ETTL ENGINEERS & CONSULTANTS INC.
GEOTECHNICAL • MATERIALS • ENVIRONMENTAL
MEMBER ACIL

June 13, 2005

James Rice
NRS Consulting Engineers
4415 Jefferson Ave.
Texarkana, Arkansas 71854

SUBJECT: Magnolia Economic Development Buildings
Magnolia Business Park, Magnolia, Arkansas
Geotechnical Investigation
ETTL Job No. G1737-05

Dear Mr. Rice:

Submitted herein is the report summarizing the results of a geotechnical investigation conducted at the site of the above referenced project. An executive summary was issued on June 3, 2005.

If you have any questions concerning this report, or if we can be of further assistance during construction, please contact us. We are available to perform any construction materials testing and inspection services that you may require.

Thank you for the opportunity to be of service.

Sincerely,
ETTL Engineers & Consultants Inc.

Arthur M. Campos
Senior Project Manager

Stephen R. Richards, P. E.
Vice President

STEPHEN R. RICHARDS
46424
6/14/05

Distribution: (2) NRS Consulting Engineers

HOME OFFICE:
1717 East Erwin Street
Tyler, Texas 75702-6398
Office: (903) 595-4421
Lab: (903) 595-6402
Fax: (903) 595-6113

TEXARKANA:
210 Beech Street
Texarkana, Arkansas 71854
Office: (870) 772-0013
Fax: (870) 216-2413

LONGVIEW:
707 West Cotton Street
Longview, Texas 75604-5505
Office: (903) 758-0402
Fax: (903) 758-8245

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ETTL ENGINEERS & CONSULTANTS INC.
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GEOTECHNICAL INVESTIGATIONS

Geotechnical Investigation
Magnolia Economic Development Buildings
Magnolia Business Park
Magnolia, Arkansas

Submitted to

NRS Consulting Engineers
Texarkana, Arkansas

Prepared by

ETTL Engineers & Consultants Inc.
Tyler, Texas

June 2005

ANALYTICAL & ENVIRONMENTAL SERVICES • CONSTRUCTION TESTING

EXECUTIVE SUMMARY

This Executive Summary is provided as a brief synopsis of the specific recommendations and design criteria provided in the attached report. It is not intended as a substitute for a thorough reading of the report in its entirety.

Project Description

Two new 12,000 sf, single-story preengineered metal buildings with steel framing and partial brick veneer. The north structure (Planning & Development building) will be used for offices and the south structure (Career Development building) for education. Up to 2' of cut in the northwest corner of each building to 2' of fill in the southeast will be required to construct the pads. Parking areas and drives will also be provided on the east and south sides of the complex.

Site Description

Open and slopes down moderately from northwest to southeast within the building limits.

Depth & Number of Borings

4 – 25' deep and 2 – 15' deep for the buildings and 4 – 5' deep for parking

Soils Encountered

Predominantly soft to very stiff sandy lean clay (CL). A 10' thick zone of medium dense sandy silt (ML) was encountered in borings B-1, B-2, B-3 & B-6 at 8' to 13' deep. Atterberg Plasticity Indices of the tested soils range from 8 to 27.

Groundwater Depth

Phreatic surface predicted to vary between 11' and 13' deep, probably confined below the clay soil at 13' deep.

Recommended Foundation Type

Shallow spread footings

Allowable Gross Bearing Pressure

2,000 psf for isolated footings or 1,500 psf for strip footings. Footings should be founded at a minimum depth of 2 feet below finished subgrade.

Building Subgrade Preparation

- Remove the existing vegetation, topsoil and loose or soft soils. Cut to proposed subgrade as required.
- Scarify the exposed subgrade and recompact.
- Place select fill as required.

Construction Considerations

The surficial soils at most portions of this site may become unstable when wet necessitating stabilization or removal and replacement of wet/soft soils to facilitate construction.

Pavement
Scarify and recompact subgrade. Place asphalt or concrete pavement section.

Pavement Options – Light Duty

Type	Surface/Base Thickness	
Flexible HMAC	2" Surface (Type 2 or Type 3)	6" Crushed Stone Base
Full Depth HMAC	2" Surface (Type 2 or Type 3) & 3" Binder (Type 2)	No Crushed Stone Base
Concrete	5"	No Crushed Stone Base

Pavement Options – Medium Duty

Type	Surface/Base Thickness	
Flexible HMAC	3" Surface (Type 2 or Type 3)	8" Crushed Stone Base
Full Depth HMAC	2" Surface (Type 2 or Type 3) & 4" Binder (Type 2)	No Crushed Stone Base
Concrete	6"	No Crushed Stone Base

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APPENDIX

1.0 INTRODUCTION

This study was performed at the request and authorization to proceed granted by James Rice, Project Manager of NRS Consulting Engineers, Texarkana, Arkansas in accordance with our proposal dated May 5, 2005. Field operations were conducted on May 23, 2005.

The purpose of this investigation was to define and evaluate the general subsurface conditions at the interior Lots 1 & 2, west side of Magnolia Business Park that is located on the north side of Hwy 82, about 0.4 mile east of its intersection with Hwy 371 in Magnolia, Arkansas. Specifically, the study was planned to determine the following:

- Subsurface stratigraphy within the limits of exploratory borings;
- Classification, strength, expansive properties, and compressibility characteristics of the foundation soils;
- Suitable foundation types and allowable loading;
- Construction related problems that may be anticipated by the investigation; and
- Pavement recommendations for the construction of parking and driveways.

To determine this information a variety of tests were preformed on the soil samples. The scope of testing for this report comprised Standard Penetration, Atterberg liquid and plastic limits, Percentage of Fines Passing the No. 200 sieve, Natural Moisture Content and Unconsolidated Undrained Triaxial Compression. These tests were conducted to classify the soil strata according to a widely used engineering classification system; identify, and provide quantitative data for active (expansive) soils; define strength characteristics relating to allowable bearing values; predict immediate settlement; and assess construction workability of the soils.

The conclusions and recommendations that follow are based on limited information regarding site grading and proposed finished floor elevations provided to ETTL by others. Borings were drilled at locations staked by the client. (ETTL did not confirm by survey that the locations indicated on the attached Plan of Borings accurately reflect the location on the ground). This information should be verified prior to design. *Should any portion of it prove incorrect, this firm should be notified in order to assess the need for revisions to this report.*

2.0 PROJECT DESCRIPTION

The project entails two Two new 12,000 sf, single-story preengineered metal buildings with steel framing and partial brick veneer. The north structure (Planning & Development building) will be used for offices and the south structure (Career Development building) for education. Up to 2' of cut in the northwest corner of each building to 2' of fill in the southeast will be required to construct the pads. Parking areas and drives will also be provided on the east and south sides of the complex.

3.0 SITE DESCRIPTION

The site is open and slopes down moderately from northwest to southeast within the building limits.

4.0 FOUNDATION SOIL STRATIGRAPHY & PROPERTIES

The soil profile is predominantly soft to very stiff sandy lean clay (CL). A 10' thick zone of medium dense sandy silt (ML) was encountered in borings B-1, B-2, B-3 & 8-6 at 8' to 13' deep. Atterberg Plasticity Indices of the tested soils range from 8 to 27.

4.1 Behavior of Expansive Soils

Moderately expansive soils such as are found In the upper 5' in boring B-6 swell when they absorb moisture and shrink as they dry. Structures placed on these soils move up and down with such volume changes of the soil. When expansive soils are covered by an impermeable surface such as a building slab or pavement, seasonal moisture fluctuation at the interior of the covered area tends to be reduced or eliminated due to the lack of exposure to natural wetting and drying conditions (i.e., wind, raln, sun, vegetative, etc.). At the edges of the structure. however, the near surface soils are still subject to seasonal drying and wetting. Where continuously irrigated areas abut a building, the risk of severe shrinkage due to seasonal evaporative drying effects is low, but excess moisture could lead to some swelling (especially if native clays are dry at the start of construction). Where areas immediately adjacent to the structure are paved both the risk of swelling due to excess moisture and shrinkage due to moisture loss are reduced significantly.

