Geotechnical Engineering Report

Paving Improvements at Utility Line Repair Facility

1505 Dickinson Avenue

League City, Texas

June 20, 2014

Terracon Project No. 91145033

Prepared for:

City of League City
League City, Texas

Prepared by:

Terracon Consultants, Inc.
League City, Texas

June 20, 2014

City of League City
1505 Dickinson Avenue
League City, Texas 77573

Attn: Mr. Bobby Morrison

Re: Geotechnical Engineering Report
Paving Improvements at Utility Line Repair Facility
1505 Dickinson Avenue
League City, Texas
Terracon Project No. 91145033

Dear Mr. Morrison:

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the project referenced above in League City, Texas. We trust that this report is responsive to your project needs. Please contact us if you have any questions or if we can be of further assistance.

We appreciate the opportunity to work with you on this project and look forward to providing additional geotechnical engineering and construction materials testing services in the future.

Sincerely,
Terracon Consultants, Inc.
(Texas Firm Registration No.: F-3272)

Daniel B. Mabirizi, E.I.T.
Staff Geotechnical Engineer

Ather Mohiuddin, P.E.
Geotechnical Services Manager

STATE OF TEXAS
ATHER MOHIUDDIN
100330
LICENSED PROFESSIONAL ENGINEER
6/20/2014

Enclosures

Copies Submitted: Addressee: (2) Bound & (1) Electronic

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EXECUTIVE SUMMARY

This geotechnical engineering report has been prepared for the proposed construction of paved parking and a drive lane associated with the existing utility line repair building located at 1505 Dickinson Avenue in League City, Texas. Five test borings, designated B-1 through B-5, were drilled to depths that ranged from about 6 to 10 feet below existing grade within the proposed pavement areas.

Based on the information obtained from our subsurface exploration, the proposed pavement can be constructed at this site. A summary of our findings and recommendations is provided below.

- Approximately 3 to 6 inches of crushed stone was observed overlying the subgrade soils at borings B-1 through B-5.
- Fill soils were observed at borings B-1 through B-5 below the surficial crushed stone and extended to depths that ranged from about 4 to 8 feet below existing grade. Support of pavements on or above existing fill soils is discussed in this report. However, even if recommendations discussed herein are implemented, an inherent risk exists for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered.
- Based on the subsurface soil conditions observed at this site and our experience with similar soil and drainage conditions, we recommend a concrete pavement system. The concrete pavement system should consist of a minimum 7 inches of reinforced concrete underlain by a minimum of 6 inches of lime treated subgrade. As an alternative, a minimum 6 inches of cement stabilized sand may be utilized in lieu of lime treated subgrade.
- The asphaltic concrete pavement system, if planned should consist of a minimum 3 inches of asphaltic concrete surface course underlain by a minimum 10 inches of asphaltic concrete base course with a minimum 6 inches of lime treated subgrade. As an alternative, a minimum 6 inches of cement stabilized sand may be utilized in lieu of lime treated subgrade.
- Post-construction subgrade movements and some cracking of the pavements are not uncommon for subgrade conditions such as those observed at this site. Reducing moisture changes in the subgrade is important to reduce shrink/swell movements. Although chemical treatment of the subgrade will help to reduce such movement, this movement cannot be economically eliminated.

This summary should be used in conjunction with the entire report for design purposes. Details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **"5.0 GENERAL COMMENTS"** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PAVING IMPROVEMENTS AT UTILITY LINE REPAIR FACILITY
1505 DICKINSON AVENUE
LEAGUE CITY, TEXAS
Project No. 91145033
June 20, 2014

1.0 INTRODUCTION

Terracon is pleased to submit our geotechnical engineering report for the proposed construction of paved parking and a drive lane associated with the existing utility line repair building located at 1505 Dickinson Avenue in League City, Texas. Five test borings, designated B-1 through B-5, were drilled to depths that ranged from about 6 to 10 feet below existing grade within the proposed pavement areas. This project was authorized by Mr. John Baumgartner, Assistant City Manager – Public Works for the City of League City, through signature of the City's "Agreement" on April 28, 2014. The project scope was performed in general accordance with Terracon Document No. P91140105, dated April 22, 2014.

The purpose of this report is to describe the subsurface conditions observed at the five test borings drilled for this report, analyze and evaluate the test data, and provide recommendations with respect to:

- Site and subgrade preparation; and
- Pavement design guidelines.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Project location	See Appendix A, Exhibit A-1, Site Location Plan.
Site layout	See Appendix A, Exhibit A-2, Boring Location Plan.
Proposed improvements	Construction of paved parking and drive lane. The proposed paved area is planned to be about 30,000 square feet in size.
Proposed pavement system	Either a reinforced concrete pavement or an asphaltic concrete pavement.

