillcroft roads.

2.2 Scope of Work

The purposes of this investigation were to determine subsurface conditions and to develop geotechnical recommendations for the design and construction of the proposed water main. The scope of this investigation was based on the information furnished by Alexander Engineering, Inc. and consisted of the following tasks.

- Drill and sample sixteen borings to depths ranging from 15 to 60 feet.
- Perform laboratory tests on soil samples recovered from the boring.
- Perform engineering analyses to develop geotechnical recommendations pertinent to the design and construction of the proposed water main.
- Prepare a geotechnical report.

3.0 SUBSURFACE INVESTIGATION PROGRAM

Subsurface conditions were explored by drilling sixteen borings to depths ranging from 15 to 60 feet. The borings, designated as B-1 through B-5, B-5A and B-6 through B-15, were drilled with a marsh buggy and truck-mounted rotary drilling rig. The approximate boring locations are shown on Figures 1.1 through 1.3. A summary of field exploration data for this study is provided in Table 1. The survey data was provided to us by Alexander Engineering, Inc.

Samples were obtained continuously to a 10-foot depth and at 5-foot intervals thereafter in the boring. Samples of cohesive soils were obtained with a 3-inch thin-walled tube sampler in general accordance with ASTM Method D 1587. Granular soils were sampled with a 2-inch split-barrel sampler in accordance with ASTM Method D 1586. Each sample was removed from the sampler in the field, carefully examined and then logged by an experienced soils technician. Suitable portions of each sample were sealed and packaged for transportation to Geotest's laboratory. The shear strength of cohesive soil samples was estimated using a pocket penetrometer in the field. Driving resistances for the split-barrel sampler in granular soils were recorded as "Blows per Foot" on the boring log.

Detailed descriptions of the soils encountered in the borings are given on the boring logs presented on Figures A-1 through A-16 in Appendix A. A key to "Symbols and Terms used on Boring Logs" is given on Figure A-17 in Appendix A. The depth at which groundwater was encountered is also noted on the boring logs.

4.0 LABORATORY TESTING PROGRAM

The laboratory testing program was designed to evaluate the pertinent physical properties and shear strength characteristics of the subsurface soils. Classification tests were performed on selected samples to aid in soil classification.

Undrained shear strengths of selected cohesive samples were determined by unconfined compression tests. The results of the unconfined compression tests are plotted on the boring logs as solid circles. The shear strength of cohesive samples was determined in the field with a calibrated hand penetrometer and also in the laboratory with a Torvane. The shear strength values obtained from the penetrometer and Torvane are plotted on the boring logs as open circles and triangles, respectively.

Water content and dry unit weight were routinely determined for each unconfined compression test sample. Water content determinations were also made on other samples to define the moisture profile at the boring location. The liquid and plastic limit tests were performed on appropriate samples. Sieve analysis were performed on selected samples. The results of all tests are plotted or summarized on the boring logs. Grain size distribution curves are presented on Figure B-1 in Appendix B.

5.0 SUBSURFACE AND SITE CONDITIONS

5.1 Natural Hazards

5.1.1 Subsidence - Land surface subsidence, related to groundwater pumpage and to a lessor extent, the withdrawal of oil and gas, has probably occurred in the Houston area since the early settlers began to drill wells. During the period of 1906 to 1978, subsidence in the project area appears to have been between 1 and 3 feet.

In 1976, the State Legislature created the Harris-Galveston Subsidence District to regulate the pumpage of groundwater. Since creation of the district, the overall rate of subsidence in Harris County and the City of Houston been has substantially reduced. Subsidence in the project area during the period of 1978 to 1987 appears to be between 0.5 and 1.5 feet. Subsidence in the project area during the period of 1987 to 1995 appears to be between 0 and 0.5 feet.

5.1.2 Geologic Faults in Vicinity of Site - A review of information in the Geotest library relating to known surface and subsurface geologic faults, in the general area of the project site, was undertaken. The information consisted of published reports, open files reports and information contained in our files relating to geologic faults in this area. In addition, the site was inspected for signs of surface faulting.

Based on the published documents, the proposed alignment is located within the area of Blue Ridge Salt Dome. The subsurface faults associated with the Blue Ridge salt dome are about 5600 to 6200 feet deep. This deep-seated salt dome does not appear to impact the proposed alignment.

The nearest known surface faults, Pier Junction Faults, are found to exist about 1.5 mile east of the north end of the alignment. The southern projection of these faults does not intersect the proposed alignment.

Based on available information and site inspection, there is no evidence that these faults would impact the proposed project alignment.

5.2 Site Stratigraphy and Geotechnical Characterization

The project site lies on the Beaumont Formation. The clays and sands of the Beaumont Formation are over consolidated as a result of desiccation or frequent rising and lowering of the sea level and subsequently the groundwater table. Consequently, clays of this formation have moderate to high shear strength and relatively low compressibility. The sands of the Beaumont Formation are typically very fine and often silty. There is evidence in the Houston area of the occurrence of cemented material (sandstone and siltstone) deposits within this Formation.

Based on the subsurface soils encountered in the discrete boreholes drilled, four boring log profiles were developed and are presented on Figures 2.1 through 2.4. To the left of each boring shown on the profile is an indication of the consistency or density of each stratum. More than one consistency for an individual stratum indicates that the consistency is different at different depths within the stratum. For cohesive soils, consistency is related to the undrained shear strength of the soil and for granular soils the consistency is related to the relative density of the soil. The symbols and abbreviations used on boring log profiles are given on Figure 2.5. To the right of each boring shown on the profile is the overall classification of the soil contained within each stratum. The classification is based on the Unified Soil Classification System (USCS).

The soils encountered are described below:

- Along Alignment - The soils encountered along the proposed alignment consist of stiff to hard clay, silty clay and sandy clay at least to a depth of about 15 feet below the ground surface. In boring B-14 and B-15, silty sand was encountered from 11 to 15 feet. The silty clay and sandy clay are of low to medium plasticity with liquid limits ranging from 31 to 46 percent and plasticity indices ranging from 22 to 26 percent. The clay is of

highly plastic with liquid limits ranging from 52 to 89 percent and plasticity indices ranging from 31 to 38 percent. The clay is slickensided at various depths. The fines content of silty sand ranged from 18 to 19 percent.

- Ditch across future Fondren. In borings B-4 and B-5, the subsurface soils consist of stiff to hard clay and silty clay to a depth of 30 feet below the existing ground surface. Sandy silt was encountered between 15 and 18 feet on north side of the ditch. The silty clay is of low to medium plasticity with a liquid limit of about 33 percent and plasticity index of about 17 percent. The clay is of highly plastic with liquid limits ranging from 64 to 67 percent and plasticity indices ranging from 39 to 42 percent. The clay is slickensided at various depths.

- Ditch across Hillcroft - In boring B-12 and B-13, fill was encountered from surface to about 4 feet depth. Below the fill, sandy clay and clay were encountered to a depth of 60 feet. In boring B-12, sand was encountered from 15 to 20 feet. The silty clay is of low to medium plasticity with liquid limits ranging from 28 to 34 percent and plasticity indices ranging from 6 to 18 percent. The clay is of highly plastic with liquid limits ranging from 54 to 81 percent and plasticity indices ranging from 32 to 52 percent. The clay is slickensided at various depths.

5.3 Groundwater

The groundwater levels encountered during field investigation are tabulated below:

Location	Depth (feet)
Near a ditch at future Fondren	22 to 28
Near a ditch at Hillcroft	13 to 15

6.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

6.1 General

It is understood that this project consists of installing water main. A pipe bridge is proposed at ditch crossing at Hillcroft. Pipe and Casing augering may be needed at the intersection of Hillcroft and West Fuqua.

6.2 Trench Excavation

6.2.1 Geotechnical Parameters. Based on the soil conditions revealed by the borings, geotechnical parameters, including soil stiffness categories, were developed for the design of the water main. The geotechnical design parameters are provided in Table 2. For design, the groundwater level should be assumed to exist at the ground surface.

6.2.2 Trench Stability. It is understood that open-cut trenching is planned for the construction for most sections of the water main. The trench excavation may be shored, laid back to a stable slope or some other equivalent means used to provide safety for workers and adjacent structures. The excavating and trenching operations should be in accordance with OSHA Standards, OSHA 2207, Subpart P, latest revision and the City of Houston requirements.

- Excavation Shallower Than 5 Feet - Excavations that are less than 5 feet deep should be appropriately protected when any indication of hazardous ground movement is anticipated.

- Excavations Deeper Than 5 Feet - Excavations that are deeper than 5 feet should be sloped, shored, shielded or provided with some other appropriate means of protection where workers might be exposed to moving ground or cave-ins. The slopes and shoring

should be in accordance with the trench safety requirements per OSHA Standards. The following items provide design criteria for trench stability.

(i) OSHA's Soil Type. Based on the soil conditions revealed by the borings and the design groundwater level, OSHA's soil type "C" should be used for the determination of allowable maximum slope and/or the design of a shoring system.

(ii) Trench Support Earth Pressure. Based on the subsurface conditions indicated by this investigation, trench support earth pressure diagrams were developed and are presented on Figures 3.1 and 3.2. The pressure diagrams can be used for the design of temporary trench bracing. For trench box a lateral earth pressure resulting from an equivalent fluid with a unit weight of 95 pcf is recommended. Effect of surcharge loads at the ground surface should be added to the computed lateral earth pressures. A surcharge load, q, will typically result in a lateral load equal to 0.5 q. The above value of equivalent fluid pressure is based upon an assumption that the groundwater level is near the ground surface, since these conditions may exist after a heavy rain or flooding.

(iii) Bottom Stability. In braced cuts, if tight sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable under a certain condition. This condition is governed by the shear strength of the soils and by the differential hydrostatic head. If semi-cohesionless or granular soils (sand, silty sand, clayey sand, silt, clayey silt and sandy silt) are encountered, excavation should be done after dewatering to avoid bottom stability problems. For cuts in cohesive soils (sandy clay, silty clay and clay), stability of the bottom can be evaluated in accordance with the procedure outlined on Figure 4.

6.2.3 Groundwater Control. Excavations for the proposed pipeline may encounter groundwater seepage to varying degrees depending upon the groundwater conditions at the time of construction and the location and depth of the trench.

In cohesive soils, groundwater may be managed by collection in trench bottom sumps for pumped disposal. When saturated deposits of granular (silty sand) or semi-cohesionless soils (sandy silt) are encountered, groundwater is typically controlled by the installation of vacuum well points or deep wells with a submersible pump. The practical maximum depth for the use of vacuum well points is considered to be about 15 feet. Where groundwater control is required below 15-foot depth, deep wells with submersible pumps have generally proved successful. However, it should be noted that contractor should verify the water level at the time of construction and should use appropriate method of dewatering, if required.

6.2.4 Pipe Bedding and Backfill. It is recommended that the City of Houston Specification 2511 "Water Main" and Drawing No. 02511-01, or latest revision should be followed for bedding and backfill.

6.2.5 Live Loads on Pipeline due to Traffic Loads on the pipe due to traffic should be considered. A graph providing calculated vertical stress on pipe due to traffic loads is given on Figure 5.

6.2.6 Piping System Thrust Restraint Unbalanced thrust forces will occur at any point in the pipe where the direction or cross sectional area of the flow changes. The force diagram shown on Figure 6 illustrates the thrust force generated by flow at a bend in the pipe. The equations for computing this thrust force are also given on this figure. The thrust force will often require more resistance or support 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.

On review of the preliminary plans for the water main a few horizontal bends were observed which may require restraint in addition to that supplied by the pipe bearing on the backfill. In general, thrust blocks, both horizontal and vertical and restrained joints are common methods of supplying additional reaction and are discussed below.

- Bearing Thrust Block - A typical thrust block arrangement for a horizontal bend is shown on Figure 7. The free body diagram of the thrust and reaction forces along with the design equations are also given on this figure. The bearing block should be placed against undisturbed soil. Usually the block height (h) should be equal to or less than one half the total depth of the block base (H_T), and also should not be less than the conduit outside diameter. In general, the block width (b) varies from one to two times the block height (h). The soil parameters provided in Table 2 may be used for the design of thrust blocks.

- Gravity Thrust Block A typical gravity thrust block and a design equation for a vertical bend are presented on Figure 8. The horizontal thrust component (T_x) is counteracted by soil pressure on the vertical face of the block (F_p) or by joint restraint. The vertical thrust component (T_y) is counteracted by the weight of the concrete (W_g). The minimum size of the block base should be computed using an allowable soil bearing pressure, q_a, as follows:

In cohesionless soils

$$q_a = 194\ H_t + 49\ B \leq 4000 \text{ psf}$$

where,

H_t = depth to bottom of block in feet, and

B = block base dimension in feet.

In clays

$$q_a = 3c, \text{ psf}$$

where,

c = cohesion in psf (from Table 2).

- Restrained Joints Occasionally, thrust blocks are not a practical or economical reaction system due to limited space, access, unstable soils, or possible disturbance due to future excavations. Where thrust blocks are not practical, restrained joints, allowing thrust and shear forces to be transmitted across the pipe joints, are employed to allow a number of pipe sections to act integrally in bearing. A plan view and free body diagram of a pipe bend employing the pipe with restrained joints to provide reaction to the thrust is given on Figure 9. The equations necessary to determine the length of joint restrained pipe are also provided on Figure 9.

The in-situ soil parameters presented in Table 2 may be used to determine the lateral soil resistance (passive soil pressure) at the bend locations. The backfill (granular soils) parameters provided below may be used to determine the sliding frictional resistance on the pipe.

Backfill internal friction angle, $\varnothing_b$	=	25°
Backfill soil cohesion, C_b	=	0 psf
Backfill unit weight, γ_b (above groundwater level)	=	120 pcf
(below groundwater level)	=	60 pcf

Reinforced concrete encasement may be used in lieu of the manufactured joint restraint system. The equations given on Figure 10 and soil parameters given above can be used for the design of reinforced concrete encasement. The following safety factors shall be used in sizing the restraining system:

a. Apply a factor of safety equal to 1.5 for passive soil resistance.

b. Apply a factor of safety equal to 2.0 for soil friction.

6.3 Trenchless Installation

It is understood that water main will be installed by pipe and casing augering at the intersection of Hillcroft and West Fuqua.

6.3.1 Geotechnical Parameters. Based on the soil conditions revealed by the borings B-9 and B-10, the basic geotechnical parameters tabulated on Table 3 may be used for the design of pipe and casing portion.

6.3.2 Earth Pressures on Pipe and Casing. The earth pressure values on the pipe and casing should be obtained from Figure 10.

6.3.3 Ground Movement Control. Ground movement, in terms of loss of ground or ground lost, is commonly associated with pipe and casing augering. If such ground movement is excessive, it may cause damage to the structures, roads and services located above the pipeline. While ground movement cannot be eliminated, it can be controlled with certain limits by the use of proper construction techniques and good quality of workmanship. These include, but are not limited to, prevention of excessive ground loss during augering, prompt grouting of voids that are created during augering, timely backfill grouting of the annular space between the pipe or casing and the surrounding soil and prevention of undue loss of fines through dewatering.

6.3.4 Auger Pits. Auger pits should be excavated as per City of Houston Standard Specification 02447.

6.3.5 Groundwater Control. Excavation for pits may encounter groundwater seepage to varying degrees depending upon the groundwater conditions at the time of construction. Groundwater control, as discussed in Section 6.2.3 of this report, should be followed for groundwater control of auger pits. To prevent the soil from "blow-up" into the pit when the pit bottom is founded in or near

water bearing sands or silts, the groundwater should be lowered to at least 5 feet below the excavation bottom.

6.3.6 Auger Pit Backfill. Auger pits should be backfilled as per City of Houston Standard Specification, Drawing No. 02447-01, latest revision.

6.3.7 Live Loads on Pipeline due to Traffic Loads on the pipe due to traffic should be considered. A graph providing calculated vertical stress on pipe due to traffic loads is given on Figure 5.

6.4 Piling for Pipe Bridge

It is understood that piling will be used to carry pipeline across the ditch along Hillcroft. Based on the subsurface conditions revealed by the borings B-12 and B-13, the pipe bridge foundations can be supported on driven prestressed precast concrete piles. The allowable axial capacities for the prestresses precast concrete piles are presented graphically on Figures 11.1 and 11.2.

If it is planned to protect the side slopes near the pipe bridge, then it is recommended that Figure 11.1 be used for end bents. However, if protection is not planned then there will be possibility of erosion. In this case Figure 11.2 should be used for calculation of allowable bearing pressures.

6.4.1 Spacing of Piles. To minimize the group effect, it is recommended that the piles be spaced so that the adjacent edge to edge distance between piles is at least 2 times the pile width.

6.4.2 Effect on Existing Bridge Foundations. The effect on the existing bridge due to the driving of new piling should be minimal, if the distance between the new pile friction surface and the existing bridge foundations is at least 7 pile width.

6.4.3 Pile Installation Considerations. Piles should be driven to the design penetrations and should not be terminated at shallower depths on the basis of any dynamic formula. No jetting or pilot hole should be used. If piles are to be installed to any appreciable depth into very dense sediments, a pile driveability analysis should be performed. Such analysis will help in evaluating the pile stiffness-hammer combination best suited for pile installation by driving. If any unusual pile driving is encountered, due to the presence of very dense sand stratum, Geotest should be notified for a reassessment of axial pile capacity. It is recommended that a Geotest engineer be present during pile installation to monitor pile driving and to evaluate pile driving data and the effect of installation procedures.

7.0 PROVISIONS

The description of subsurface conditions and the design information contained in this report are based on the test boring made at the time of drilling at specific locations. However, some variation in soil conditions may occur between test boring. Should any subsurface conditions other than those described in our boring be encountered, Geotest should be immediately notified so that further investigation and supplemental recommendations can be provided.