The moderately expansive soils found in the upper 5' in boring B-6 are generally moderate in moisture content. Potential for swelling is considered to be low to moderate under conditions at the time of drilling. Potential for shrinkage is predicted to be low. As the moisture content of the soil changes from what it was in our samples, the potential for swelling and shrinkage will change accordingly.

One method for quantifying the potential for subgrade movement at any given location is to calculate the Potential Vertical RIse (PVR) (Tex 124 E Modified). This calculation takes into account the inter-relationship between depth, PI, and fluctuations in soil moisture. The maximum potential movement of the eXisting subgrade, PVR, due to normal climatological fluctuations in soil moisture content is predicted to be on the order of 1 inch at the *existing grade* and less than 1 Inch at the finished slab subgrade near boring B-6 (based on assumed dry conditions and an estimated annual seasonal moisture fluctuation zone of approximately 10 feet).

5.0 GROUNDWATER OBSERVATIONS

Groundwater levels and seepage depths were monitored during and upon completion of drilling as well as at some point fol/owing completion. Seepage was observed at 13 feet deep. Groundwater depths were measured at 11 to 20 feet deep 30 minutes to 5.5 hours and after completion of drilling. The phreatic surface is predicted to vary from 11 feet to 13 feet deep, probably confined below the clay soil at 13 feet deep.

It should be noted, however, that seasonal groundwater conditions might vary throughout the year depending upon prevailing climatio conditions. This magnitude of variance will be largely dependent upon the duration and intensity of precipitation, surface drainage characteristics of the surrounding area, and significant changes In site topography.

6.0 FOUNDATION DESIGN RECOMMENDATIONS

A system of individual and/or continuous shallow spread footings with a monolithic flat slab is recommended for support of the proposed superstructure loads for both structures. The risk of distress due to shrink/swell movement of the native soil is considered very low for the education building and somewhat higher (although still relatively low) for the office building (due to the native expansive clay seam in boring B-6 which will remain beneath the structure). That is, shrink/swell movements of the clay that remains beneath the buildings, sh.ould they occur, are predicted to be small and, thus, resulting distress would be relatively minor. A system of shallow footings incorporated in a stiffened slab can be considered as an option to further reduce the risk of movement and recommendations for this system will be provided upon request. Recommendations and pertinent design parameters for a shallow foundation system are presented below. With ground supported floor systems it is *essential* that measures be taken to assure subgrade moisture stability (see section 11.2 Site Design) in order to enhance the chances of satisfactory structure perfolTTlance. Proper site design that prevents water from soaking Into the subgrade solis around the building is essential to reduce the potential for excessive movement caused by saturation of foundation soils.

6.1 Shallow Spread Footings

Shallow footings should be designed to bear in undisturbed native subgrade or properly compacted select fill at a minimum depth of 2 feet below the finished Slab subgrade or adjacent exterior grade (whichever is deeper). Isolated footings should have a minimum width of 3 feet and strip footings shOUld be at least 12 inches wide. Footings should be proportioned for allowable gross bearing pressures of 2,000 pSf for Individual (isolated) footings and 1,500 psf for continuous (strip) shallow footings. These allowable pressures incorporate a safety factor relative to shear failure of the soil of at least 3 and may be increased up to 33% for intermittent loads such as wind. Predicted immediate settlement due to a loading of 2,000 psf for footing Widths less than 6 feet is less than 1 inch (total) and 0.5 Inch (d.ifferential). Detailed testing for the prediction of long-term consolidation settlement due to load is beyond the scope of this investigation, but the magnitUde of such settlement is not anticipated to be significant

7.0 FLOOR SYSTEMS

The floor system for use with a shallow spread footing system consists of a flat slab that is either monolithic with, or isolated from, shallow footings.

7.1 Flat Slab

This floor system consists of a cast-in-place concrete, unstiffened, flat slab on prepared subgrade (according to section 8.0 BUILDING SUBGRADE PREPARATION, below), which is placed monolithically with shallow footings, or can be isolated from them. ProviSion should be made to account for the fact that a heavily loaded foundation element, which is monolithic with an unloaded slab, may result in significant stress in the transition zone between the unloaded slab and the foundation element Reinforcing in the slab is used primarily to control shrinkage.

8.0 BUILDING SUBGRADE PREPARATION

In order to validate the design assumptions given above regarding allowable foundation loads, and, in order to provide a serviceable floor system (within the limitations stated above), it is imperative that the subgrade of the building be properly prepared. The following procedures are recommended as a minimum:

- Remove surficial vegetation and topsoil. Cut to proposed subgrade as required. Proof roll exposed subgrade to detect loose of soft soils, which should be removed and replaced. Backfill any disturbed areas with property compacted select fill.
- Scarify the exposed subgrade to a depth of 8 Inches, adjust the moisture contentto, and maintain it within a range of optimum to optimum +3 percent and recompact to a minimum density of 95% of the maximum density defined by ASTM 0698 (Standard Proctor).
- Place select fill to finished slab subgrade. Specifications for the placement of select fill are covered in section 11.3.Select Fill.

A durable moisture barrier should be provided belween the concrete building slab and the underlying soil subgrade. An Intact membrane installation with lapped and sealed joints and which is repaired If damaged during construction will help to Inhibit moisture migration from the subgrade through the slab.

9.0 CONSTRUCTION CONSIDERATIONS

Surficial soils in most areas may become unstable when wet necessitating stabilization or removal and replacement of wet soils to facilitate construction.

10.0 PAVEMENT RECOMMENDATIONS

General recommendations for the design of *minimal* pavement structures are provided herein for your infonnation. A more detailed pavement analysis would require additional laboratory tests on bulk samples of the materials to be used in pavement construction and is beyond the scope of this Investigation.

These recommendations are based on surface soil characteristics inferred from the borings drilled for the building and at the areas to be paved. Both flexible and rigid pavement sections are presented. A summary of proposed designs is provided in Tables 10.1 and 10.2, below.

10.1 Pavement Subgrade Preparation

As a minimum, strip the native subgrade to remove topsoil and other deleterious materials. Cut to the proposed sUbgrade elevation as required. Exposed subgrade should be proof rolled prior to compaction in accordance with TxDOT Item 216 with the exception of roller size. The use of a 20 ton pneumatic roller or a fully loaded dump truck is recommended. Unstable areas will need to be cut out and replaced with select fill. Scarify the exposed subgrade to a depth of 6 inches. adjust the moisture content to within a range of optimum – 1% to optimum +3%, and recompact to a minimum of 95% of the density as defined by ASTM D 698 (Standard Proctor). Fill material required to achieve final grade in paving areas should be selected and placed in accordance with section 11.3 Select Fill with the exception that only the soil in the top two feet of finished subgrade need meet the *material* requirements for select fill {it should still meet density requirements}, Positive surface drainage should be provided during construction (especially in low areas) to maintain pavement subgrade in a dry and stable condition.

Islands and irrigated areas adjacent to pavement edges can be a source of pavement problems, especially where travel lanes (as opposed to parking spaces) are adjacent. Over watering can lead to infiltration (and consequent destabilization) of flexible base material adjacent to the area. Where a flexible pavement option is chosen, landscaped areas subject to over watering (especially sprinklered islands) should be designed to contain all irrigation water (i.e. prevent leakage out the bottom into adjacent stone base material). An alternate, but less desirable solution is to place a strip of base material in the immediate vicinity of the potential infiltration comprised of HMAC base of the same thickness as the crushed stone base material in lieu of the crushed stone.

10.2 Light-Duty Pavements

10.2.1 Flexible Pavement

The minimum pavement section (and a section commonly used) for light-duty driveways and parking areas consists of 6 inches of crushed stone base with 2 inches of hot mix asphaltic concrete (HMAC). Crushed stone base Should consist of a stone that meets or exceeds the requirements of Section 303, Class 7, AHTD Standard Specifications for Highway Construction. Compaction of the stone base should be to a minimum of 95 percent of ASTM D 1557 (modified proctor) maximum denSity at optimum moisture ±3 percent. Asphaltic concrete surfacing should comply with the requirements of Type 2 or Type 3, Section 407 of the noted AHTD Specifications and should be compacted to a density of 92 to 94 percent of maximum theoretical density.