2.2 Site Description

Item	Description
Site location	1505 Dickinson Avenue in League City, Texas.
Existing conditions	The proposed pavement alignment is covered with crushed stone. A drainage ditch was observed along the south side of the proposed pavement alignment. The utility line repair building is generally located adjacent west and north of the proposed paving. The rain gutters associated with building flows directly towards the proposed pavement.
Current ground cover	Crushed stone and flatwork associated with utility repair building.
Existing topography	Relatively level.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

The site for the proposed construction is located on the Beaumont clay formation, a deltaic nonmarine Pleistocene deposit. The Beaumont clay is a heterogeneous formation containing thick interbedded layers of clay, fine sand and silt.

The clay fraction is primarily composed of montmorillonite, illite, kaolinite, and finely ground quartz. The clay present in the formation has been preconsolidated by a process of desiccation. Numerous wetting and drying cycles have produced a network of small randomly oriented, closely-spaced joints within some depth zones. These small joints frequently have a shiny appearance and the clays are called slickensided in these cases. The joint pattern may have an influence on the construction and engineering behavior of the soil.

The coastal plain in this region has a complex tectonic geology, several major features of which are: Gulf Coastal geosyncline, salt domes, and major sea level fluctuations during the glacial stages, subsidence and geologic faulting activities. Most of these geologic faulting activities have ceased for millions of years, but some are still active. A geologic fault investigation and study of the site geology are beyond the scope of this report.

3.2 Typical Profile

The particular subsurface stratigraphy, as evaluated from our field and laboratory programs, is shown in detail on the Boring Logs in Appendix A. Approximately 3 to 6 inches of crushed stone was observed overlying the subgrade soils at borings B-1 through B-5. Fill soils were observed at borings B-1 through B-5 below the surficial crushed stone and extended to depths that ranged from 4 to 8 feet below existing grade. The underlying native subsurface soils generally consisted of lean clay soils to the termination depths of the borings (about 6 to 10 feet below existing grade). Conditions observed at each boring location are indicated on the individual Boring Logs. Stratification boundaries on the Boring Logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for each boring can be found on the Boring Logs in Appendix A of this report.

Based on our field and laboratory programs, engineering values for the subsurface conditions can be summarized as follows:

Subsurface Soils				
Depth Range (feet)	**Description**	**Plasticity Index (%)**	**Moisture Content (%)**	**Undrained Shear Strength[1] (psf)**
0.3 – 10	Fill: Lean Clays	19 to 30	14 to 23	1,400 to 2,800
4 – 6	Lean Clays	---	---	1.0 to 3.5[2]

1. Based on unconfined compressive strength tests.
2. Pocket penetrometer reading in tons per square foot (tsf).

3.3 Groundwater

The borings were advanced using dry drilling techniques to their termination depths (approximately 6 to 10 feet below the existing grade) in an effort to evaluate groundwater conditions at the time of our field program. Groundwater was not observed at borings B-1 through B-5 during or upon completion of drilling. These groundwater measurements are considered short-term, since the borings were open for a short time period. On a long-term basis, groundwater may be present within the depths explored. Additionally, groundwater will fluctuate seasonally with climatic changes and should be evaluated at the time of construction.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

The following recommendations are based upon the data obtained in our field and laboratory programs, project information provided to us, and on our experience with similar subsurface and site conditions.

4.1 Geotechnical Considerations

As previously stated, fill soils were observed at borings B-1 through B-5 below the surficial crushed stone and extended to depths that ranged from 4 to 8 feet below existing grade (grade at the time of our field program). Fill soils may be present at varying depths at other locations within the site not explored during our field program. Support of the pavements on or above existing fill soils is discussed in this report. However, even if recommendations discussed herein are implemented, an inherent risk exists for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill.

Post-construction subgrade movements and some cracking of the pavements are not uncommon for subgrade conditions such as those observed at this site. Reducing moisture changes in the subgrade is important to reduce shrink/swell movements. Although chemical treatment of the subgrade will help to reduce such movement/cracking, this movement/cracking cannot be economically eliminated.

4.2 Earthwork

Planned finished grades were not available at the time of this report. We anticipate that the finished elevations for the proposed pavement areas are planned to be within approximately one foot of the existing grade (and match existing concrete flatwork elevation). If significant cuts and/or fills are planned, Terracon should be notified to review and/or modify our recommendations given in this subsection.