The depth of the groundwater level may vary with changes in environmental conditions such as frequency and magnitude of rainfall. The stratification lines on the log of borings represent the approximate boundaries between soil types, however, the transition between soil types may be more gradual than depicted.

This report has been prepared for the exclusive use of Alexander Engineering Inc., and the City of Houston for the design and construction of New Water Main Project.

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ILLUSTRATIONS

FIGURES 1 through 11

Job No. 1140099601

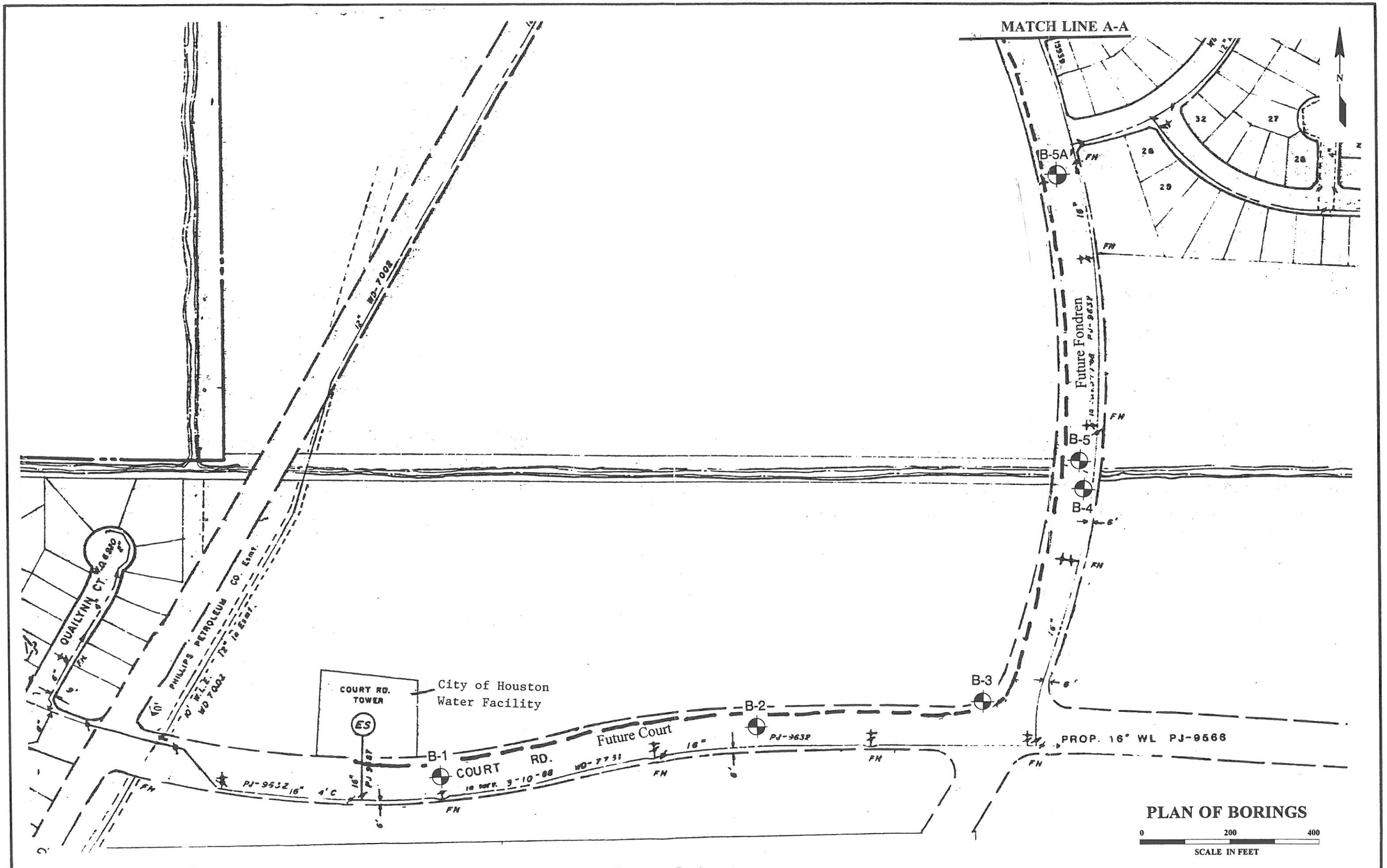

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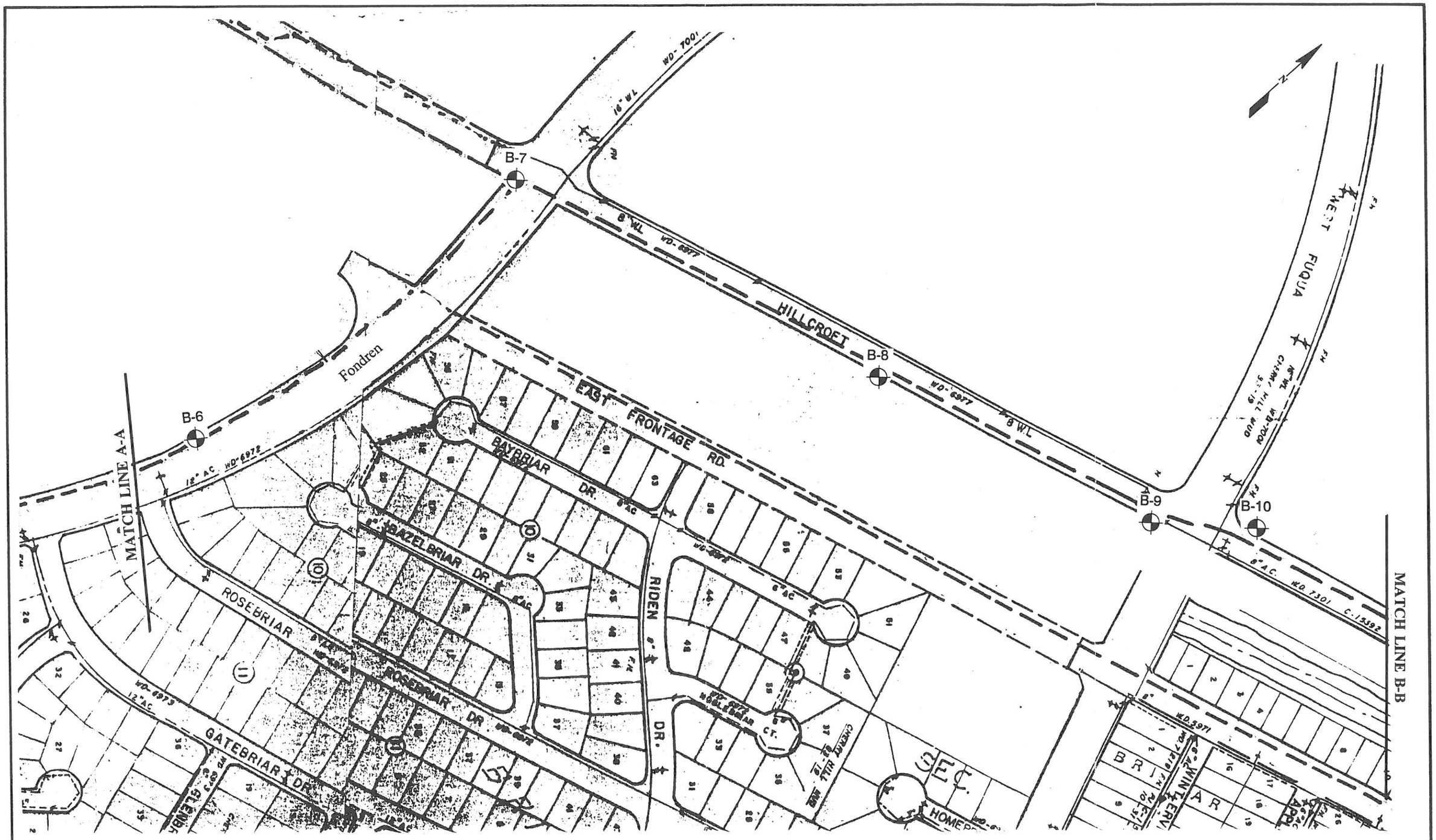
FIGURE 1.1

Job No. 1140699001



PLAN OF BORINGS

0 200 400

SCALE IN FEET

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FIGURE 1.2

Job No. 1140099601

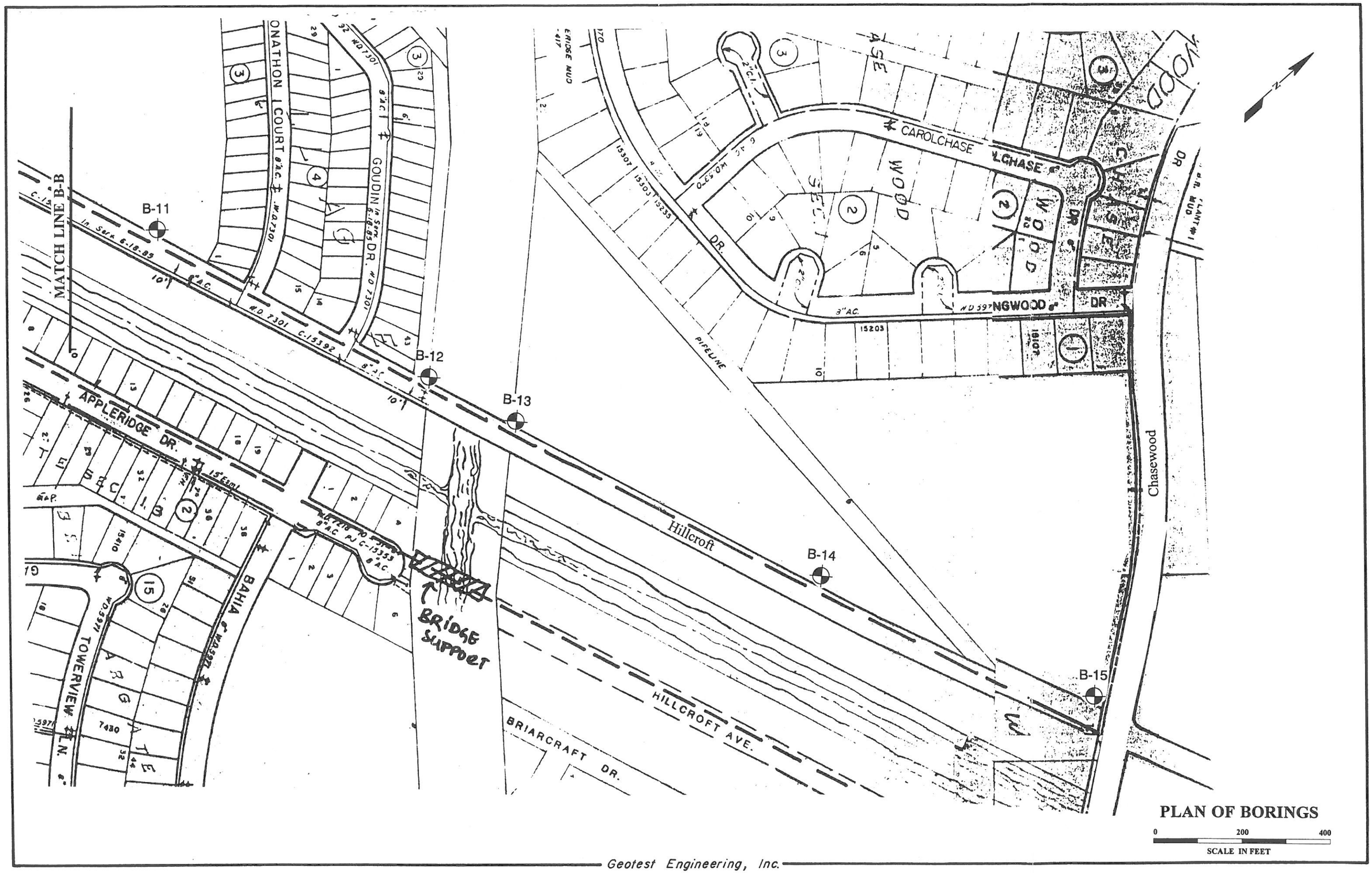

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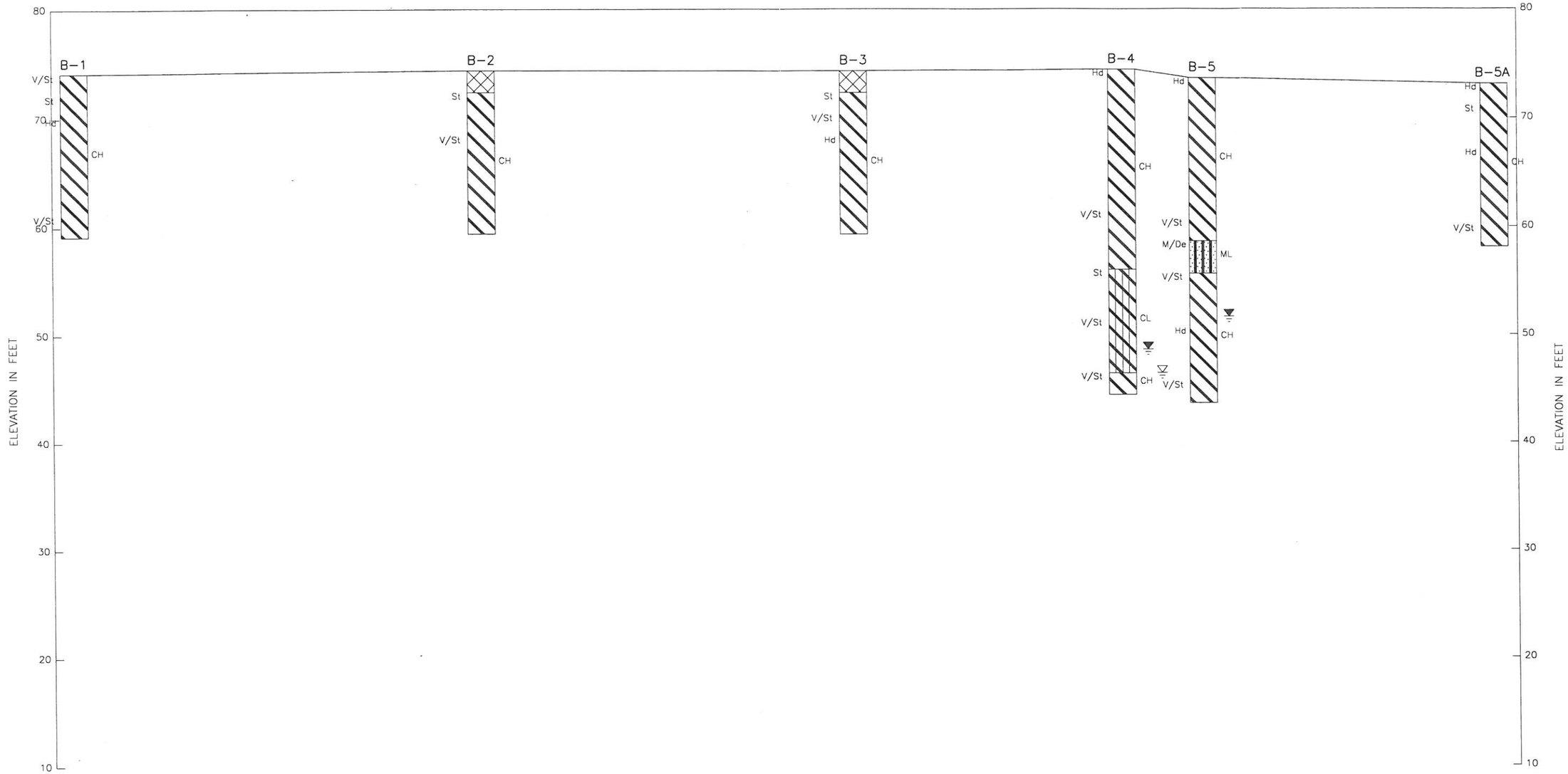
FIGURE 1.3



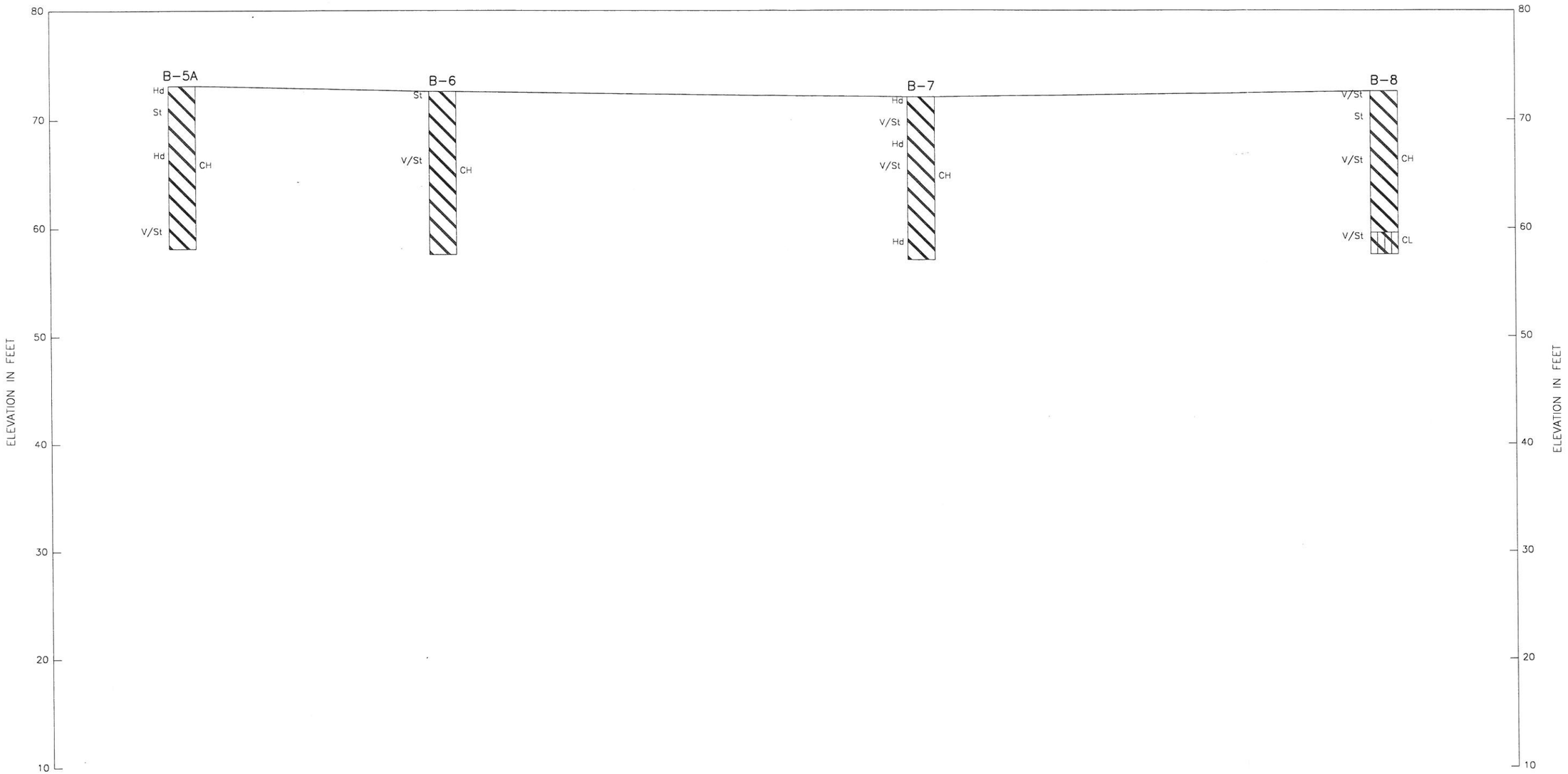
GENERAL NOTES:

1. See Figure 1.1 for approximate location of borings.
2. Data concerning subsurface conditions have been obtained at boring locations only. Actual conditions between borings may differ from the profile shown here.
3. See logs of boring for detailed description of soils encountered in each borehole.
4. See Figure 2.5 for symbols and abbreviations used on this profile.
5. Ground surface elevation at each boring location was based on survey data provided to us by Alexander Engineering, Inc.