10.2.2 Full Depth Asphalt

The minimum full depth asphalt pavement section consists of 3 inches of hot mixed asphaltic concrete binder course (Type 2) with 2 inches of hot mixed asphaltic concrete surfacing (Type 2 or 3). Asphaltic concrete surfacing should comply with the requirements of Type 2 or Type 3, Section 407 of the noted AHTD Specifications and the asphaltic concrete binder should comply with the requirements of Type 2, Section 406. All HMAC should be compacted to a density of 92 to 94 percent of maximum theoretical density.

10.2.3 Rigid Pavement

The performance of concrete pavement is dependent on many factors including weight and frequency of traffic, subgrade conditions, concrete quality (Which itself is dependent on a host of factors), joint type and layout, jointing procedures, and numerous construction practices. A detailed discussion of all of these items is beyond the scope of this report By way of general guidance, the following recommendations are offered:

- Minimum concrete compressive strength of 3,500 psi at 28 days placed with a maximum slump of 5 inches. The mix should contain 4% - 6% entrained air for durability.

- Minimum pavement thickness of 5 inches. Concrete thickness may be increased to 6" in lieu of lime stabilized subgrade.

- Sawcut or preformed control joints at maximum spacing of 12 feet each way. Layout of joints should form basically square panels. Timing of the cutting of joints is critical to their performance and generally should be within 4 - 18 hours of concrete placement. *Sealing of joints and cracks and maintenance of the seal are critical for satisfactory performance.*

- Adequate site drainage to prevent ponding on or near the pavement
- Cure concrete via use of liquid membrane curing compound.
- Concrete quality should be controlled and jointing properly executed. Minimum reinforcement should consist of 6 x 6 No.6 welded wire fabric or No.3 at 18 inches each way and should not be continuous through control joints.
- All edges of pavement should be thickened to 9 inches (transitioning back to 5 inches over a minimum distance of 3 feet).
- Allow a minimum of 7 days curing time before permitting traffic on the pavement

The reader is referred to the American Concrete Institute Publication No. ACI 330R, *Guide for Design and Construction of Concrete Parking Lots* for more detailed information.

10.3 Medium-Duty Pavements

10.3.1 Flexible Pavement

For areas that will be subject to trash or delivery truck parking and traffic, the minimum recommended flexible pavement section consists of 8 inches of crushed stone base (Class 7, Section 303, AHTD Standard Specifications for,Highway Construction) and 3 inches of asphaltic concrete surfacing (Type 2 or Type 3, Section 407). Paving materials should be specified as discussed previously.

10.3.2 Full Depth Asphalt

For a medium-duly full depth asphalt section, the minimum recommended section is 6 inches of HMAC paving consisting of 2 inches wearing surfacing (Type 2 or Type 3, Section 407) over 4 inches of asphaltic binder (Type 2, Section 406). Paving materials should be specified as discussed previously.

10.3.3 Rigid Pavement

Recommendations for medium-duty concrete paving are the same as for light duty except that 6 inches of portland cement concrete should be considered the minimum pavement section and the edges should be thickened to 9 inches. Increase thicknesses by 1" where subgrade is not lime stabilized or 12" of select fill is not placed for finished subgrade.

Table 10.1 - Pavement Options - Light Duty

Type	Surface/Sase Thickness	
Flexible HMAC	2" Surface Type 2 or Type 3)	6" Crushed Stone Base
Full Depth HMAC	2" SUrface (Type 2 or Type 3) & 3" Binder (Type 2)	No Crushed Stone Base
Concrate	5"	No Crushed Stone Base

Table 10.2 - Pavement Options - Medium Duty

Type	SurfacelBase Thickness	
Flexible HMAC	3" Surface pe 2 or Type 3)	8" Crushed Stone Base
Full Depth HMAC	2" Surface (Type 2 or Type 3) & 4" Binder (Type 2)	No Crushed Stone Base
Concrete	6"	No Crushed Stone Base

11.0 GENERAL CONSTRUCTION CONSIDERATIONS

11.1 Shallow Footings

All footing excavations should be inspected by qualified personnel to insure that subgrade is composed of firm, undisturbed native soil or properly compacted select fill as recommended in this report. Water and/or loose material in footing excavations should be removed prior to final shaping of the footing excavation and placement of concrete.

11.2 Site Design

The following recommendations are derived from years of experience with structures founded on expansive soils and are considered essential to satisfactory structure performance. especially where the slab is to be placed on grade:

- Sidewalks should be sloped away from buildings and should not be tied to the structures. The joint between the sidewalk and the foundation should be sealed. Sidewalks should not impound water adjacent to the structure. Potential heave of newe ground adjacent to the structure needs to be taken into consideration when constructing the walk so as to avoid a sidewalk which Impounds water adjacent to the structure.

- The ground surface around the building as well as paved areas should be sloped away from the building on all sides so that water will drain away from the structure. A minimum slope of 5% is recommended for the area 10 feet wide immediately adjacent to the structure. Drainage swales should have a minimum longitudinal slope of 2%. Roof drainage should be conveyed by an appropriate means for a distance of at least 15 feet from the building before it is allowed to drain into the subgrade. Water should not be allowed to pond near the building after the floor system has been placed.

- Trees should not be closer than their mature height to the structure and shrubbery should not be planted adjacent to the building unless they can be contained in watertight planter boxes and irrigation waler can be prevented from seeping Into the subgrade around the building. A horizontal moisture barrier (e.g. Mirafi 1212 reinforced polyethylene permanently sealed to the foundation edge at the ground line and sloped away from the building) and placed beneath planting beds is an alternative to planter boxes provided it is maintained In a watertight condition (Le.• joints sealed and punctures repaired). Planting bed edging should not impound water. A root banier around the entire structure perimeter will provide some added assurance against desiccation of the soil due to roots growing beneath the structure. Periodic root pruning may be required to limit drying of soils beneath foundations due to vegetation. *Over irrigation adjacent to the structure can cause* an *increase in subsurface moisture contents that could lead* to *heaving.*

- To help limit surface water infiltration beneath the structure, backfill in the area 10 feet wide adjacent to the structure should be native lean or fat clay soil compacted to a minimum density of 95% of ASTM D 698 (Standard Proctor) at a moisture content of optimum or above. This zone should be at least 2 feet thick. This backfill is not necessary where pavement abuts the structure and the joint is sealed.

- Backfill for utility line ditches should be carefully controlled and should consist of a relatively impenneable material (clayey sand or lean clay), especially in the area beneath and immediately outside of the structure. Old utility lines should be removed from beneath the structure. Fill in new or old utility trenches should be placed to the same specifications as select fill. The top 6 inches under paving should be compacted to a density equal to that specified for the pavement subgrade.

- Utility connections to the building should be flexible to allow for anticipated soil movements that will be different than the anticipated movement of the structure to which they are connected (e.g. where a suspended slab is used).

11.3 Select Fill

Select fill shall consist of homogeneous soils (i.e. not sand with clay lumps) free of organic matter and rocks larger than 6 inches in diameter and possessing an Atterberg PI of 8 to 18. with a liquid limit of 40 or less. Atterberg limits testing of the fill at a rate of 1 test per every 250 cubic yards of fill placed is recommended to verify that fill specifications are met. The material should be placed in the following manner.

- Prepare the subgrade in accordance with the recommendations discussed in a previous section of this report entitled BUILDING SUBGRADE PREPARATION section 8.0. Sites that slope more than about 15% should be benched With 5-foot wide benches prior to placing fill.

- Place subsequent lifts of select fill in thin, loose layers not exceeding nine inches In thickness to the desired rough grade and compact to a minimum of 95% of the maximum density defined by ASTM 0 698. Maintain moisture within a range of optimum to optimum +3%.
- Conduct in-place field density tests at a rate of one test per 3,000 square feet for every lift with a minimum of 2 tests per lift. Density testing is essential to assure that the soil, which supports the structure, is properly placed.
- Prevent excessive loss of moisture during construction.
- For select fill placed above the existing groundline, extend the lateral limits of the fill at least 5 feet beyond the perimeter of the building area, transitioning back to the existing groundline on a 3:1 (horizontal/verticaJ) slope.