The construction areas should be stripped of crushed stone, vegetation, topsoil, and other debris/unsuitable material. Proper site drainage should be maintained during construction so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access.

Once final subgrade elevations have been achieved, the exposed soil subgrade areas should be carefully proofrolled with a 20-ton pneumatic roller or similar equipment, such as a fully loaded dump truck, to detect weak areas. Special care should be exercised when proofrolling areas containing fill soils to detect soft/weak areas within the fill soils. Weak areas detected during proofrolling, as well as zones of fill containing organics and/or debris, should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in-situ soils. Proofrolling should be performed under the direct observation of the geotechnical engineer or his/her representative.

Subsequent to proofrolling, and just prior to placement of fill (if required), the exposed subgrade within the construction areas should be evaluated for moisture and density. The subgrade should be within 2 percent of the optimum content, and should have an in-place dry density of at least 95 percent of the Standard Effort (ASTM D698) maximum dry density. If the moisture or density does not meet the above criteria, the subgrade should be scarified to a minimum depth of 6 inches, moisture adjusted to within 2 percent of the optimum content, and compacted to at least 95 percent of the Standard Effort (ASTM D698) maximum dry density.

If required, the fill soils used for grade adjustments should consist of soils with similar characteristics as the on-site soils and should be compacted to at least 95 percent of the Standard Effort (ASTM D698) maximum dry density at a moisture content within 2 percent of the optimum content in lifts not exceeding 8 inches loose measure.

Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

4.2.1 Wet Weather / Soft Subgrade Considerations

Construction operations may encounter difficulties due to wet or soft surface soils becoming a general hindrance to equipment due to rutting and pumping of the soil surface, especially during and soon after periods of wet weather. If the subgrade cannot be adequately compacted to the minimum densities as described above, one of the following measures will be required: 1) removal and replacement with select fill, 2) chemical treatment of the soil to dry and improve the condition of the subgrade, or 3) drying by natural means if the schedule allows. In our experience with similar soils in this area, chemical treatment is the most efficient and effective method to increase the supporting value of wet and weak subgrade. Terracon should be contacted for additional recommendations if chemical treatment of the soils is needed.

4.3 Pavements

Based on the subsurface conditions, we anticipate that the pavement subgrade will generally consist of on-site medium to high plasticity clay soils. We recommend that the top 6 inches of the finished subgrade soils directly beneath the pavements be chemically treated. Chemical treatment will increase the supporting value of the subgrade and decrease the effect of moisture on subgrade soils. This 6 inches of treatment is a required part of the pavement design and is not a part of site and subgrade preparation for wet/soft subgrade conditions.

The on-site medium to high plasticity clay soils should be treated with lime. For planning purposes, we recommend the use of about 6 to 8 percent lime, which is typically equivalent to about 40 to 50 pounds of lime per square yard per 6-inch depth. These treatment percentages are given as application by dry weight of soil. The actual amount of lime required should be determined at the time of construction by the use of lime determination tests on bulk samples of the subgrade obtained from the final subgrade elevation. The subgrade soils should be treated in accordance with TxDOT 2004 Standard Specifications Item 260 for lime treated subgrade.

Due to the presence of adjacent structures, we understand that pavement subgrade may consist of cement stabilized sand in lieu of lime treated subgrade. The cement stabilized sand can be utilized immediately beneath the paving sections provided the subgrade is compacted to at least 95 percent of the Standard Effort (ASTM D558) maximum dry density.

Detailed traffic loads and frequencies were not available at the time of this report. However, we understand that traffic will primarily consist of 6-wheeler and 10-wheeler utility repair trucks, passenger vehicles and other maintenance vehicles. We estimated the traffic loading in Equivalent 18-kip Single Axle Loads (ESALs) based on a minimum 7-inch thick concrete pavement section. The pavement component thicknesses provided in the following tables can support traffic consisting of approximately 500,000 ESALs. If the anticipated traffic for the proposed pavement system is planned to exceed 500,000 ESALs, Terracon should be contacted to revise our pavement design analysis.