BORING LOG PROFILE

0 100 200 300 400

HORIZONTAL SCALE IN FEET



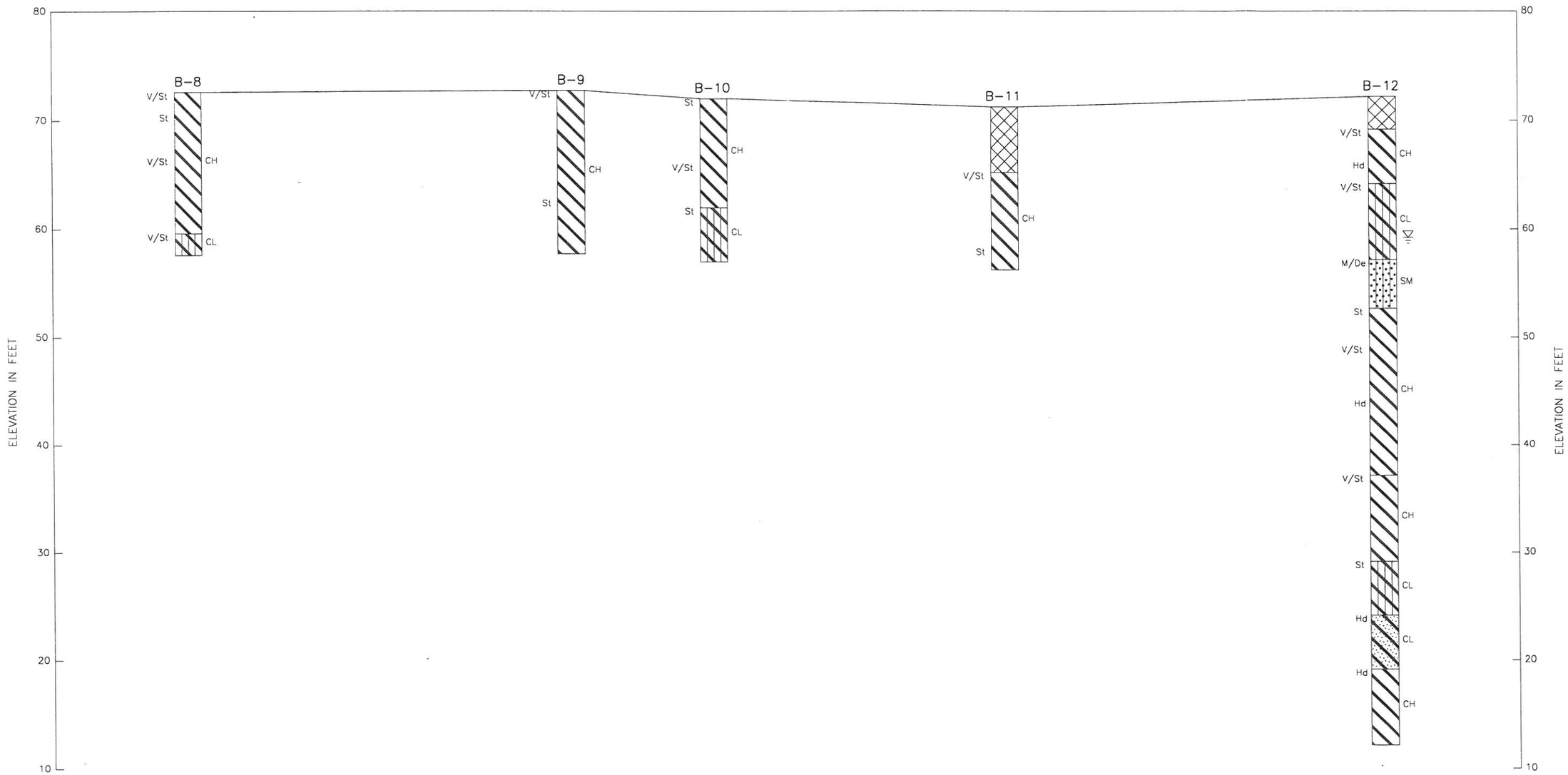
GENERAL NOTES:

1. See Figures 1.1 and 1.2 for approximate location of borings.
2. Data concerning subsurface conditions have been obtained at boring locations only. Actual conditions between borings may differ from the profile shown here.
3. See logs of boring for detailed description of soils encountered in each borehole.
4. See Figure 2.5 for symbols and abbreviations used on this profile.
5. Ground surface elevation at each boring location was based on survey data provided to us by Alexander Engineering, Inc.

BORING LOG PROFILE

0 100 200 300 400

HORIZONTAL SCALE IN FEET



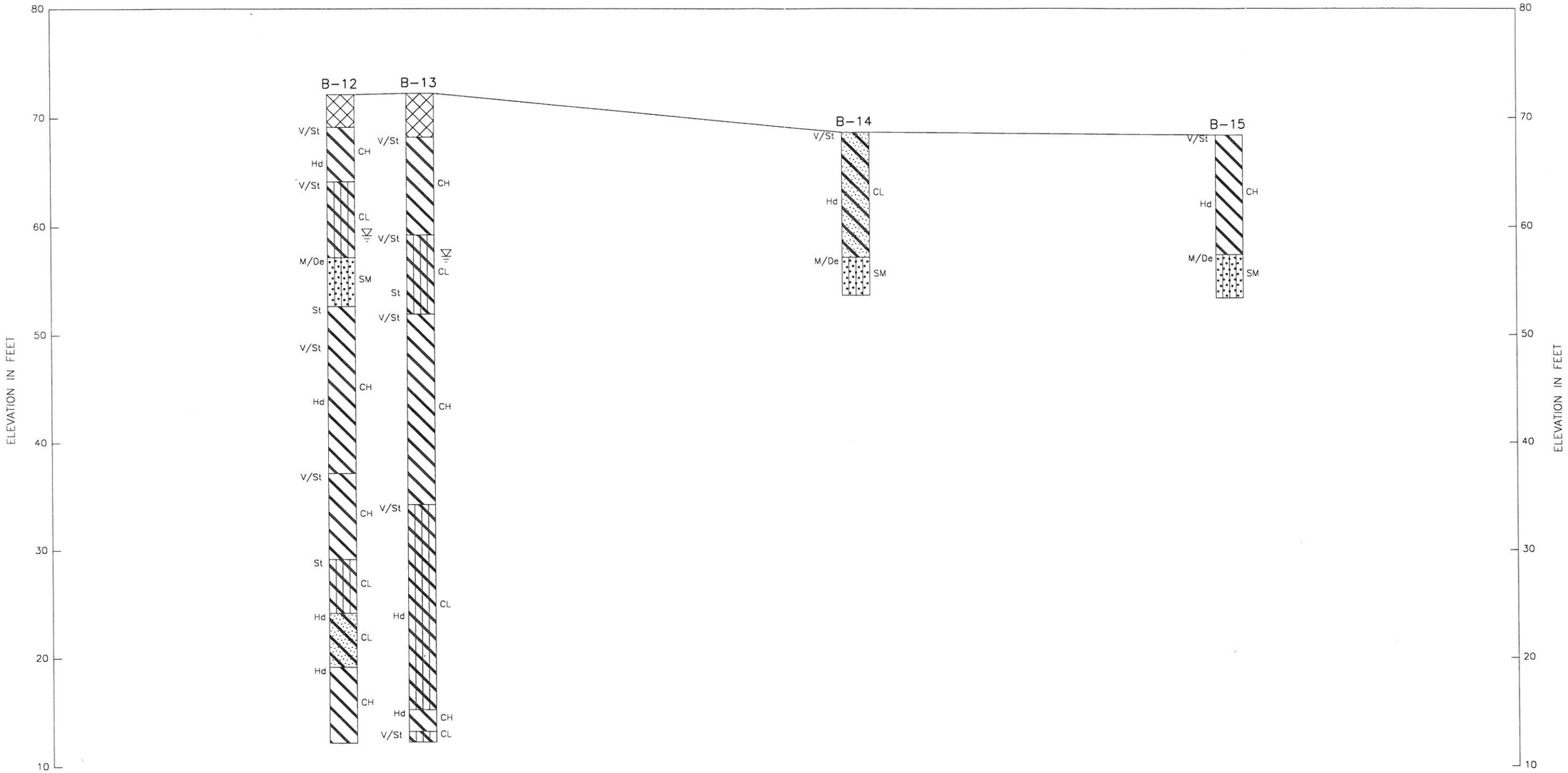
GENERAL NOTES:

1. See Figures 1.2 and 1.3 for approximate location of borings.
2. Data concerning subsurface conditions have been obtained at boring locations only. Actual conditions between borings may differ from the profile shown here.
3. See logs of boring for detailed description of soils encountered in each borehole.
4. See Figure 2.5 for symbols and abbreviations used on this profile.
5. Ground surface elevation at each boring location was based on survey data provided to us by Alexander Engineering, Inc.

BORING LOG PROFILE

0 100 200 300 400

HORIZONTAL SCALE IN FEET



GENERAL NOTES:

1. See Figure 1.3 for approximate location of borings.
2. Data concerning subsurface conditions have been obtained at boring locations only. Actual conditions between borings may differ from the profile shown here.
3. See logs of boring for detailed description of soils encountered in each borehole.
4. See Figure 2.5 for symbols and abbreviations used on this profile.
5. Ground surface elevation at each boring location was based on survey data provided to us by Alexander Engineering, Inc.

BORING LOG PROFILE

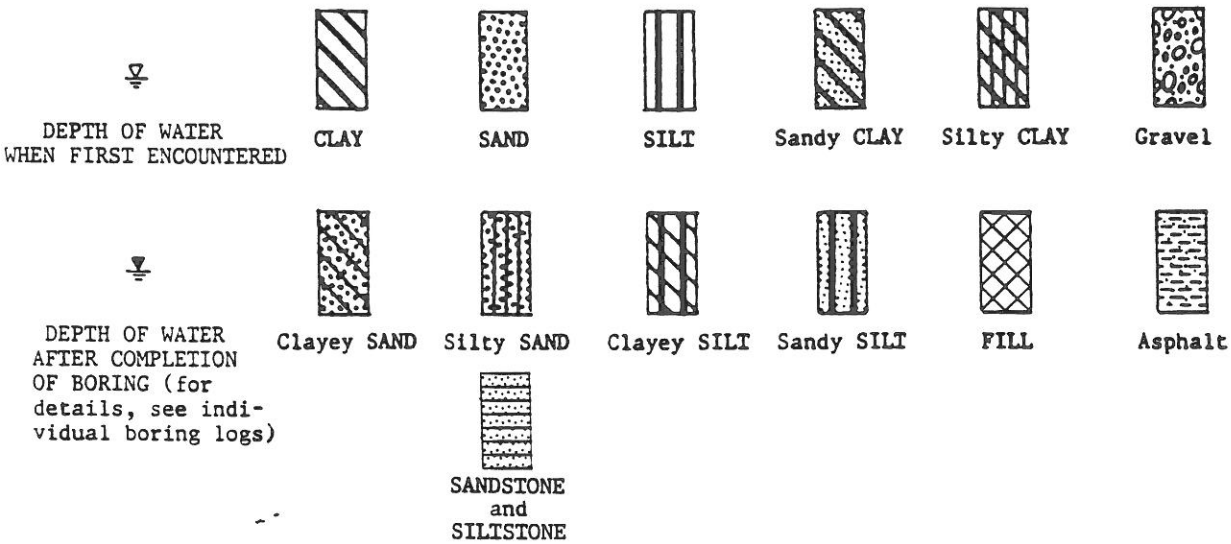
0 100 200 300 400

HORIZONTAL SCALE IN FEET

Job No.: _____

SYMBOLS AND ABBREVIATIONS USED ON BORING LOG PROFILE

LEGEND



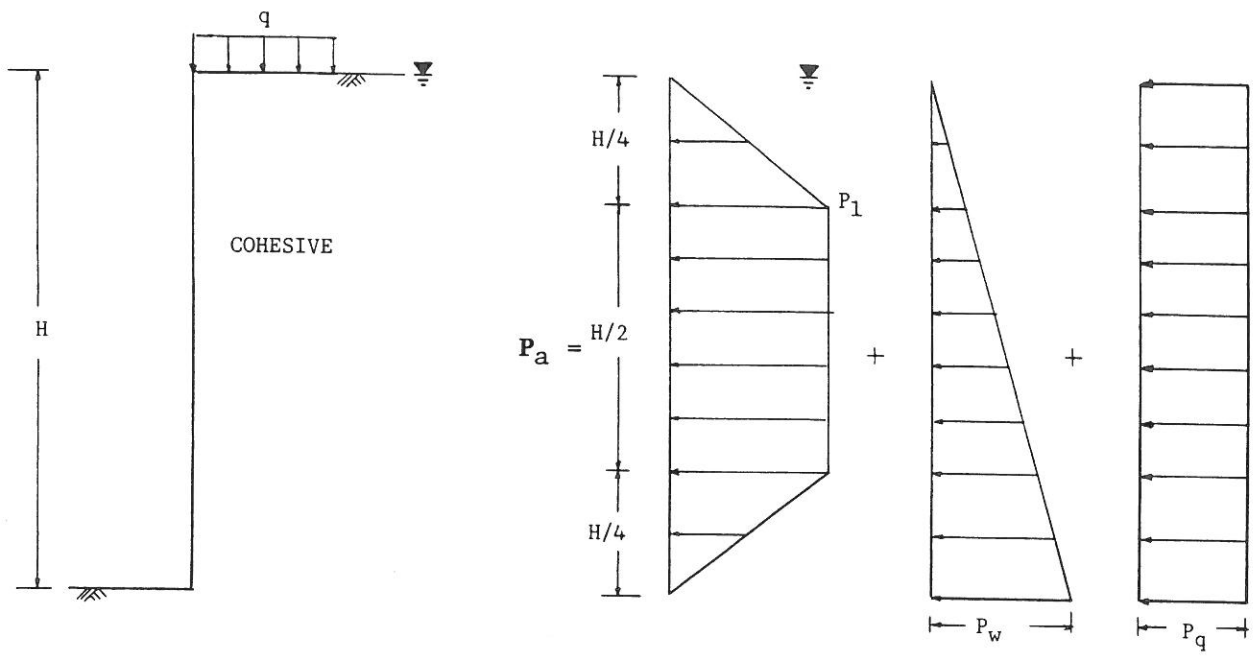
ABBREVIATIONS USED FOR CONSISTENCY/DENSITY

COHESIVE SOILS

V/So	:	Very Soft
So	:	Soft
Fm	:	Firm
St	:	Stiff
V/St	:	Very stiff
Hd	:	Hard
V/Hd	:	Very Hard

GRANULAR SOILS

V/Lo	:	Very Loose
Lo	:	Loose
S/Co	:	Slightly Compact
Co	:	Compact
M/De	:	Medium Dense
De	:	Dense
V/De	:	Very Dense