12.0 LIMITATIONS

Geotechnical design work is characterized by the presence of a calculated risk that soil and groundwater conditions may not have been fully revealed by the exploratory borings. This risk derives from the practical necessity of basing interpretations and design condusions on a limited sampling of the subsoil stratigraphy at the project site. The number of borings and spacing is chosen in such a manner as to decrease the possibility of undiscovered anomalies, while considering the nature of loading, size and cost of the project. The recommendations given in this report are based upon the conditions that existed at the boring locations at the time they were drilled. The term "existing groundline" or "existing subgrade" refers to the ground elevations and soil conditions at the time of our field operations.

It is conceivable that soli conditions throughout the site may vary from those observed in the exploratory borings. If such discontinuities do exist, they may not become evident until construction begins or possibly much later. Consequently, careful observations by the geotechnical engineer must be made of the construction as It progresses to help detect significant and obvious deviations of actual conditions throughout the project area from those inferred from the exploratory borings: Should any conditions at variance with those noted in this report be encountered during cons1ruction, this office should be notified immediately so that further investigations and supplemental recommendations can be made.

This company is not responsible fur the conclusions, opinions, or recommendations made by others based on the contents of this report. The purpose of this study is only as stated elsewhere herein and is not intended to comply with the requirements of 30 TAC 330 Subchapter T regarding testing to determine the presence of a landfill. Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. No warranties are either expressed or implied.

APPENDIX

1.0 FIELD OPERATIONS

Subsurface conditions at the site were defined by 10 sample core borings drilled to depths of 5 feet and 25 feel **ETTL personnel** drilled the borings at locations staked by the client. The field boring logs were prepared as drilling and sampling progressed and final boring logs are included in the Appendix. Descriptive tenns and symbols used on the logs are in accordance with the Unified Soli Classification System (ASTM D 2487). A reference key is provided on the final page of this report

A truck-mounted rotary drill rig utilizing dry auger drilling procedures was used to advance the borings. Soils were sampled by means of sampled by means of a 1 *3lB-inch* I.D. by 24-inch long split-spoon sampler driven into the bottom of the borehole in accordance with ASTM D 1586 procedures. In conjunction with this sampling technique, the Standard Penetration Test was conducted by recording the N-value, which is the number of blows required by a 140-pound weight falling 30 inches to drive a split-spoon sampler 1 foot into the ground. For very dense strata, the number of blows is limited to a maximum of 50 blows within a 6-inch increment Where possible, the sampler is "seated" 6 inches before the N-value is detennined. The N-vatue obtained from the Standard Penetration Test provides an approximate measure of the relative density that correlates with the shear strength of soil. The disturbed samples were removed from the sampler, logged, packaged, and transported to the laboratory for further identification and classification.

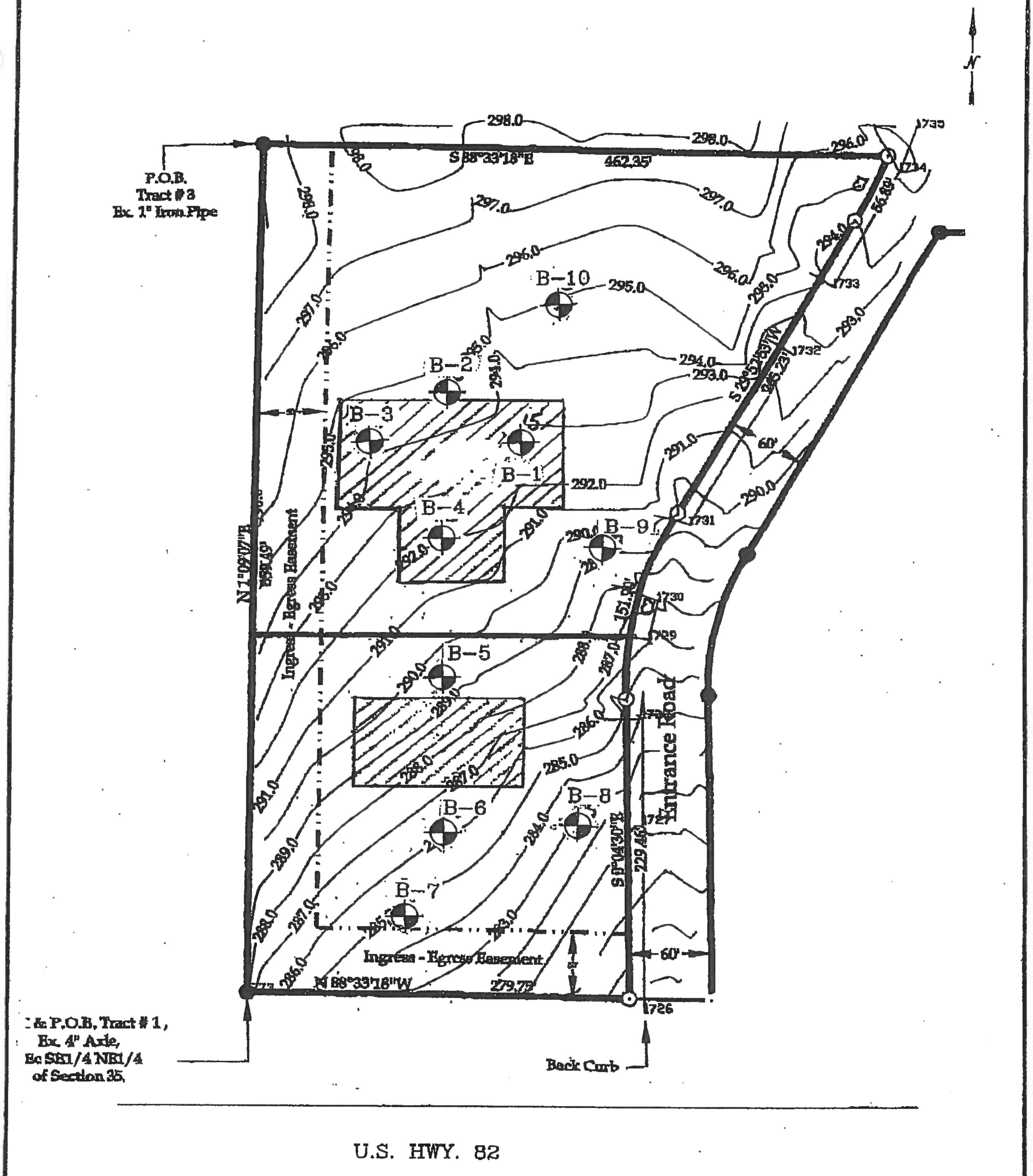
Soils were also sampled by means of a 3-inch *O.D.* by 24-inch long thick-walled Shelby Tube sampler. Using the drilling rig's hydraulic pressure, the sampler was pushed smoothly into the bottom of the borehole. The consistency of these samples was measured in the field by a calibrated pocket penetrometer. These values, recorded in tons per square foot, are shown on the boring logs. Such samples were extruded in the field, logged, sealed to maintain *in situ* conditions. and paCkaged for transport to the laboratory.

Samples obtained during our field studies and not consumed by laboratory testing procedures will be retained in our Tyler office free of charge for a period of 60 days. To arrange storage beyond this point in time, please contact the Tyler office.

11.0 LABORATORY TESTING

Upon retum to the laboratory, a geotechnical engineer visually examined all samples and several specimens were selected for representative identification of the substrata. By detennining the Atterberg liquid and plastic limits (ASTM 0 43'18) and percentage of fines passing the No. 200 sieve (ASTM 0 1140), field classification of the various strata was verified. Also conducted were natural moisture content tests (ASTM D 2216). The results of these tests are presented on each respective log in this Appendix.

Strength characteristics of the cohesive substrata were evaluated by conducting unconsolidated, undrained triaxial compression tests (ASTM D 2850) on selected undisturbed field samples obtained with the Shelby tube sampler. In this type of compression test, confining pressures were chosen that approximate in situ pressures at the sample depth below existing ground. The specimens were axially loaded until failure occurred. The shear strength (or cohesion) is equal to one-half the peak compressive stress. Moisture content (ASTM 02216) and dry density (ASTM 0 2437) are determined as part of this test. The results of these tests are also presented in the individual log of boring provided in this Appendix.