TYPICAL SOIL PARAMETERS

See Table 2 for typical values of Soil Parameters

BRACED WALL

$P_1 = 0.3\ \gamma_c'\ H$

$P_w = \gamma_w\ H = 62.4\ H$

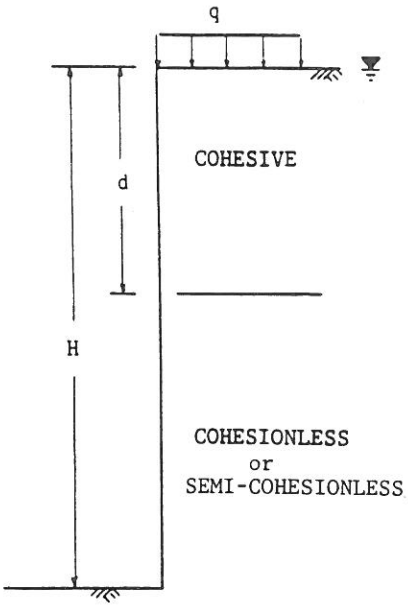
$P_q = 0.5q$

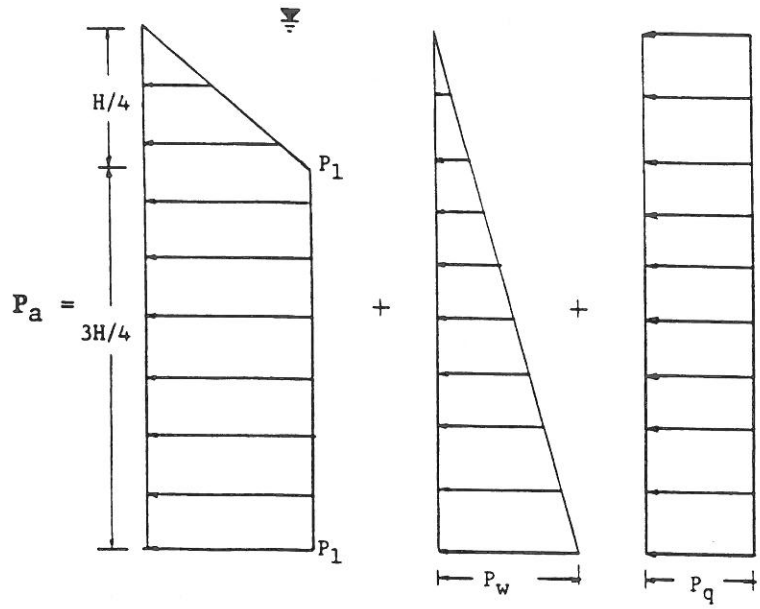
Where:

γ_c' = Submerged unit weight of cohesive soil, pcf ;
γ_w = Unit weight of water, pcf;
q = Surcharge load at surface, psf;
P_a = Lateral pressure, psf;
P_1 = Active earth pressure, psf;
P_q = Horizontal pressure due to surcharge, psf;
p_w = Hydrostic pressure due to groundwater, psf;
H = Depth of braced excavation, feet

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL





TYPICAL SOIL PARAMETERS
See Table 2 for
typical values of
Soil Parameters

$$\gamma_{avg} = \frac{\gamma_c' d + \gamma_s' (H-d)}{H}$$

BRACED WALL

$P_1 = 0.3\ \gamma_{avg} H$
$P_w = 62.4\ H$
$p_q = 0.5\ q$

Where:

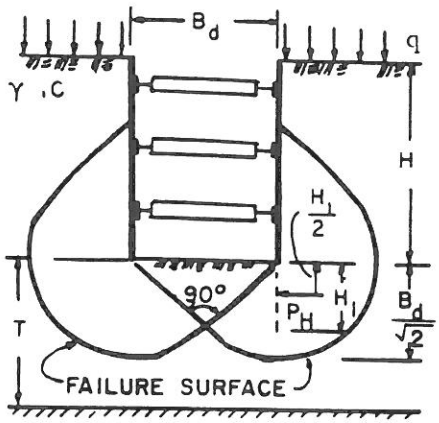
γ_c' = Submerged unit weight of cohesive soil, pcf;
γ_s' = Submerged unit weight of cohesionless or semi-cohesionless soil, pcf ;
γ_{avg} = Average unit weight of soils, pcf;
q = Surcharge load at surface, psf;
P_a = Lateral pressure, psf;
P_1 = Active earth pressure, psf;
P_q = Horizontal pressure due to surcharge, psf;
P_w = Hydrostatic pressure due to groundwater, psf;
H = Depth of braced excavation, feet

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL OVER
COHESIONLESS OR SEMI-COHESIONLESS SOIL

CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLIMITED ($T > 0.7\ B_d$)

L = LENGTH OF CUT



If sheeting terminates at base of cut:

$$\text{Safety factor, } F_S = \frac{N_C C}{\gamma H + q}$$

N_C = Bearing capacity factor, which depends on dimensions of the excavation : B_d , L and H (use N_C from graph below)

C = Undrained shear strength of clay in failure zone beneath and surrounding base of cut (See Table 2)

γ = Unit weight of soil (See Table 2)

q = Surface surcharge

If safety factor is less than 1.5, sheeting or soldier piles must be carried below the base of cut to insure stability - (see note)

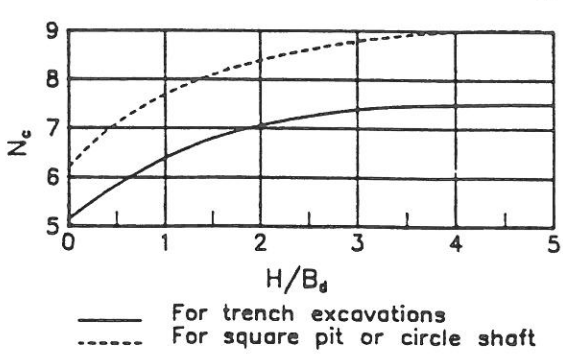
$$H_1 = \text{Buried length} = \frac{B_d}{2} \geq 5 \text{ feet}$$

Note : If soldier piles are used, the center to center spacing should not exceed 3 times the width or diameter of soldier pile .

Force on buried length, P_H:

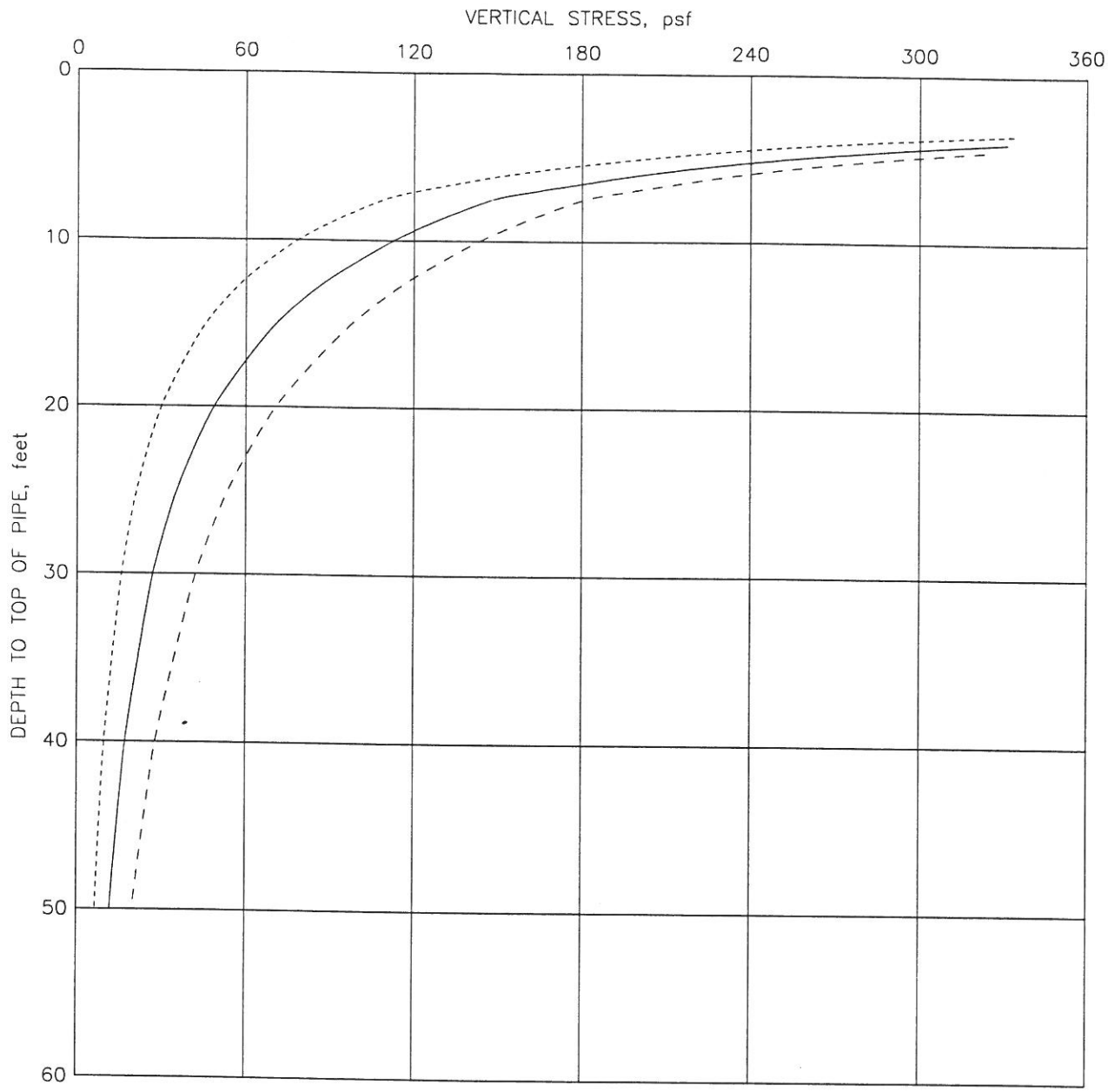
If $H_1 > \frac{2}{3}\frac{B_d}{\sqrt{2}}$, $P_H = 0.7\,(\gamma\, HB_d - 1.4CH - \pi CB_d)$ in lbs/ linear foot

If $H_1 < \frac{2}{3}\frac{B_d}{\sqrt{2}}$, $P_H = 1.5H_1\,(\gamma\, H - \frac{1.4CH}{B_d} - \pi C)$ in lbs/ linear foot



STABILITY OF BOTTOM
FOR
BRACED CUT

Job No. _____



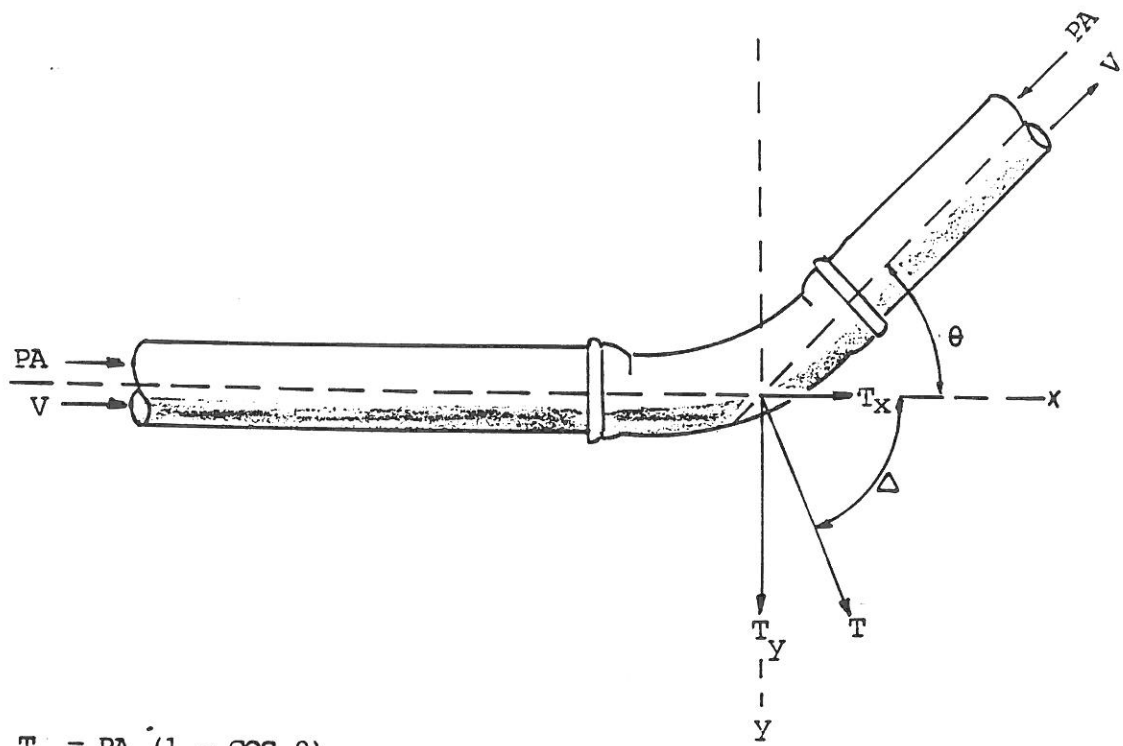
Legend:

------ One passing truck
——— Two passing trucks
– – – Four passing trucks

Notes: 1. The vertical stress was estimated using AASHTO H20 or HS20 truck axle loadings on paved surfaces.
2. Impact factor was included in the vertical stress.

VERTICAL STRESS ON PIPE DUE TO TRAFFIC LOADS

Job No. 1140099601



$$T_x = PA\,(1 - \cos\theta)$$

$$T_y = PA \sin\theta$$

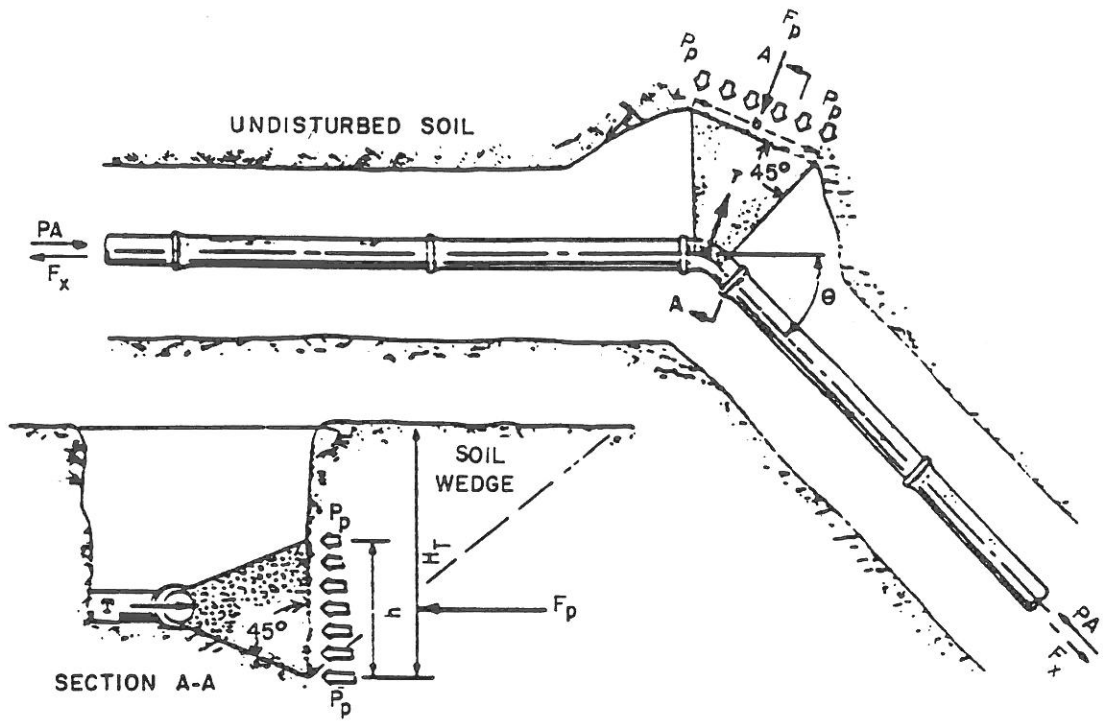
$$T = 2\,PA \sin\frac{\theta}{2}$$

$$\Delta = \left(90 - \frac{\theta}{2}\right)$$

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

THRUST FORCES ACTING ON A BEND



Where:

T	is the resultant thrust force on the bend
F_b	is the resistance force developed by passive soil pressure
A_b	is the minimum bearing area of block base
h	is the height of the thrust block
b	is the width of thrust block
A	is pipe cross-sectional area
θ	is bend deflection angle
p_p	is the passive soil pressure
H_T	is the depth to the bottom of block
γ	is the soil unit weight
$N_\emptyset$	is flow value
∅	is the soil internal friction angle
C	is the soil cohesion
S_f	is a factor of safety (usually 1.5)
H_c	is the mean depth from ground surface to the plane of resistance (center of bearing area of a thrust block)
P	is maximum sustained pressure

Required Bearing Area

$$A_b = hb = \frac{S_f 2PA \sin\frac{\theta}{2}}{p_p}$$

Required Block Width

$$b = \frac{2S_f PA \sin\frac{\theta}{2}}{h\, p_p}$$

Where

$$p_p = \gamma H_c N_\emptyset + 2C\sqrt{N_\emptyset}$$

$$N_\emptyset = \tan^2 (45° + \emptyset/2)$$

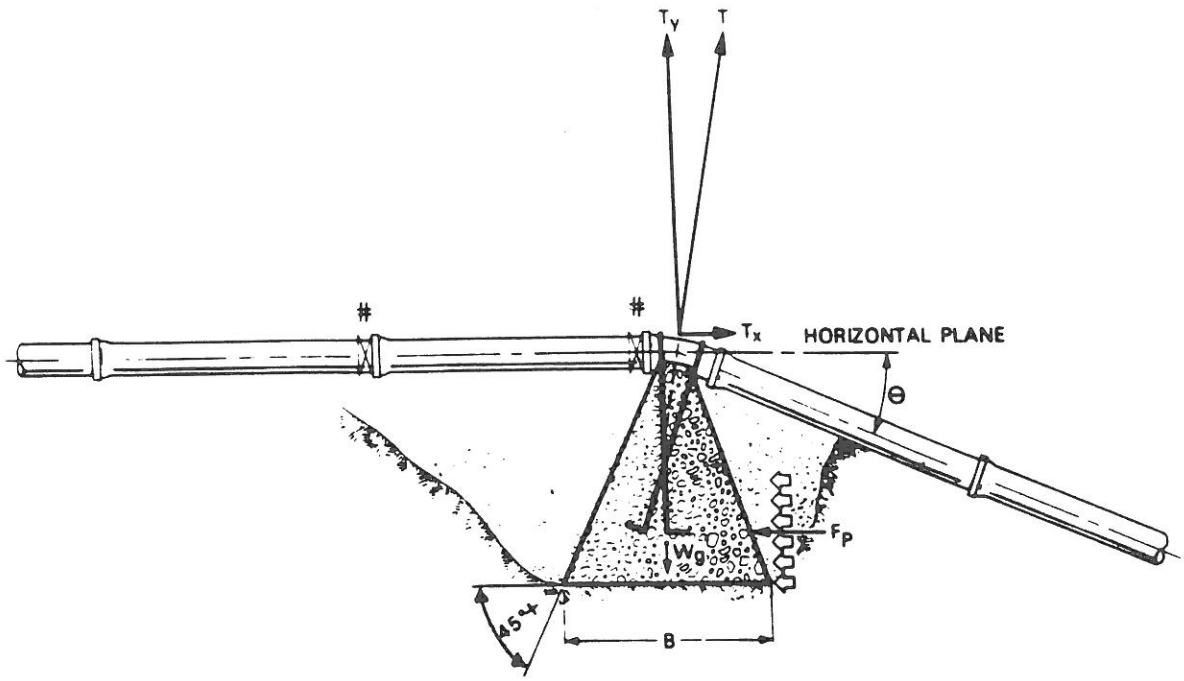
For $h = 1/2\, H_T$

$$b = \frac{S_f 2PA \sin\frac{\theta}{2}}{3/8\, \gamma H_T^2 N_\emptyset + CH_T\sqrt{N_\emptyset}}$$

DESIGN PARAMETERS FOR BEARING THRUST BLOCK

Geotest Engineering, Inc.

FIGURE 7



Restrained joints may be used when $T_x > F_p$

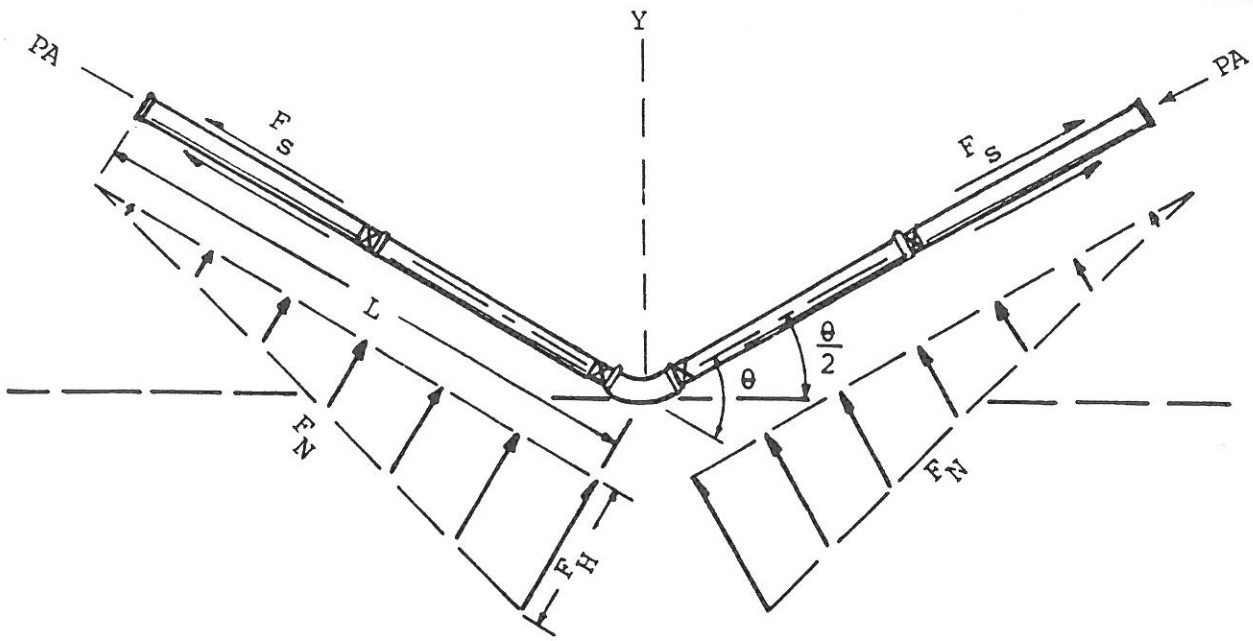
Required volume of gravity block

$$V_G = \frac{S_f \, PA \sin\theta}{W_m}$$

Where

- T = Resultant thrust force
- T_X = X thrust force component
- T_Y = Y thrust force component
- V_G = Volume of gravity block
- P = Maximum sustained pressure
- A = Pipe cross-sectional area
- θ = Bend deflection angle
- W_m = Density of block material
- W_g = Weight of gravity block
- F_p = Resisting force developed by passive soil pressure
- B = Gravity block base dimension
- S_f = Safety factor (usally 1.5)

DESIGN PARAMETERS FOR GRAVITY THRUST BLOCK



Required Length

Horizontal Bend:

$$L = \frac{S_f\ KPA}{KF_s + B_c\ p_p}$$

Vertical Bend:

$$L = \frac{S_f\ KPA}{KF_s + 2\ W_t}$$

in which

$$K = 4\ \mathrm{Tan}\frac{\theta}{2}$$

$$F_s = A_p f + W\ \mathrm{Tan}\ \delta$$

$$p_p = \gamma_s H_c N_\phi + 2C_s \sqrt{N_\phi}$$

$$N_\phi = \mathrm{Tan}^2\ (45° + \phi_s/2)$$

$$A_p = \frac{\pi D}{2}$$

$$W = \pi \gamma_b H B_c R$$

$$W_t = W_e + W_p + W_w$$

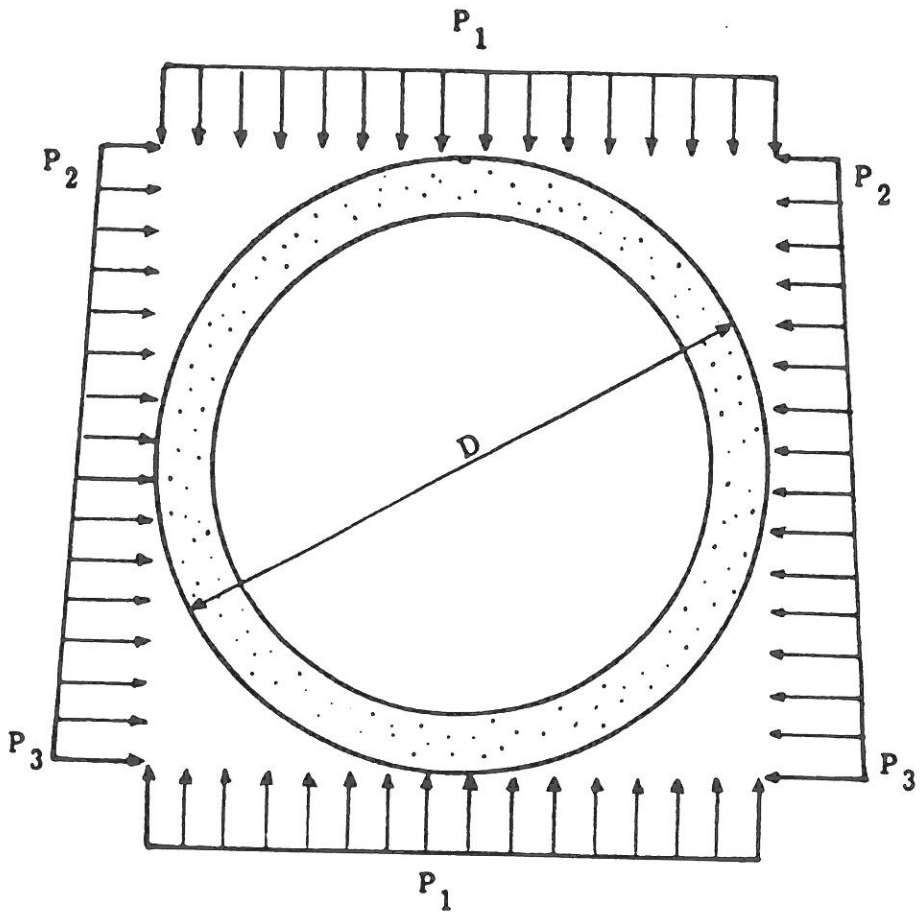
Where

- L is the restrained pipe length on each side of the bend
- S_f is a factor of safety (suggest 1.50)
- K is the bend coefficient
- p is the maximum sustained pressure
- A is pipe cross-sectional area
- F_s is the conduit frictional resistance per unit length.
- B_c is outside diameter of the conduit
- D is inside diameter of the conduit
- P_p is the passive soil pressure
- θ is bend deflectional angle
- A_p is the conduit surface area per unit length (assume 1/2 the pipe circumference bears against the backfill soil)
- C_b is the backfill soil cohesion
- C_s is the in-situ soil cohesion
- ϕ_b is the backfill soil internal fraction angle
- ϕ_s is the in-situ soil internal friction angle
- γ_b is the backfill soil unit weight
- γ_s is the in-situ soil unit weight
- f is the cohesion between conduit and backfill (use $0.5C_b$)
- W is the normal force on the pipe per unit length
- W_t is the vertical thrust
- W_e is prism earth load
- W_p is weight of pipe
- W_w is contained liquid weight
- δ is the fractional angle between the conduit and the backfill soil (use $0.75\ \phi_b$)
- H is the depth to top of conduit
- H_c is the mean depth from ground surface to the plane of resistance (center line of a pipe)
- N_ϕ is flow value
- R is reduction factor depending on trench condition (use 3/4 for well-compacted backfill and selected backfill)

DESIGN PARAMETERS FOR RESTRAINED JOINT

Geotest Engineering, Inc.

FIGURE 9



$$P_1 = [(H + \frac{D}{2}) \times (\gamma - \gamma_w) + D_w \times \gamma_w] + q_s \text{, for } D_w < H + \frac{D}{2}$$

$$P_1 = [(H + \frac{D}{2}) \times \gamma] + q_s \text{, for } D_w \geq H + \frac{D}{2}$$

$$P_2 = (H \times \gamma) + q_s$$

$$P_3 = [(H + D) \times \gamma] + q_s$$

Where: P_1, P_2, P_3 = Tunnel liner load, psf.

D = Tunnel outside diameter, ft.

H = Depth to top of tunnel; ft.

D_w = Depth to ground water level; ft.

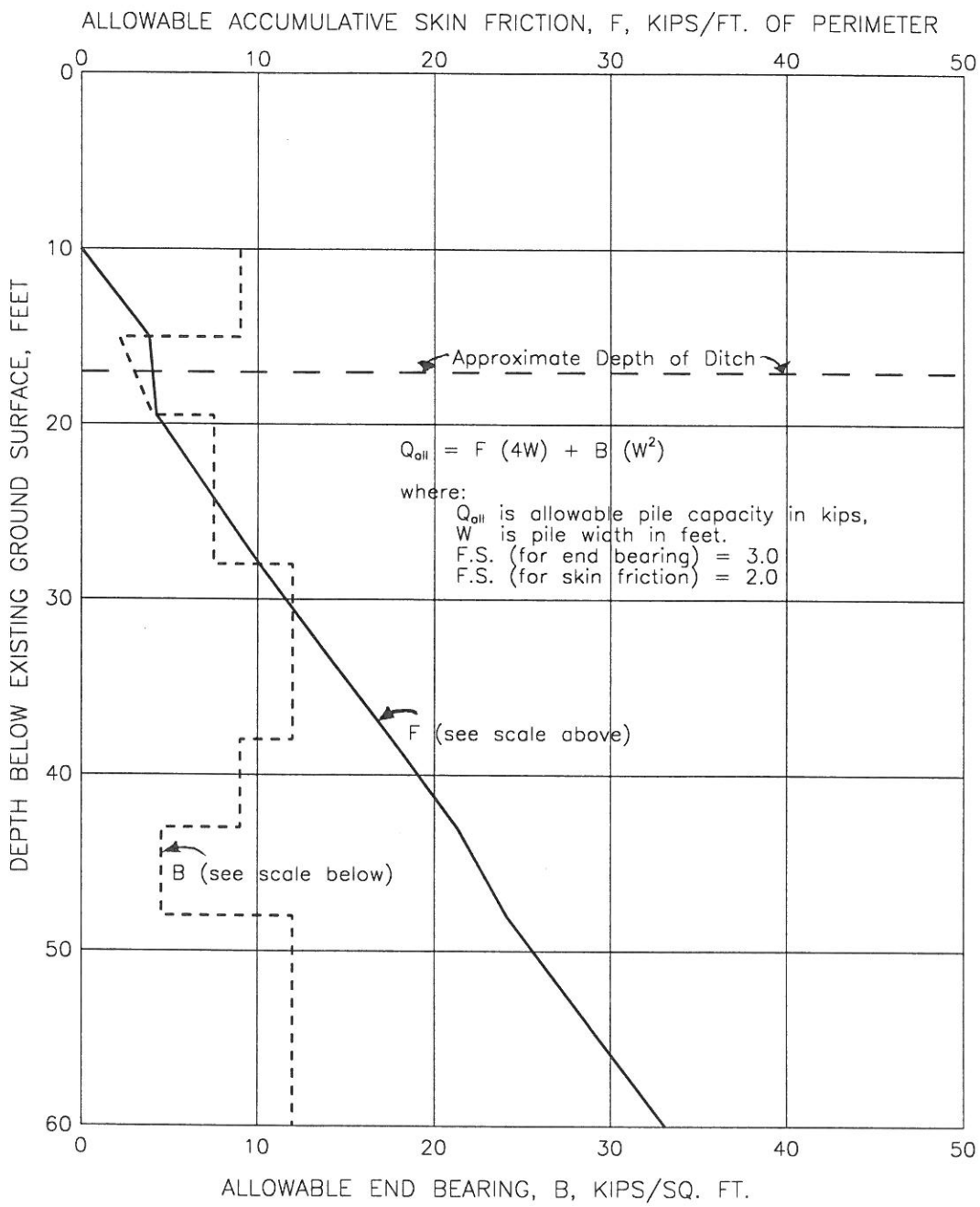
γ = Wet unit weight of soil, pcf (See Table 2)

γ_w = Unit weight of water, 62.4 pcf

q_s = Surcharge load, psf.

EARTH PRESSURE
ON PIPE AND CASING AUGERING

Job No. 1140099601



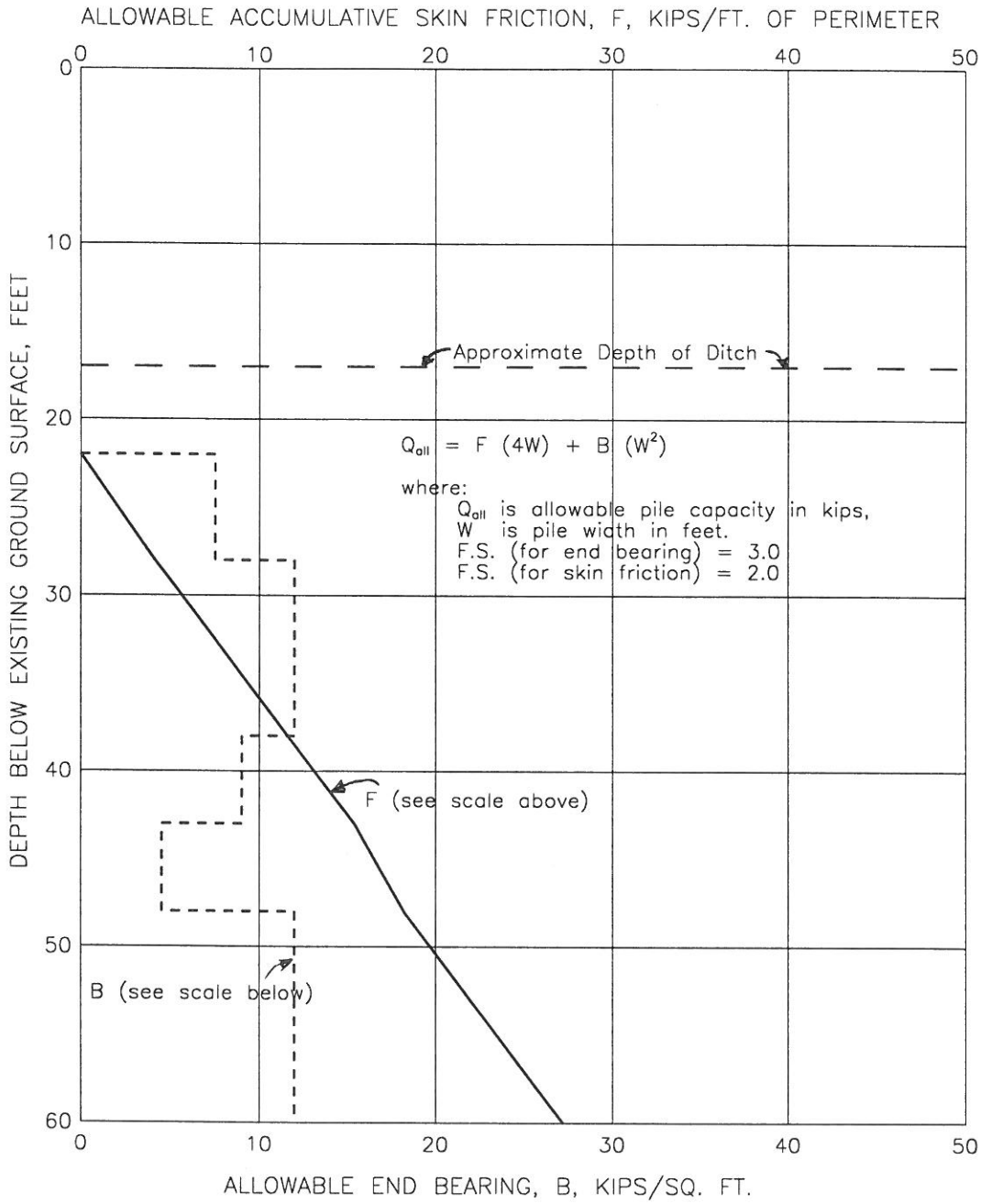
ALLOWABLE PILE CAPACITY CURVES (END BENT)

(DITCH ACROSS HILLCROFT)

Geotest Engineering, Inc.