ETTL ENGINEERS & CONSULTANTS
MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

MAGNOLIA
ECONOMIC DEVELOPMENT
BUILDINGS
MAGNOLIA, ARKANSAS

PLATE I – PLAN OF BORINGS

JOB No.: G 1737-05

DATE: JUNE 2005

SCALE: N.T.S.

APPROVED BY:

DRAWN BY:
K.C.R.

ETTL
ENGINEERS &
CONSULTANTS

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

LOG OF BORING B-1

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

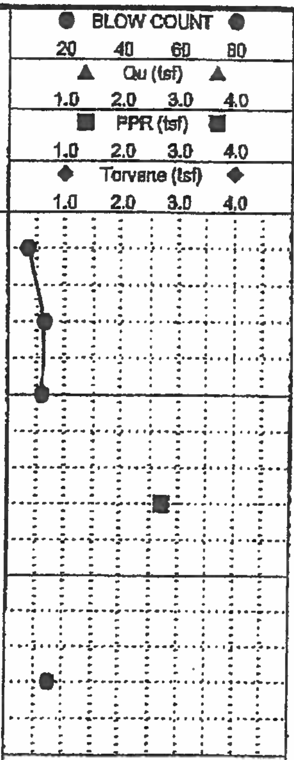
PROJECT NO.: G 1737-05

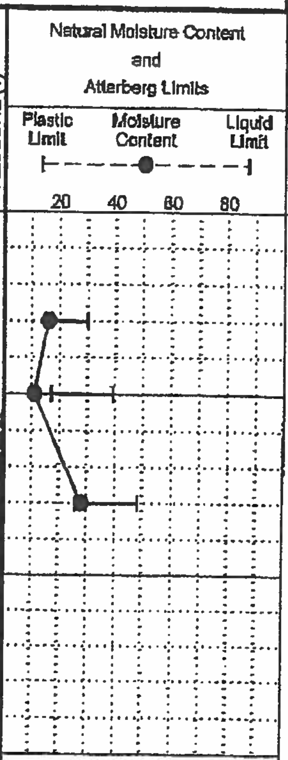
BORING TYPE: Dry Auger

DATE 5/23/05

SURFACE ELEVATION ~293'

DEPTH (ft)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (t)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
0	CL	SANDY LEAN CLAY(CL) medium stiff; tan	N=7										
		--stiff	N=13					16	30	16	14	58	+40 Sieve =1%
5		--tan and red	N=12					11	39	17	22	66	+40 Sieve =0%
		--tan and gray	P=2.7					28	48	26	22	61	+40 Sieve =3%
10													
	ML	SANDY SILT(ML) medium dense; tan; moist	N=15										
15		Bottom of Boring @ 15'											





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

Water Observations: Seepage @ 13' while drilling. Water level @ 13' and open upon completion. Water level @ 11' and open after 5 hours and 20 minutes.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'07.6", W 93 14'40.6"

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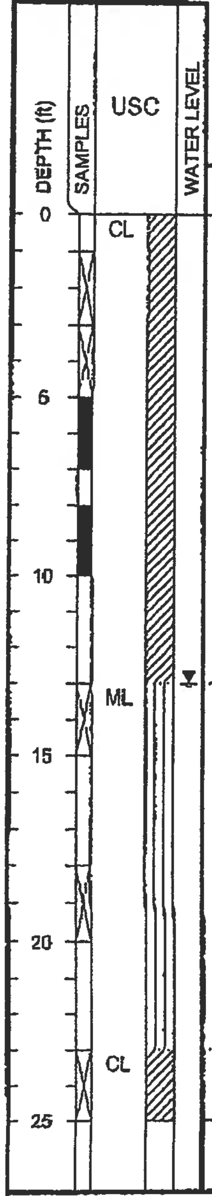
LOG OF BORING B-2

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

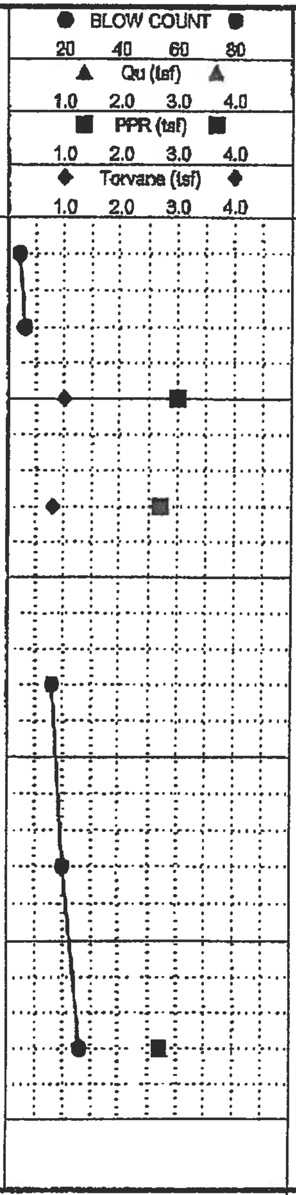
PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

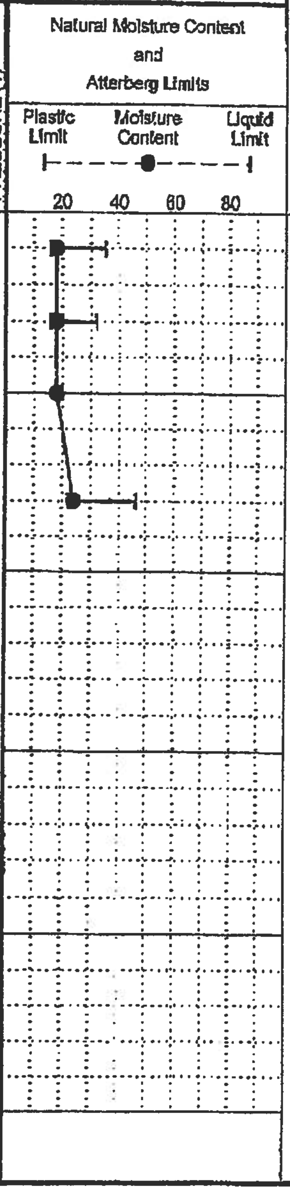
DATE 5/23/05

SURFACE ELEVATION ~293.5'



USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
CL	SANDY LEAN CLAY(CL) medium stiff; brown	N=4					18	35	16	19	66	+40 Sieve =2%
		N=6					18	32	16	16	60	+40 Sieve =2%
		P=3.0 T=1.0	107	1.30	4	6	18					
	–very stiff; gray and red	P=2.7 T=0.8					24	46	22	24	50	+40 Sieve =2%
ML	SANDY SILT(ML) medium dense; tan and gray	N=16										
	–gray and tan	N=20										
CL	LEAN CLAY(CL) very stiff; brown	N=26 P=2.7										
	Bottom of Boring @ 25'											





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

Water Observations: Seepage @ 13' while drilling. Water level @ 20' and open upon completion. Water level @ 13' and caved to 21' after 3 hours and 45 minutes.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'07.6", W 93 14'40.3"

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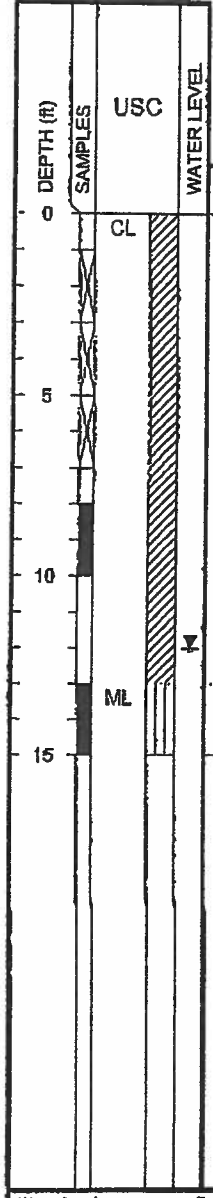
LOG OF BORING B-3