FIGFURE 11.1

Job No. 1140099601



ALLOWABLE PILE CAPACITY CURVES (CENTER BENT)

(DITCH ACROSS HILLCROFT)

Geotest Engineering, Inc.

FIGFURE 11.2

TABLES

TABLES 1 through 3

TABLE 1

SUMMARY OF FIELD EXPLORATION

Boring No.	Depth (feet)	Alignment	Station No.	Offset (feet)	Elevation (feet)
B-1	15	Court	7+67.99	25.39 Rt	74.13
B-2	15	Court	15+16.6	47.84 Rt	74.40
B-3	15	Court	22+00.95	1.06 Lt	74.34
B-4	30	Fondren	27+45.10	84.78 Rt	74.45
B-5	30	Fondren	27+95.22	66.69 Rt	73.67
B-5A	15	Fondren	33+84.61	2.65 Rt	73.12
B-6	15	Fondren	38+63.14	0.48 Rt	72.58
B-7	15	Fondren	47+43.42	3.03 Lt	72.05
B-8	15	Hillcroft	55+96.71	17.54 Rt	72.58
B-9	15	Hillcroft	63+00.89	23.86 Rt	72.73
B-10	15	Hillcroft	65+61.68	20.33 Lt	71.99
B-11	15	Hillcroft	70+97.62	20.40 Lt	71.21
B-12	60	Hillcroft	77+94.22	42.73 Lt	72.17
B-13	60	Hillcroft	79+38.33	30.17 Lt	72.26
B-14	15	Hillcroft	87+39.40	16.85 Lt	68.67
B-15	15	Hillcroft	94+27.33	32.66 Lt	68.42

TABLE 2

GEOTECHNICAL DESIGN PARAMETER SUMMARY
OPEN-CUT EXCAVATION

Water main Alignment	Stratigraphic Unit	Range of Depths, ft	Wet Unit Weight, γ, pcf	Submerged Unit Weight, γ', pcf	Undrained Cohesion, psf	Internal Friction Angle, ϕ, degree	Soil Stiffness Categories
Along Court	Cohesive	0 - 6	122	61	1500	--	D
(from City of	Soils	6 - 15	122	61	2500	--	C
Houston water							
facility to future							
Fondren)							
Along Fondren	Cohesive	0 - 6	120	60	1400	--	D
(Between future	Soils	6 - 15	120	60	2500	--	C
Court and Hillcroft)							
Along Hillcroft	Cohesive	0 - 6	120	60	1100	--	D
(Between Fondren	Soils	6 - 10	120	60	2000	--	C
and Chasewood)		10 - 15	120	60	1500	--	D
	Cohesionless Soils	11 - 15	120	60	--	25	D

Notes:

1. Cohesive soils include clay, sandy clay and silty clay.

2. Cohesionless soil includes silty sand

TABLE 3

GEOTECHNICAL DESIGN PARAMETER SUMMARY
TRENCHLESS INSTALLATION
AT INTERSECTION OF HILLCROFT AND WEST FUQUA ROADS
(BASED ON BORINGS B-9 AND B-10)

Stratigraphic Unit	**Cohesive Soils**
Range of Depth, ft.	0-15
Wet Unit Weight, γ, pcf	118
Submerged Unit Weight, γ', pcf	59
Undrained Cohesion, C, psf	1500
Internal Friction Angle, ϕ, degree	0
Elastic Modulus, E, psf	450,000
Coefficient of Lateral Earth Pressure at Rest, K_0	0.8-1.2
Poisson's Ratio	0.45
DRAINED PROPERTIES	
Drained Cohesion, C′, psf	0
Internal Friction Angle, ϕ', degree	22
Elastic Modulus, E', psf	300,000

APPENDIX A

	Figure
Log of Borings	A-1 thru A-16
Key to Symbols and Terms used on Boring Logs	A-17

LOG OF BORING NO. B-1

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 7+67.99, 25.39' Rt. (Court Road)

COMPLETION DEPTH : 15.0 FT.

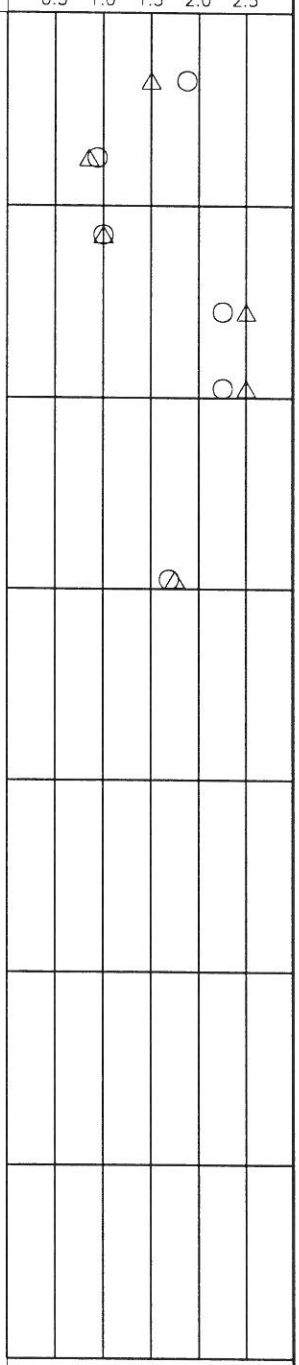
SURFACE ELEVATION : 74.13 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
74.1	0			Very stiff dark gray CLAY (CH) w/ferrous nodules							
				-w/grass roots 0-2'				20			
				-w/sand seams 2'-4'							
				-stiff 2'-6'							
				-hard 6'-10'				23	57	23	34
	5			-slickensided 4'-15'							
				-reddish brown & gray w/calcareous nodules & ferrous stains 6'-15'				24			
								21			
	10							22			
				-very stiff 13'-15'							
59.1	15							26			
	20										
	25										
	30										
	35										



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-1

LOG OF BORING NO. B-2

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : 15+16.6, 47.84' Rt. (Court Road)

COMPLETION DEPTH : 15.0 FT.

SURFACE ELEVATION : 74.40 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
74.4	0	Fill: Dark gray & brown clay w/grass roots							
72.4		Stiff dark gray CLAY (CH)				24			
						27			
	5	-slickensided, w/ferrous nodules & ferrous stains 4'-15'				26			
		-very stiff reddish brown & gray w/calcareous nodules 6'-15'				23	63	24	39
	10					28			
59.4	15					28			
	20								
	25								
	30								
	35								

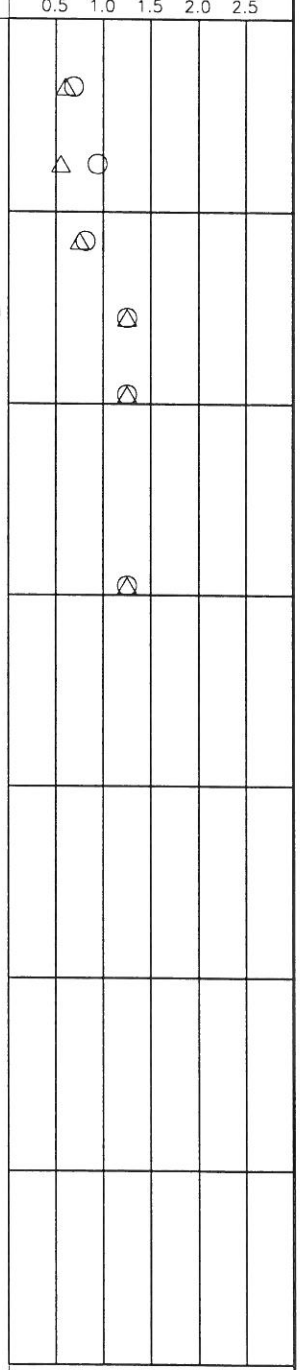
SYMBOL

SAMPLES

UNDRAINED SHEAR STRENGTH, TSF

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

0.5 1.0 1.5 2.0 2.5



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-2

LOG OF BORING NO. B-3

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 22+00.95, 1.06' Lt. (Court Road)

COMPLETION DEPTH : 15.0 FT.

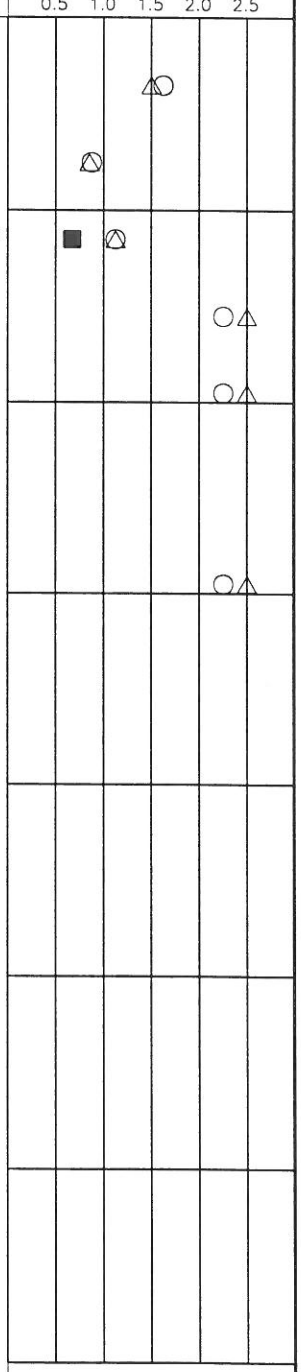
SURFACE ELEVATION : 74.34 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
74.3	0			Fill: Dark gray & brown clay w/grass roots							
72.3				Stiff dark gray CLAY (CH), slickensided -w/ferrous nodules 2'-13' -very stiff 4'-6' -gray & brown 4'-10' -hard w/calcareous nodules 6'-15'				20			
								25			
	5						98	25	68	26	42
								20			
	10							21			
				-red 13'-15'							
59.3	15							26			
	20										
	25										
	30										
	35										

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-3

LOG OF BORING NO. B-4

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 27+45.10, 84.78' Rt (Fondren Road)

COMPLETION DEPTH : 30.0 FT.

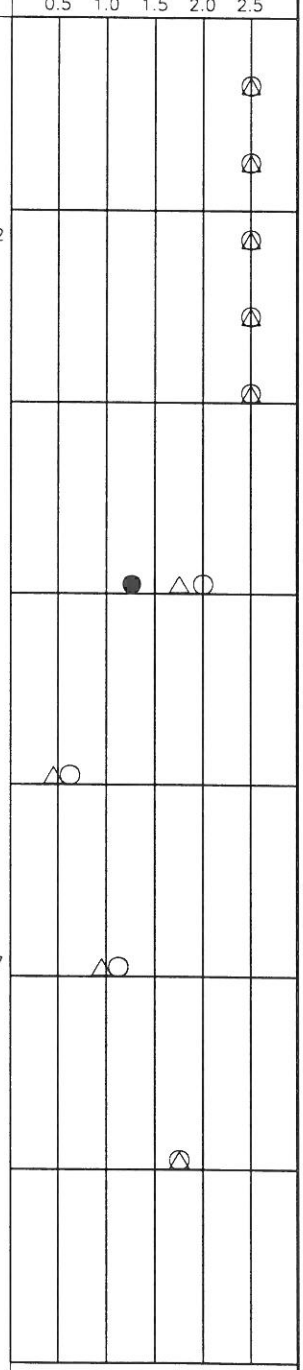
SURFACE ELEVATION : 74.45 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 30.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
74.4	0			Hard dark gray CLAY (CH), slickensided w/ferrous nodules -w/grass roots 0-2'				22			
								19			
	5							20	67	25	42
				-reddish brown & gray w/calcareous nodules 8'-15'				20			
	10							22			
				-very stiff 13'-15'							
	15						107	23			
				-w/silty sand layer 18'-18'5"							
56.0				Stiff reddish brown SILTY CLAY (CL)							
	20							24			
				-w/calcareous nodules 22'-28' -very stiff 23'-25'							
	25							20	33	16	17
46.4				Very stiff gray & brown CLAY (CH), slickensided w/calcareous nodules & ferrous stains							
44.4	30							26			
	35										



DEPTH TO WATER IN BORING :
▽: FREE WATER ENCOUNTERED AT 28.0 FT. DURING DRILLING.
▼: WATER DEPTH AT 25.8 FT., HOLE OPENED TO 30.0 FT. AT END OF DRILLING.

Geotest Engineering, Inc.

FIGURE A-4

LOG OF BORING NO. B-5

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 27+95.22, 66.69' Rt. (Fondren Road)

COMPLETION DEPTH : 30.0 FT.

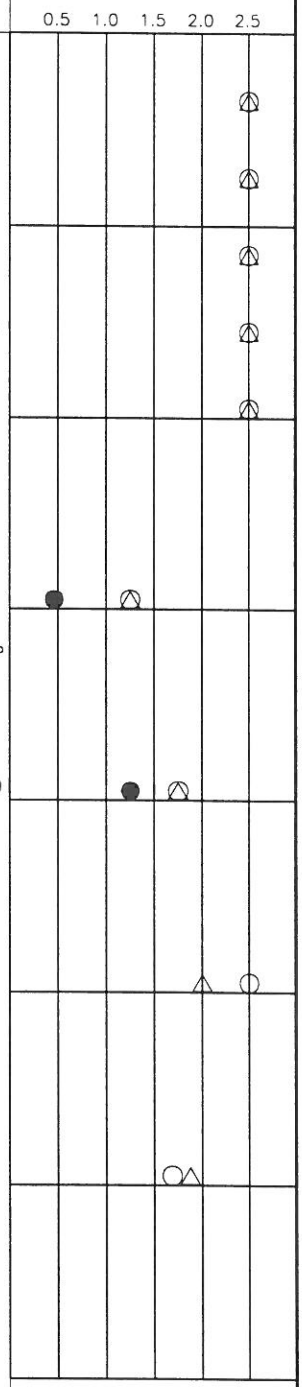
SURFACE ELEVATION : 73.67 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 30.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
73.7	0	Hard dark gray CLAY (CH)							
		-w/grass roots 0-2'							
		-gray 2'-6'				22			
		-w/ferrous nodules, slickensided 2'-15'				26			
	5								
		-brown & gray 6'-8'				18			
		-w/calcareous nodules & ferrous stains 6'-15'							
		-reddish brown & gray 8'-15'				22	66	25	41
	10					20			
		-very stiff 13'-15'							
58.7	15				106	26			
		Medium dense reddish brown SANDY SILT (ML)	28	83		18	NP	NP	NP
55.7		Very stiff red CLAY (CH)							
		-w/silt pockets 18'-25'							
	20	-slickensided w/ferrous stains 18'-30'			107	22	64	25	39
		-w/calcareous nodules 21'-30'							
		-hard 23'-25'							
	25					21			
		-very stiff olive gray 28'-30'							
43.7	30					25			
	35								



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.
▼: WATER DEPTH AT 22.0 FT. AT END OF DRILLING.

Geotest Engineering, Inc.

FIGURE A-5

LOG OF BORING NO. B-5A

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 33+84.61, 2.65' Rt. (Fondren Road)

COMPLETION DEPTH : 15.0 FT.

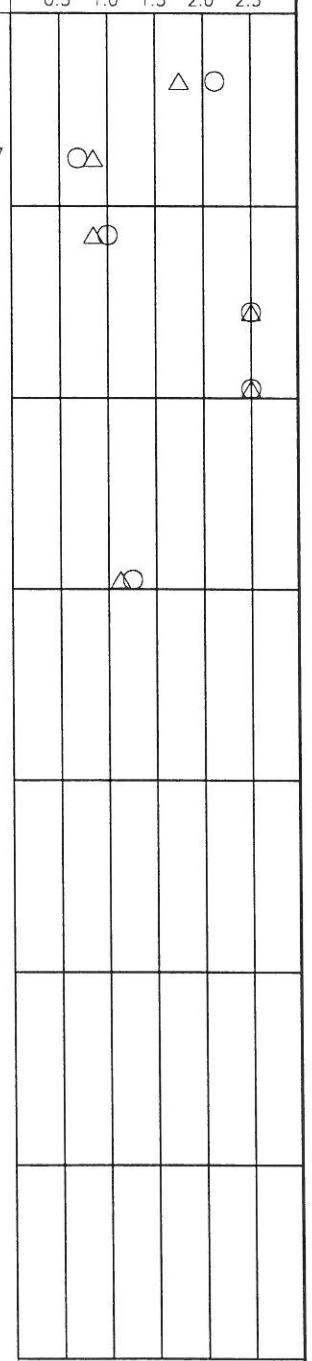
SURFACE ELEVATION : 73.12 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
73.1	0			Hard Dark gray CLAY (CH) w/ferrous nodules							
				-w/grass roots 0-2'				23			
				-stiff 2'-6'							
								30	74	27	47
	5							36			
				-yellowish brown 6'-8'							
				-hard 6'-10'							
				-w/calcareous nodules, slickensided 6'-15'				24			
				-reddish brown 8'-15'							
	10							26			
				-very stiff 13'-15'							
58.1	15							26			
	20										
	25										
	30										
	35										



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-6

LOG OF BORING NO. B-6

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 38+63.14, 0.48' Lt. (Fondren Road)

COMPLETION DEPTH : 15.0 FT.

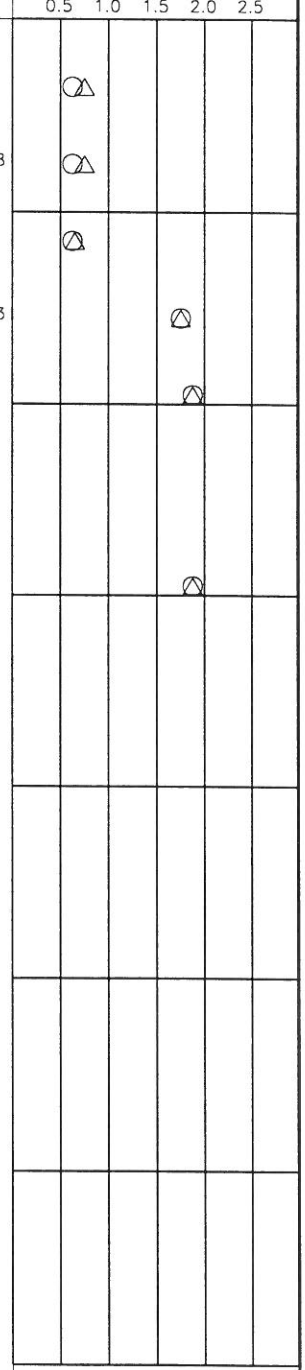
SURFACE ELEVATION : 72.58 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.6	0			Stiff dark gray CLAY (CH), slickensided, w/ferrous nodules				36			
				-w/grass roots 0-2'							
				-w/organic material 2'-4'				34	76	28	48
				-gray 4'-8'							
	5							38			
				-very stiff w/calcareous nodules and ferrous stains 6'-15'							
				-red 8'-15'				29	83	30	53
	10							28			
57.6	15							25			
	20										
	25										
	30										
	35										

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-7

LOG OF BORING NO. B-7

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 47+43.42 3.03' Lt. (Fondren Road)

COMPLETION DEPTH : 15.0 FT.

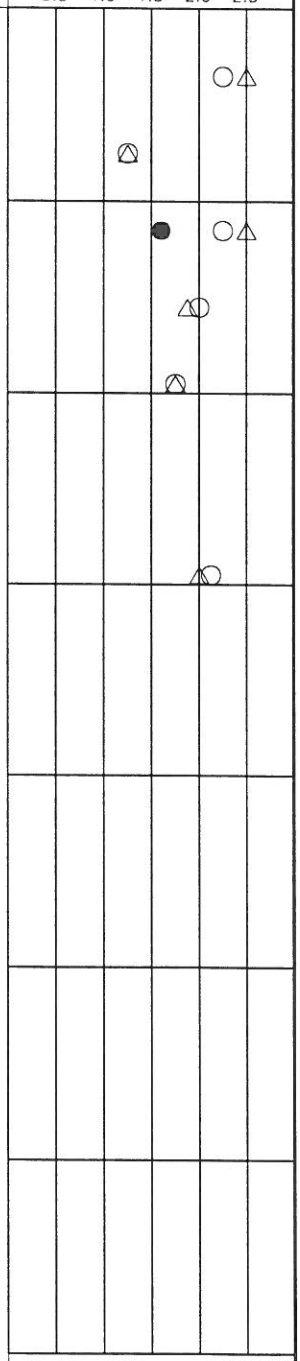
SURFACE ELEVATION : 72.05 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.1	0	Hard dark gray CLAY (CH)							
		-w/grass roots 0-2'							
		-very stiff 2'-4'				23			
		-w/ferrous stains 2'-15'							
		-hard 4'-6'				27			
	5	-gray & brown 4'-8'							
		-w/calcareous & ferrous nodules, slickensided 4'-15'			92	27	89	31	58
		-very stiff 6'-10'				29			
		-red 8'-15'							
	10					23			
		-hard 13'-15'							
57.1	15	-w/silty clay at 15'				23			
	20								
	25								
	30								
	35								



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-8

LOG OF BORING NO. B-8

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 55+96.71, 17.54' Rt. (Hillcroft Road)

COMPLETION DEPTH : 15.0 FT.

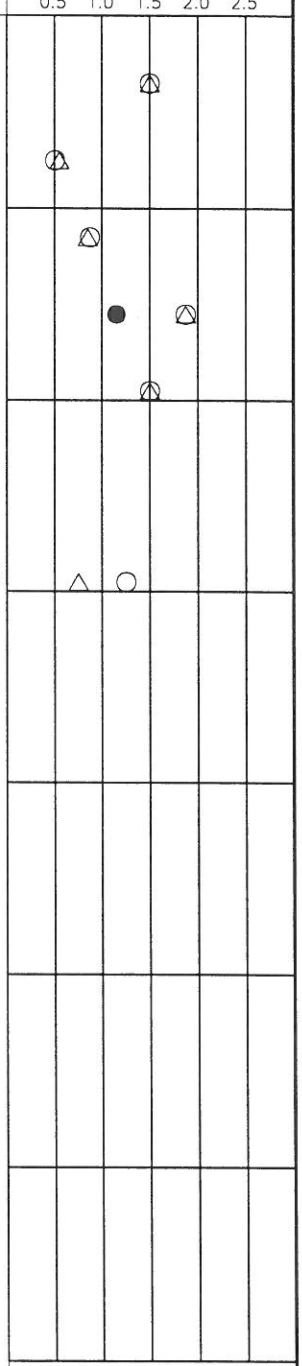
SURFACE ELEVATION : 72.58 FT.

DATE : 5-9-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.6	0			Very stiff dark gray CLAY (CH)							
				-w/grass roots 0-2'				26			
				-stiff 2'-6'							
				-slickensided w/ferrous nodules 2'-13'				33	84	30	54
	5			-w/ferrous stains 4'-13'							
				-gray & red 6'-8'				31			
				-very stiff w/calcareous nodules 6'-13'							
				-red & gray 8'-13'			88	30			
	10							29			
59.6				Very stiff red & gray SILTY CLAY (CL) w/calcareous nodules & ferrous stains & silt seams							
57.6	15							24	40	18	22
	20										
	25										
	30										
	35										

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-9

LOG OF BORING NO. B-9

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 63+00.89, 23.86' Rt. (Hillcroft Road)

COMPLETION DEPTH : 15.0 FT.

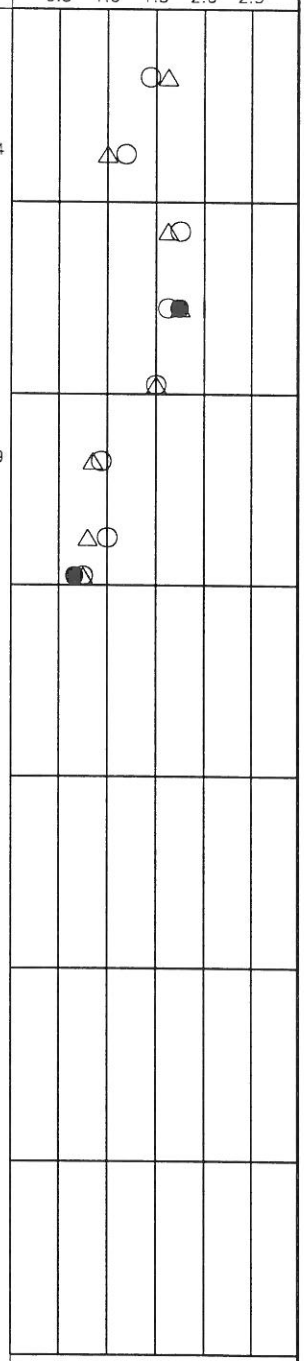
SURFACE ELEVATION : 72.73 FT.

DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.7	0			Very stiff dark gray CLAY (CH)							
				-w/grass roots & sand pockets 0-2'				20			
				-w/sand seams 2'-6'							
				-w/ferrous nodules 4'-10'				21	56	22	34
	5										
				-yellowish gray & gray 6'-8'				21			
				-slickensided w/calcareous nodules 6'-10'							
				-yellowish brown & yellowish gray 8'-10'			98	22			
	10			-stiff w/ferrous stains, sand pockets & sand seams 10'-15'				25			
								28	64	25	39
								25			
57.7	15						90	26			
	20										
	25										
	30										
	35										



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-10

LOG OF BORING NO. B-10

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 65+61.68 20.33' Lt. (Hillcroft Road)

COMPLETION DEPTH : 15.0 FT.

SURFACE ELEVATION : 71.99 FT.

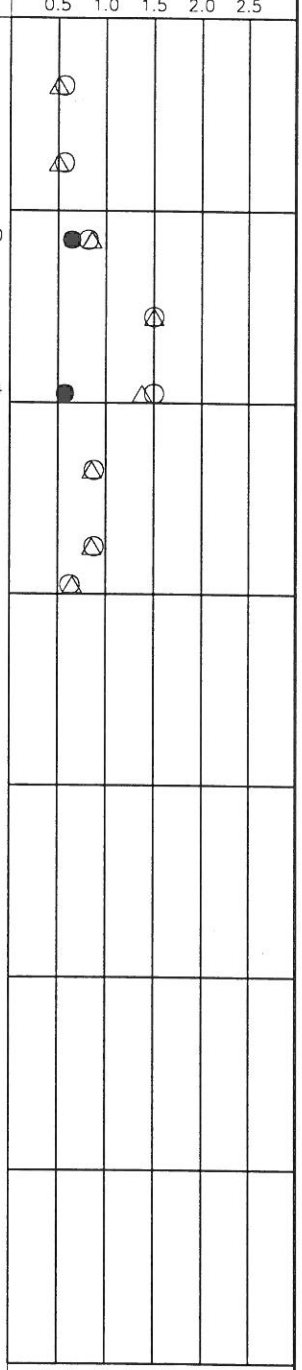
DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.0	0	Stiff dark gray CLAY (CH) -w/grass roots 0-2'				26			
		-yellowish gray 4'-6'				31			
	5	-slickensided w/sand seams, ferrous nodules & ferrous stains 4'-10'			98	22	65	25	40
		-very stiff reddish brown w/calcareous nodules 6'-10'				23			
62.0	10	Stiff reddish brown & gray SILTY CLAY (CL) w/ferrous nodule, ferrous stains, silt seams & silt pockets			95	25	56	22	34
		-w/siltstone at 12'				20			
		-w/calcareous nodules 12'-15'				22			
57.0	15					23			
	20								
	25								
	30								
	35								

SYMBOL
SAMPLES

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-11

LOG OF BORING NO. B-11

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 70+97.62, 20.40' Lt (Hillcroft Road)

COMPLETION DEPTH : 15.0 FT.

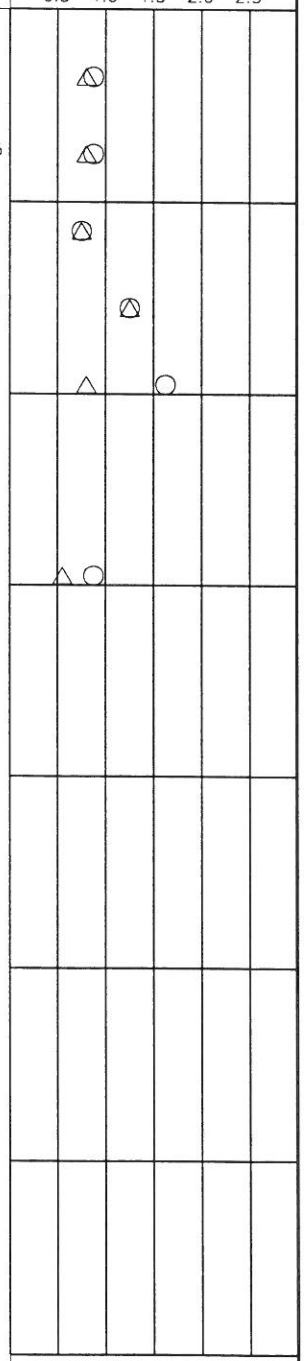
SURFACE ELEVATION : 71.21 FT.

DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
71.2	0			Fill: Dark gray & gray caly w/sand seams -w/grass roots 0-2'				20			
								23	58	23	35
	5										
65.2				Very stiff Yellowish brown & gray CLAY (CH) w/sand seams, ferous stains, calcareous & ferrous nodules				24			
								20	52	21	31
	10							18			
				-stiff 13'-15'							
56.2	15							19			
	20										
	25										
	30										
	35										



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-12

LOG OF BORING NO. B-12

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 77+94.22, 42.73' Lt. (Hillcroft Road)

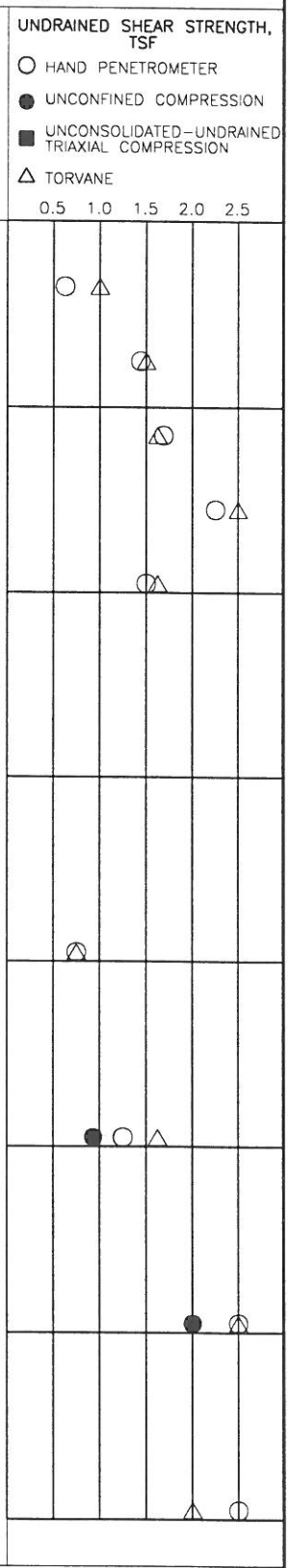
COMPLETION DEPTH : 60.0 FT.

SURFACE ELEVATION : 72.17 FT.

DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : 15.0 TO 60.0 FT.

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.2	0	Fill: Dark gray & brown clay w/sand seams -w/grass roots 0-2' -w/ferrous nodules 2'-3'				23			
69.2		Very stiff gray & dark gray CLAY (CH), slickensided w/sand seams, ferrous stains, calcareous & ferrous nodules -hard yellowish gray 6'-8'				22			
	5					21			
64.2		Very stiff reddish brown & gray SILTY CLAY (CL) w/ferrous stains, calcareous & ferrous nodules -w/silt layer 13'-15'				16			
	10					18			
57.2	15	Medium dense reddish brown SILTY SAND (SM)	11	26		24	31	16	15
						25			
52.7	20	Stiff red CLAY (CH), slickensided w/calcareou nodules & ferrous stains -very stiff 23'-25'				15	68	26	42
	25	-hard 28'-29'			96	25			
	30				107	17	54	22	32
37.2	35					21			



DEPTH TO WATER IN BORING :
▽: FREE WATER ENCOUNTERED AT 13.0 FT. DURING DRILLING.

Continued on Figure A-13a

Geotest Engineering, Inc.

FIGURE A-13

LOG OF BORING NO. B-12 Cont'd

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 77+94.22, 42.73' Lt. (Hillcroft Road)

COMPLETION DEPTH : 60.0 FT.

SURFACE ELEVATION : 72.17 FT.

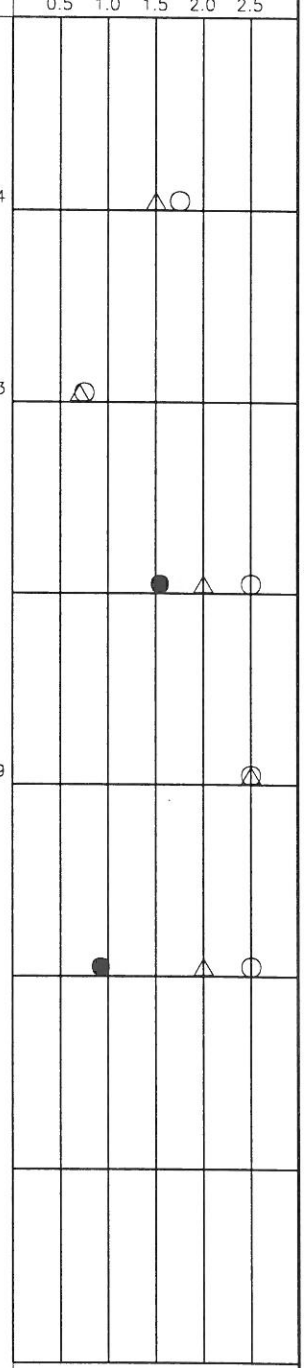
DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : 15.0 TO 60.0 FT.