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

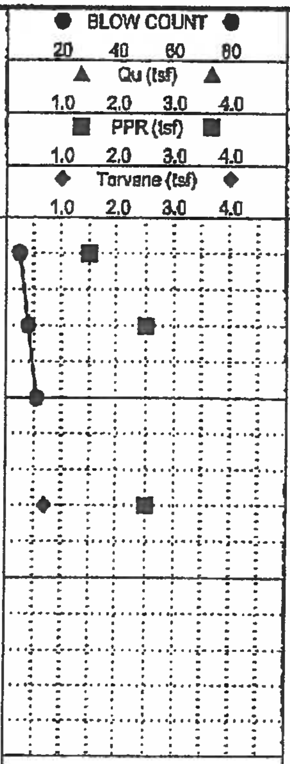
DATE 5/23/05

SURFACE ELEVATION ~294.5'

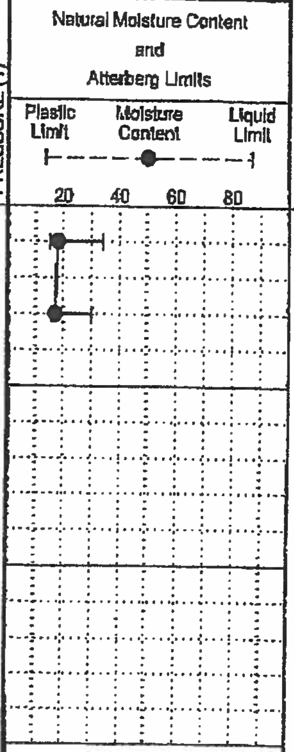


MATERIAL DESCRIPTION

Depth (ft)	Material Description	Field Strength Data
0	SANDY LEAN CLAY(CL) stiff; brown and red	N=5 P=1.5
	--very stiff	N=8 P=2.5
5	--with roots	N=11
		P=2.5 T=0.7
13	SANDY SILT(ML) tan; wet	
15	Bottom of Boring @ 15'	



DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (1)



MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
18	34	15	19	63	+40 Sieve =1%
17	30	16	14	60	+40 Sieve =2%

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

Water Observations: Seepage @ 13' while drilling. Water level @ 13' and open upon completion. Water level @ 12' and open after 2 hours and 15 minutes.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'07.0", W 93 14'40.9"

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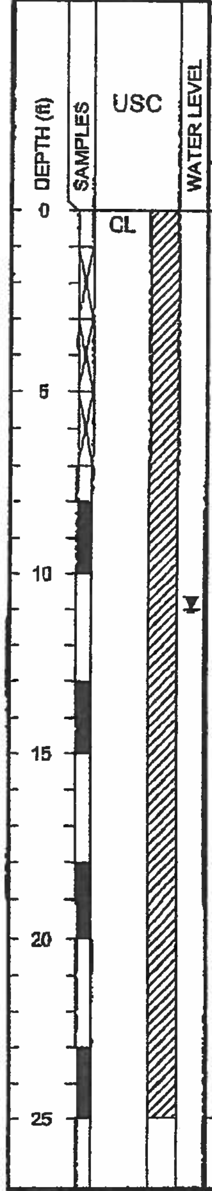
LOG OF BORING B-4

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

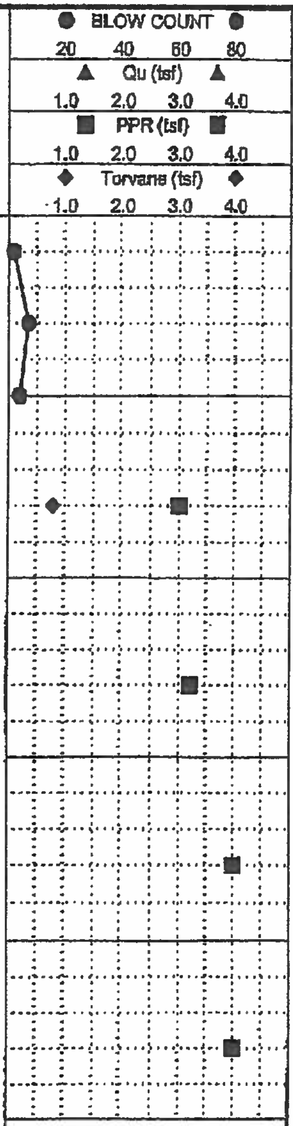
PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

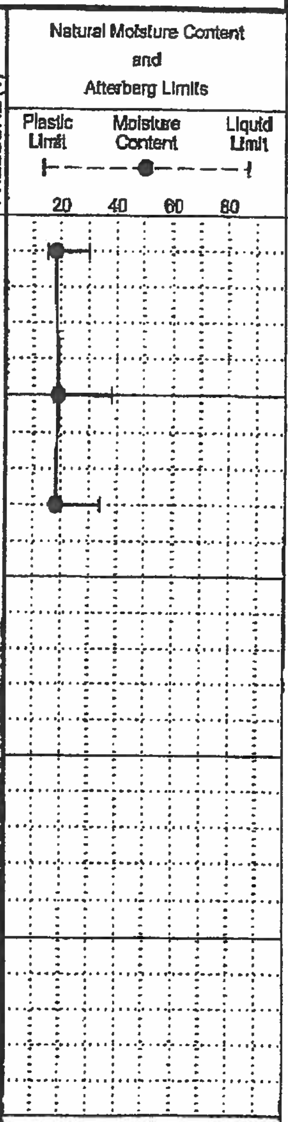
DATE 5/23/05

SURFACE ELEVATION ~292'



MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
SANDY LEAN CLAY(CL) soft; red and gray	N=2					18	30	15	15	61	+40 Sieve =1%
--medium stiff	N=7										
--gray and red	N=4					19	38	17	21	68	+40 Sieve =2%
--very stiff	P=3.0 T=0.8					18	34	17	17	58	+40 Sieve =1%
--tan	P=3.2										
--gray; with sand seams	P=4.0										
	P=4.0										
Bottom of Boring @ 26'											





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

Water Observations: Seepage @ 13' while drilling. Water level @ 21' and open upon completion. Water level @ 11' and caved to 22' after 1 hour and 20 minutes.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
1 - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'06.2", W 93 14'40.3"

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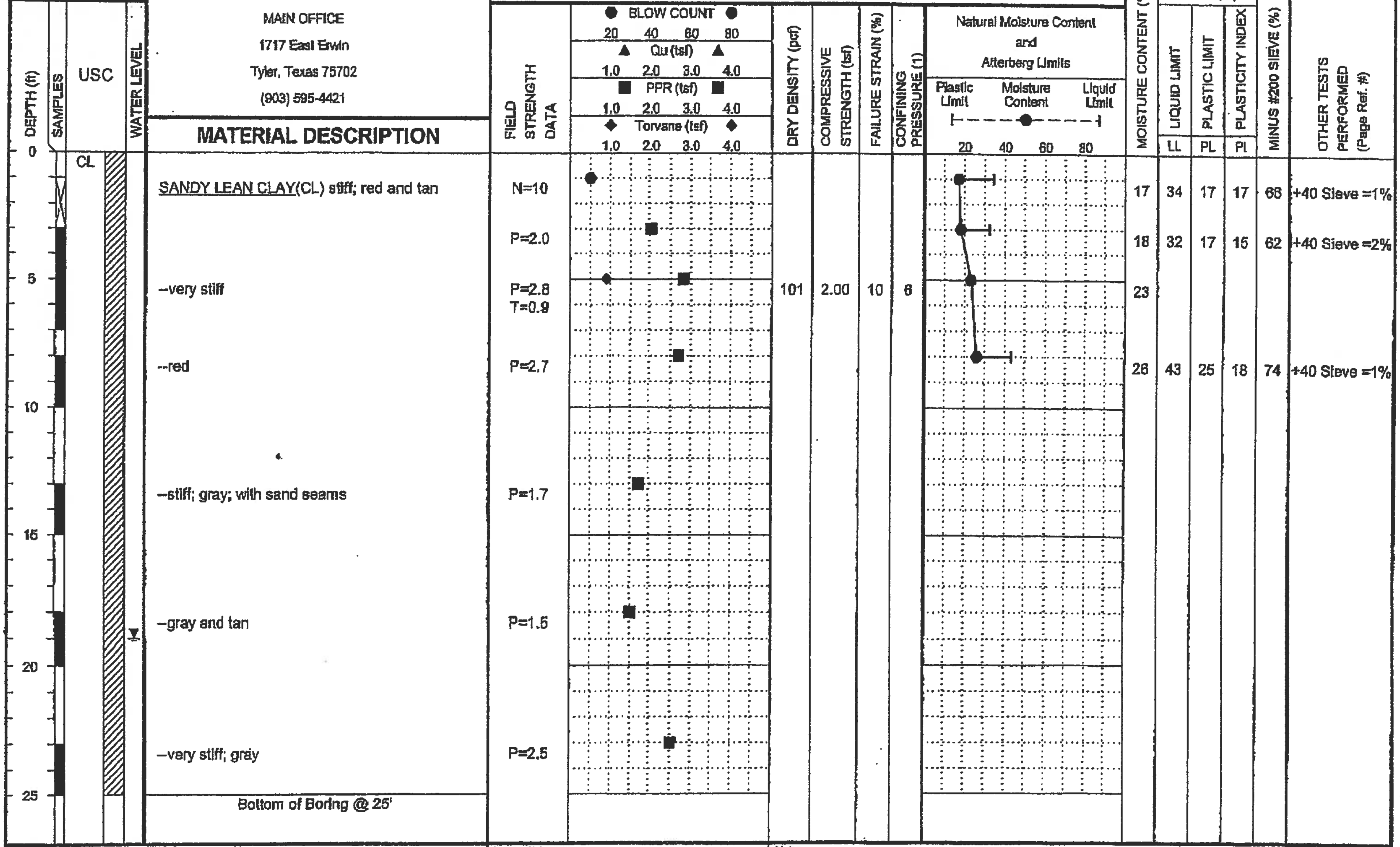
LOG OF BORING B-5