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
37.2	35	Very stiff red CLAY (CH), slickensided w/calcareous nodules & ferrous stains							
		-w/sandy silt layer 38'-40'							
	40					19	56	22	34
29.2		Stiff yellowish gray SILTY CLAY (CL) w/ferrsous nodules & sand seams							
	45	-w/clayey silt & silty sand layer 43'-45'				17	28	15	13
24.2		Hard gray & yellowish gray SANDY CLAY (CL) w/ferrous stains, sand seams & sand pockts							
	50				112	16			
19.2		Hard red & gray CLAY (CH), slickensided w/calcareous nodules & ferrous stains							
	55					24	64	25	39
12.2	60				93	27			
	65								
	70								

SYMBOL
SAMPLES

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE



DEPTH TO WATER IN BORING :
▽: FREE WATER ENCOUNTERED AT 13.0 FT. DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-13a

LOG OF BORING NO. B-13

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 79+38.33, 30.17' Lt. (Hillcroft Road)

COMPLETION DEPTH : 60.0 FT.

SURFACE ELEVATION : 72.26 FT.

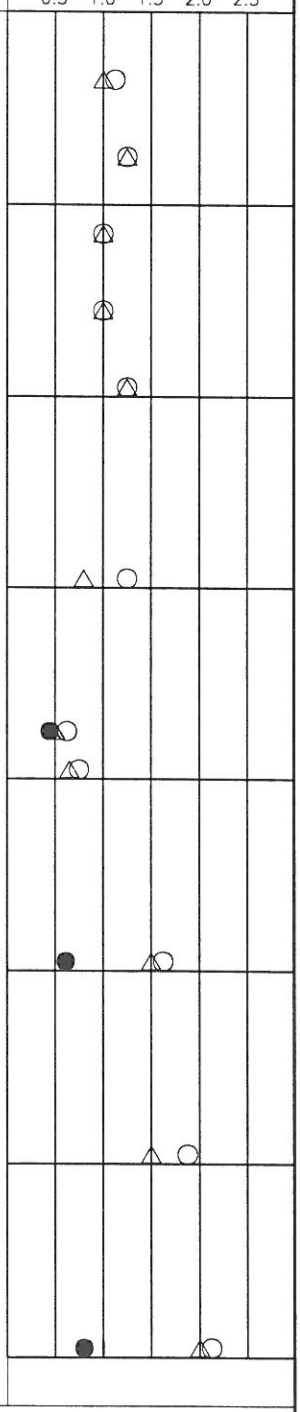
DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : 15.0 TO 60.0 FT.

ELEVATION, FEET	DEPTH, FEET	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
72.3	0	Fill: Dark gray & brown sandy clay w/sand seams -w/grass roots 0-2' -w/ferrous nodules 2'-4'				17			
68.3		Very stiff dark gray CLAY (CH) -w/sand seams 4'-6' -w/ferrous nodules 4'-8' -gray 6'-8' -slickensided, w/calcareous nodules 6'-13' -gray & brown 8'-13'				21			
	5					26			
						23			
	10					21			
59.3		Very stiff brown & gray SILTY CLAY (CL) -w/ferrous stains & silt seams 13'-15'				20	31	16	15
	15	-w/silt layer 18'-19' -stiff 18'-20' -w/silty sand seams 20'-20.3'			96	25	34	16	18
						26			
52.0	20	Very stiff red CLAY (CH), slickensided w/ferrous stains -w/calcareous nodules 23'-38'	15			24			
	25				97	24	68	26	42
	30					20			
37.3	35				98	25			

SAMPLES

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE



DEPTH TO WATER IN BORING :
▽: FREE WATER ENCOUNTERED AT 15.0 FT. DURING DRILLING.

Continued on Figure A-14a

Geotest Engineering, Inc.

FIGURE A-14

LOG OF BORING NO. B-13 Cont'd

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 79+38.33, 30.17' Lt. (Hillcroft Road)

COMPLETION DEPTH : 60.0 FT.

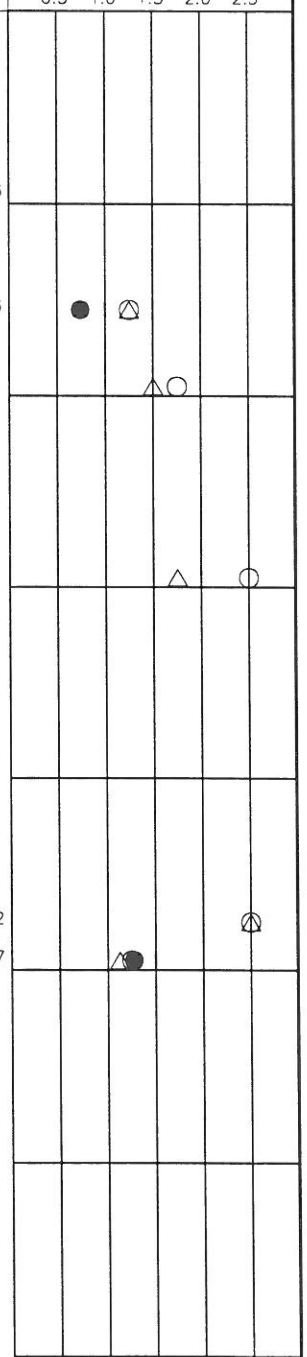
SURFACE ELEVATION : 72.26 FT.

DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : 15.0 TO 60.0 FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
37.3	35			Very stiff red CLAY (CH), slickensided w/ferrous stains							
34.3				Very stiff reddish brown & gray SILTY CLAY (CL) -w/silt seams (CL-ML) 38'-40'				20	28	22	6
	40			-w/ferrous nodules ferrous stains & sand seams 43'-50'			112	17	32	16	16
	45							15			
				-hard 48'-50'							
	50							15			
				-w/gray & yellowish gray silty sand layer 53'-55'							
	55							20			
15.3				Hard red & gray CLAY (CH), slickensided w/ferrous stains, calcareous & ferrous nodules				32	81	29	52
13.3											
12.3	60			Very stiff gray & brown SILTY CLAY (CL) w/ferrous stains & sand seams			103	20	33	16	17
	65										
	70										



DEPTH TO WATER IN BORING :
▽: FREE WATER ENCOUNTERED AT 15.0 FT. DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-14a

LOG OF BORING NO. B-14

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 87+39.40, 16.85' Lt. (Hillcroft Road)

COMPLETION DEPTH : 15.0 FT.

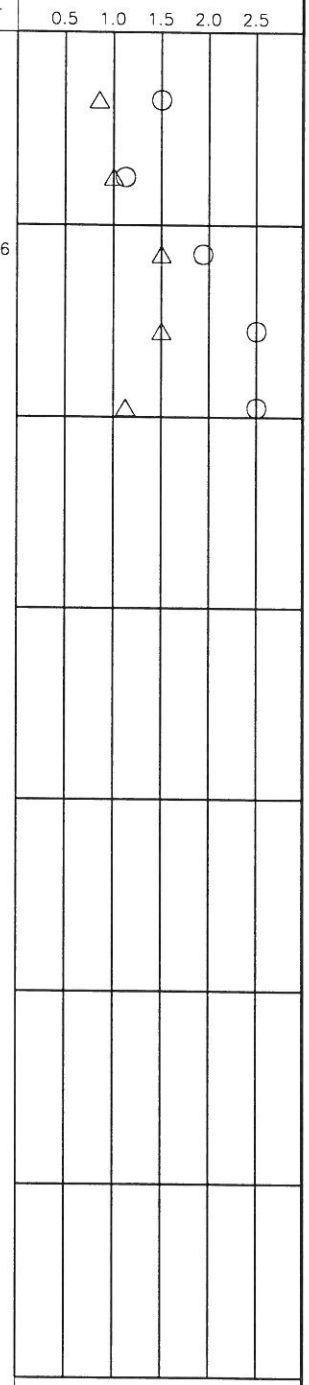
SURFACE ELEVATION : 68.67 FT.

DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
68.7	0			Very stiff gray & brown SANDY CLAY (CL) w/calcareous nodules, ferrous stains & sand seams							
				-w/grass roots 0-4'				15			
								20			
	5			-hard yellowish brown & gray 6'-10'				17	46	20	26
								15			
	10							14			
57.2				Medium dense gray & brown SILTY SAND (SM)	14	18		8			
53.7	15				10			18			
	20										
	25										
	30										
	35										



DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-15

LOG OF BORING NO. B-15

PROJECT : New Water Main Project along Court, Fondren & Hillcroft
City of Houston Water Project No. 10447
G.F.S. No. S-1002-02-2

PROJECT NO. : 1140099601

LOCATION : Sta. 94+27.33, 32.66' Lt. (Hillcroft Road)

COMPLETION DEPTH : 15.0 FT.

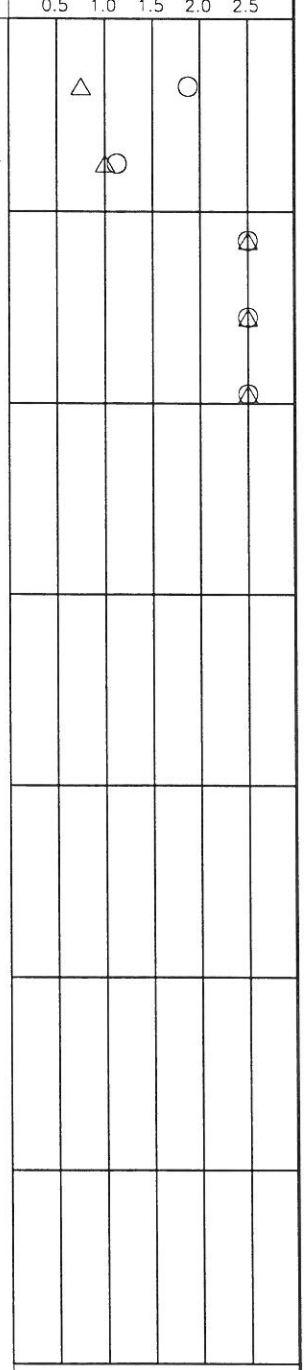
SURFACE ELEVATION : 68.42 FT.

DATE : 5-8-97

SAMPLER : Shelby Tube/Split Spoon
DRY AUGER : 0.0 TO 15.0 FT.
WASH BORE : -- TO -- FT.

UNDRAINED SHEAR STRENGTH, TSF
○ HAND PENETROMETER
● UNCONFINED COMPRESSION
■ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
△ TORVANE

ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
68.4	0			Very stiff gray CLAY (CH) w/sand seams, ferrous stians, calcareous & ferrous nodules				12			
				-w/grass roots 0-4'				26	70	26	44
	5			-hard yellowish brown & gray 6'-10'				14			
								14			
	10							13			
57.4				Medium dense gray & brown SILTY SAND (SM) -clay seams 13'-15'	12	19		9			
53.4	15							19			
	20										
	25										
	30										
	35										



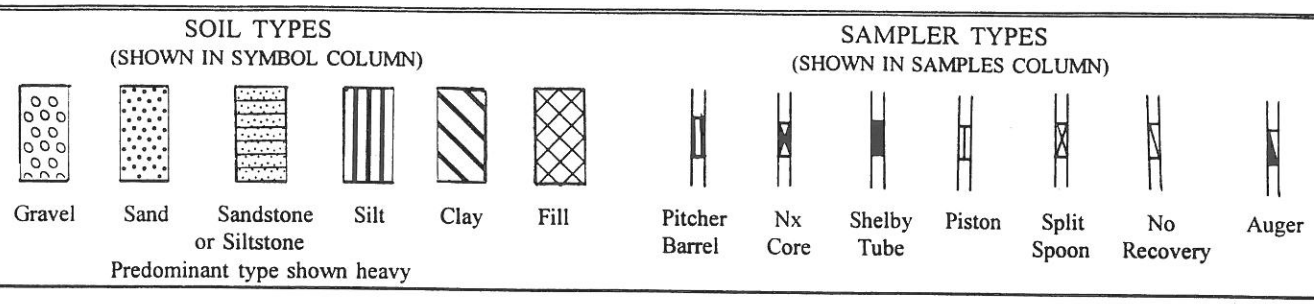
DEPTH TO WATER IN BORING :
NO GROUNDWATER ENCOUNTERED DURING DRILLING.

Geotest Engineering, Inc.

FIGURE A-16

SYMBOLS AND TERMS USED ON BORING LOGS

JOB NO. _____



TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (Major Portion Retained on No.200 Sieve): Includes(1) clean gravels and sands, and(2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

Descriptive Term	Standard Penetration, Resistance, Blows/Ft.	Relative Density
Loose	0 - 10	0 to 40%
Medium dense	10 - 30	40 to 70%
Dense	30 - 50	70 to 100%

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

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH TONS / Sq. Ft.
Very soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	4.00 and higher

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

TERMS CHARACTERIZING SOIL STRUCTURE

Parting: -paper thin in size Seam: -1/8"-3" thick Layer: -greater than 3"

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.

Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.

Laminated - composed of thin layers of varying color and texture.

Interbedded - composed of alternate layers of different soil types.

Calcareous - containing appreciable quantities of calcium carbonate.

Well graded - having wide range in grain sizes and substantial amounts of all intermediate particle sizes.

Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

Flocculated - pertaining to cohesive soils that exhibit a loose knit or flakey structure.

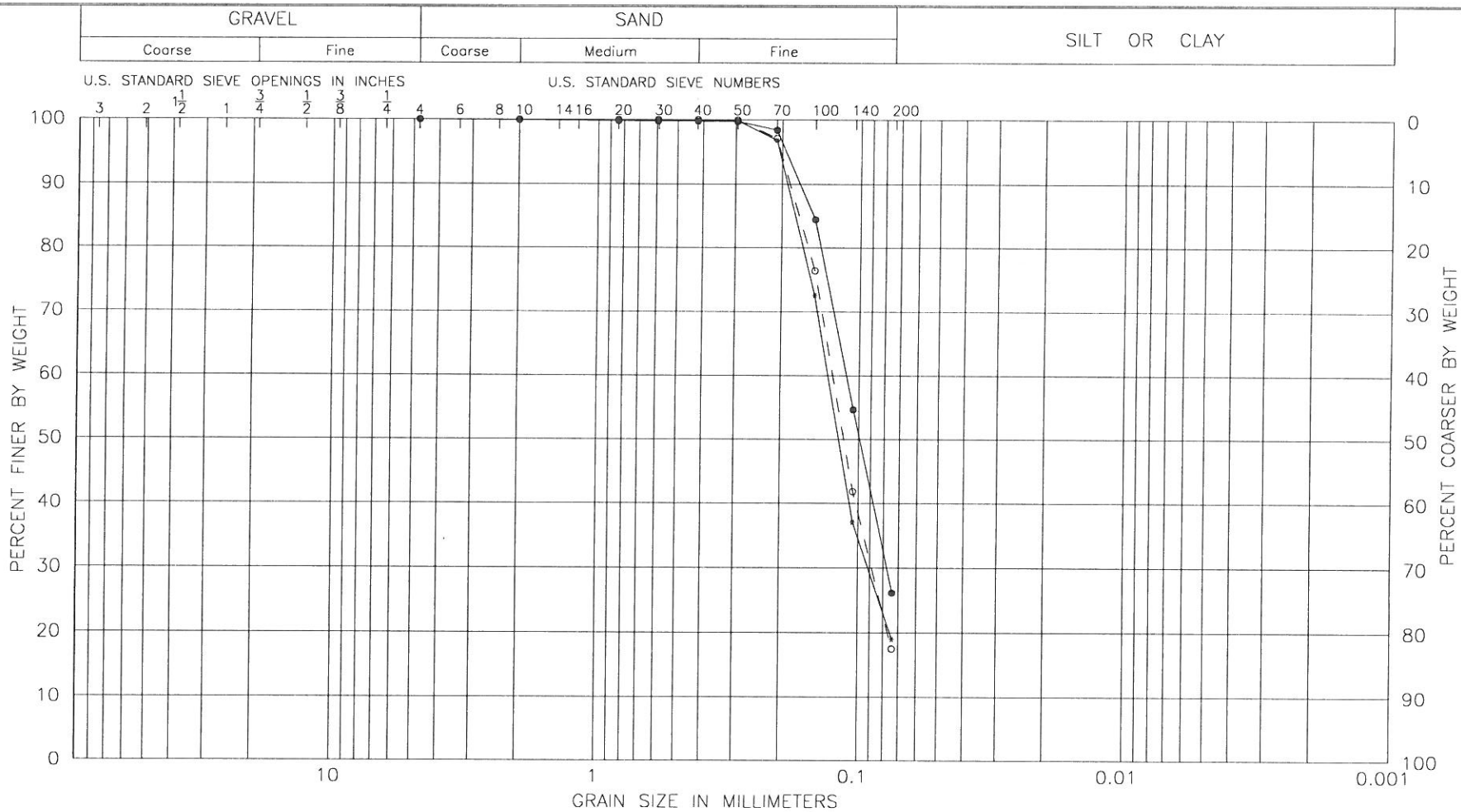
Geotest Engineering, Inc.

FIGURE A-17

APPENDIX B

	Figure
Grain Size Distribution Curve	B-1

Job No. 1140099601



LEGEND	BORING NO.	SAMPLE NO.	DEPTH FT.	SAMPLE DESCRIPTION
●●●●●	B-12	S-6	15.0-16.5	Reddish brown silty sand
○○○○○	B-14	S-6	11.5-13.0	Gray and brown silty sand
++++++	B-15	S-6	11.0-12.5	Gray and brown silty sand

GRAIN SIZE DISTRIBUTION CURVES

Geotest Engineering, Inc.

FIGURE B-1