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

DATE 5/23/05

SURFACE ELEVATION ~289.5'



MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
SANDY LEAN CLAY(CL) stiff; red and tan	N=10					17	34	17	17	68	+40 Sieve =1%
	P=2.0					18	32	17	15	62	+40 Sieve =2%
--very stiff	P=2.8 T=0.9	101	2.00	10	6	23					
--red	P=2.7					26	43	25	18	74	+40 Sieve =1%
--stiff; gray; with sand seams	P=1.7										
--gray and tan	P=1.5										
--very stiff; gray	P=2.5										
Bottom of Boring @ 25'											

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

Water Observations: Seepage @ 13' while drilling. Water level @ 22' and open upon completion. Water level @ 19' and caved to 22' after 30 minutes.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'05.2", W 93 14'40.3"

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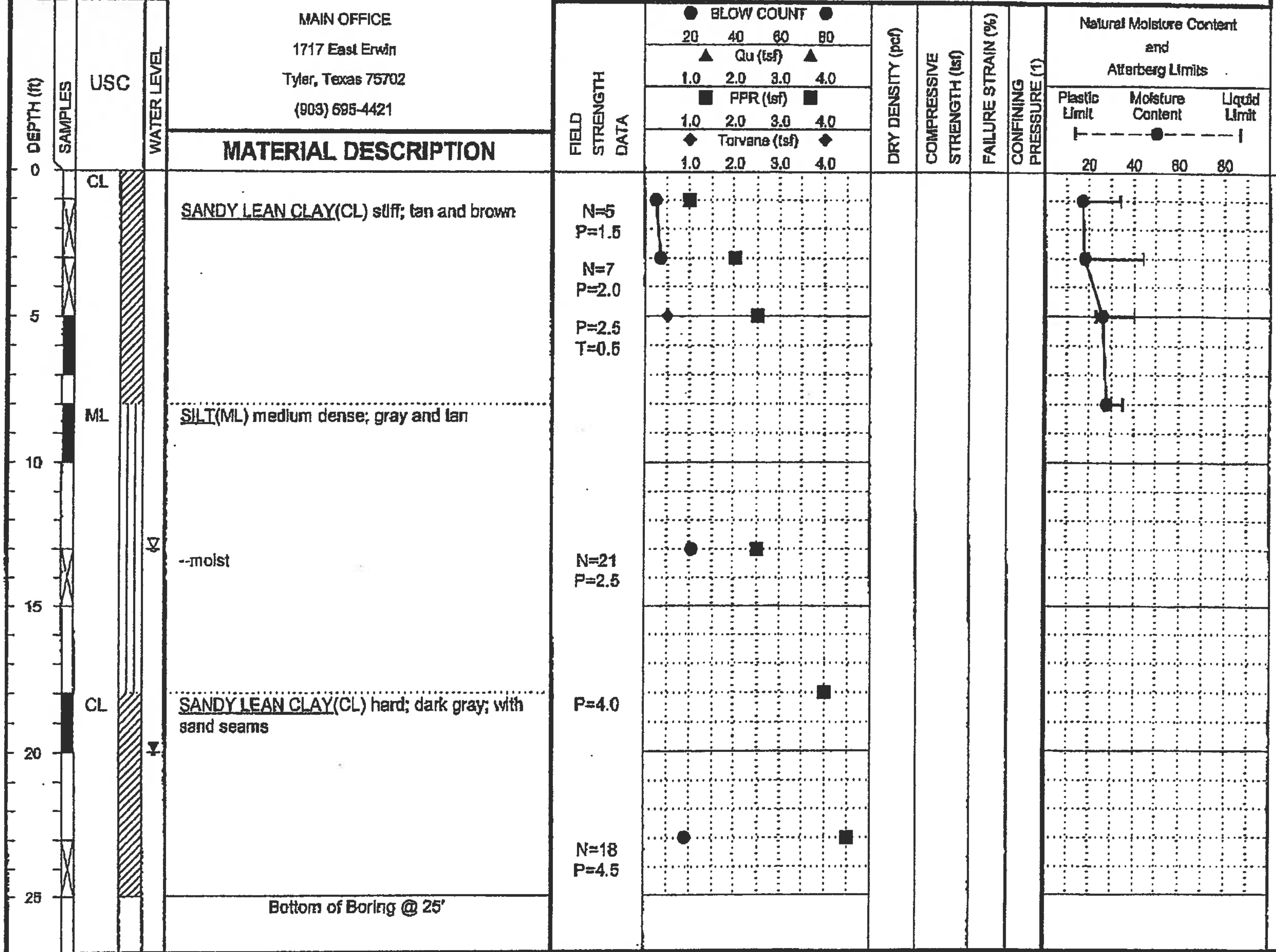
LOG OF BORING B-6

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

DATE 5/24/05

SURFACE ELEVATION ~286'



MATERIAL DESCRIPTION	FIELD STRENGTH DATA	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
SANDY LEAN CLAY(CL) stiff; tan and brown	N=5 P=1.5	17	34	17	17	65	+40 Sieve =2%
	N=7 P=2.0	18	44	17	27	66	+40 Sieve =10%
	P=2.5 T=0.5	26	40	23	17	74	+40 Sieve =2%
SILT(ML) medium dense; gray and tan		28	35	27	8	95	+40 Sieve =2%
--moist	N=21 P=2.5						
SANDY LEAN CLAY(CL) hard; dark gray; with sand seams	P=4.0						
	N=18 P=4.5						
Bottom of Boring @ 25'							

Water Level Est: ∇ Measured: ▼ Perched: ∇

Water Observations: Seepage @ 13' while drilling. Water level @ 23' and open upon completion. Water level @ 20' and caved to 22' after 1 hour and 30 minutes.

Key to Abbreviations:
- N - SPT Data (Blows/Ft)
- P - Pocket Penetrometer (tsf)
- T - Torvane (tsf)
- L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'04.8", W 93 14'40.1"

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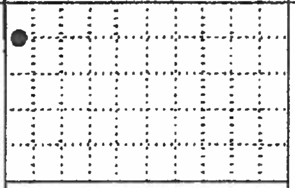
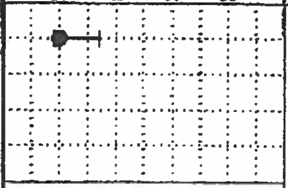
LOG OF BORING B-7

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

DATE 5/24/05

SURFACE ELEVATION ~285'

DEPTH (ft)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	● BLOW COUNT ● 20 40 60 80 ▲ Qu (tsf) ▲ 1.0 2.0 3.0 4.0 ■ PPR (tsf) ■ 1.0 2.0 3.0 4.0 ◆ Torvane (tsf) ◆ 1.0 2.0 3.0 4.0	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	Natural Moisture Content and Atterberg Limits Plastic Limit ├ – – Moisture Content ● – – ┤ Liquid Limit 20 40 60 80	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
0		CL		<u>LEAN CLAY WITH SAND</u>(CL) medium stiff; light red and tan	N=5							20	34	18	16	73	+40 Sieve =1%
5				Bottom of Boring @ 5'													

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

Water Observations: Dry and open upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'02.6", W 93 14'40.5"

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LOG OF BORING B-8

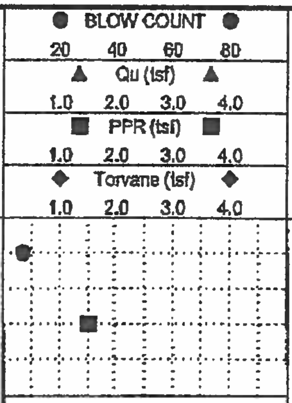
PROJECT: Magnolia Economic Development
Magnolia, Arkansas

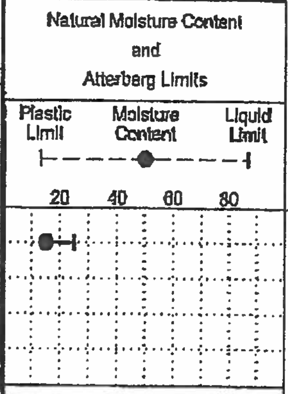
PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

DATE 5/24/05

SURFACE ELEVATION ~283'

DEPTH (ft)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
0	CL	SANDY LEAN CLAY(CL) stiff; light brown and light red	N=7 P=1.5					15	25	16	9	64	+40 Sieve =3%
5		Bottom of Boring @ 5'											





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

Water Observations: Dry and open upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'03.4", W 93 14'39.8"

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LOG OF BORING B-9

PROJECT: Magnolia Economic Development
Magnolia, Arkansas

PROJECT NO.: G 1737-05

BORING TYPE: Dry Auger

DATE 5/24/05

SURFACE ELEVATION ~289'

DEPTH (ft)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	● BLOW COUNT ● 20 40 60 80 ▲ Qu (tsf) ▲ 1.0 2.0 3.0 4.0 ■ PPR (tsf) ■ 1.0 2.0 3.0 4.0 ◆ Torvane (tsf) ◆ 1.0 2.0 3.0 4.0	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	Natural Moisture Content and Atterberg Limits Plastic Limit ├ Moisture Content ● Liquid Limit ┤ 20 40 60 80	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	ATTERBERG LIMITS(%) PLASTIC LIMIT PL	ATTERBERG LIMITS(%) PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
0	☒	SC		CLAYEY SAND(SC) loose; tan and red	N=5	●											
5	■			Bottom of Boring @ 5'													

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

Water Observations: Dry and open upon completion.

Key to Abbrevations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'05.7", W 93 14'39.4"

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LOG OF BORING B-10

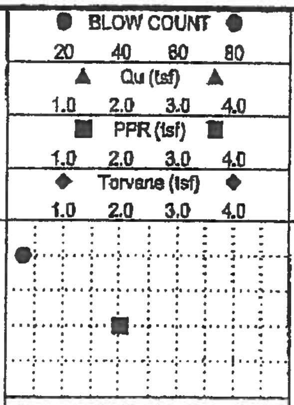
PROJECT: Magnolia Economic Development
Magnolia, Arkansas

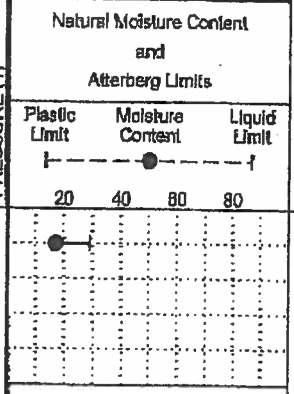
PROJECT NO.: G 1737-05 **BORING TYPE:** Dry Auger

DATE 5/24/05

SURFACE ELEVATION ~295.0'

DEPTH (ft)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (1)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
0		CL		SANDY LEAN CLAY(CL) medium stiff; tan and red	N=6					17	29	16	13	60	+40 Sieve =1%
				--very stiff	P=2.0										
5				Bottom of Boring @ 5'											





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

Water Observations: Dry and open upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
Coordinates: N 33 18'08.1", W 93 14'39.6"

KEY TO SOIL CLASSIFICATIONS AND SYMBOLS

UNIFIED SOIL CLASSIFICATION SYSTEM (1)

Major Divisions		Letter	Symbol	Color	Name
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	▨	Red	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	▨		Poorly-graded gravels or gravel-sand mixtures, little or no fines
		GM	▨	Yellow	Silty gravels, gravel-sand-clay mixtures.
		GC	▨		Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	▨	Red	Well-graded sands or gravelly sands, little or no fines
		SP	▨		Poorly-graded sands or gravelly sands, little or no fines
		SM	▨	Yellow	Silty sands, sand-silt mixtures
		SC	▨		Clayey sands, sand-clay mixtures
FINED GRAINED SOILS	SILTS AND CLAYS LL < 50	ML	▨	Green	Inorganic silts and very fine sands, rock flour, fine sandy silts, gravelly silts or silts with slight plasticity
		CL	▨		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	▨		Organic silts and organic silt-clays of low plasticity.
	SILTS AND CLAYS LL > 50	MH	▨	Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	▨		Inorganic clays of high plasticity, fat clays
		OH	▨		Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		Pt	▨	Orange	Peat and other highly organic soils

TERMS CHARACTERIZING SOIL STRUCTURE

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 (VARVED)-composed of thin layers of varying color and texture, usually grading from sand or silt at the bottom to clay at the top

CRUMBLY-cohesive soils which break into small blocks or crumbs on drying.

CALCAREOUS-containing appreciable quantities of calcium carbonate, generally nodular.

WELL GRADED-having wide range in grain sizes and substantial amounts of all intermediate particle sizes.

POORLY GRADED-predominantly of one grain size (uniformly graded) or having a range of sizes with some intermediate size missing (gap or skip graded).

SYMBOLS FOR TEST DATA

M/C = 15 - Natural moisture content in percent

δ = 95 -- Dry unit weight in lbs/cu ft.

Qu = 1.23 - Unconfined compression strength in tons/sq. ft.

Qc = 1.68 (21 psi) - Confined compression strength at indicated lateral pressure.

51-21-30 - Liquid limit, Plastic limit and Plasticity index.

30% FINER - Percent finer than No. 200 mesh sieve.

30 B/F - Blows per foot, standard penetration test.

▼ - Ground water table.

TERMS DESCRIBING CONSISTENCY OF SOIL (2)

COARSE GRAINED SOILS		FINE GRAINED SOIL		
DESCRIPTIVE TERM	NO. BLOWS/FT. STANDARD PEN. TEST	DESCRIPTIVE TERMS	NO. BLOWS/FT. STANDARD PEN. TEST	UNCONFINED COMPRESSION TONS PER SQ.FT.
Very loose	0-4	Very Soft	< 2	< 0.25
Loose	4-10	Soft	2 - 4	0.25 - 0.50
Medium Dense	10-30	Medium Stiff	4 - 8	0.50 - 1.00
Dense	30-50	Stiff	8 - 15	1.00 - 2.00
Very Dense	over 50	Very Stiff	15 - 30	2.00 - 4.00
		Hard	over 30	over 4.00

Field classification for "Consistency" is determined with a 0.25" diam. penetrometer.

SAMPLER TYPES

■	◫	☒	▥	○
Shelby Tube	Rock Core	Split Spoon	Auger	No Recovery

1 - From Waterways Experiment Station Technical Memorandum No. 3-367
2 - From "Soil Mechanics in Engineering Practice" by Terzaghi and Peck