Concrete Pavement System		
Estimated Traffic	**Component**	**Material Thickness (Inches)**
500,000 ESALs	Reinforced Concrete	7
	Lime Treated Subgrade or Cement Stabilized Sand	6

Asphalt Pavement System		
Estimated Traffic	**Component**	**Material Thickness (Inches)**
500,000 ESALs	Asphaltic Concrete Surface Course	3
	Cement Treated Base Material	10
	Lime Treated Subgrade or Cement Stabilized Sand	6

Based on the subsurface soil conditions observed at this site and our experience with similar soil conditions, and existing drainage conditions, we recommend a concrete pavement system be considered for this project.

The pavement section thicknesses were estimated based on general characterization of the subgrade. Specific testing (such as CBR tests, resilient modulus tests, etc.) was not performed for this project to evaluate the support characteristics of the subgrade. At the time of construction, we recommend to perform a laboratory compaction (standard proctor) test and a laboratory California Bearing Ratio (CBR) test on at least one bulk sample of the anticipated pavement subgrade material to verify our design assumptions.

The pavement materials should meet the following recommended specifications:

<u>Reinforced Concrete Pavement</u> – The materials and properties of portland cement concrete shall meet applicable requirements in the ACI Manual of Concrete Practice. The portland cement concrete mix should have a minimum 28-day compressive strength of 3,500 psi.

The reinforcing steel, expansion joints, contraction joints, and construction joints should be constructed in accordance with the 2011 City of League City "General Design and Construction Standards" for concrete pavement.

Hot Mix Asphaltic Concrete Surface Course – The asphaltic concrete surface course should be plant mixed, hot laid Type C or D (Fine Graded Surface Course) meeting the specifications requirements in TxDOT 2004 Standard Specifications Item 340. Specific criteria for the job specifications should include compaction to within an air void range of 5 to 9 percent calculated using the maximum theoretical gravity mix measured by TxDOT Tex-227-F. The asphalt cement content by percent of total mixture weight should be within ± 0.5 percent asphalt cement from the job mix design.

Cement Treated Base Material – The base material should consisit of crushed limestone or crushed concrete meeting the requirements of TxDOT 2004 Standard Specifications Item 247, Type A or D, Grade 1. The base material should be compacted to at least 95 percent of the Modified Effort (ASTM D1557) maximum dry density at a moisture content within 2 percent of the optimum moisture content.

The base material should be treated with cement applied at a rate of 3 percent cement. This percentage is typically equivalent to about 25 pounds of cement per square yard per 10-inch treated depth. This treatment percentage is given as application by dry weight. The base material should be treated in accordance with TxDOT 2004 Standard Specifications Item 275.

Lime Treated Subgrade – The on-site medium to high plasticity clay soils should be treated with lime in accordance with the TxDOT 2004 Standard Specifications Item 260. We recommend that 6 to 8 percent lime by dry weight be used for estimating and planning. The actual quantity of the lime should be determined at the time of construction based on lime determination testing conducted using bulk samples of the subgrade soils. The pulverization, mixing and curing of the lime treated subgrade is of particular importance in these plastic clays. The subgrade should be compacted to a minimum of 95 percent of the Standard Effort (ASTM D698) maximum dry density between optimum and +4 percent of the optimum moisture content. Preferably, traffic should be kept off the treated subgrade for 7 days to facilitate curing of the soil-chemical mixture. In addition, the subgrade is not suitable for heavy construction traffic prior to paving.

The pavement design methods described above are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade such as the soils encountered at this site. Thus the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. Post-construction subgrade movements and some cracking of the pavements are not uncommon for subgrade conditions such as those observed at this site. Reducing moisture changes in the subgrade is important to reduce shrink/swell movements. Although chemical treatment of the subgrade will help to reduce such movement/cracking, this movement/cracking cannot be economically eliminated.

Related civil design factors such as subgrade drainage, shoulder support, cross-sectional configurations, surface elevations and environmental factors which will affect the service life must be included in the preparation of the construction drawings and specifications. Normal periodic maintenance will be required.

4.3.1 Preventative Maintenance

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventative maintenance. The following recommendations should be implemented to help promote long-term pavement performance.

- The subgrade and the pavement surface should be designed to promote proper surface drainage;
- Install joint sealant, and seal cracks immediately;
- Extend curbs (if any) into the treated subgrade for a depth of at least 4 inches to help prevent moisture migration into the subgrade soils beneath the pavement section; and
- Place compacted, low permeability clayey backfill against the exterior side of the curb and gutter.

Preventative maintenance should be planned and provided for the pavements at this site. Preventative maintenance activities are intended to slow the rate of pavement deterioration, and consist of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Prior to implementing any maintenance, additional engineering observations are recommended to determine the type and extent of preventative maintenance.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, pavement, and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

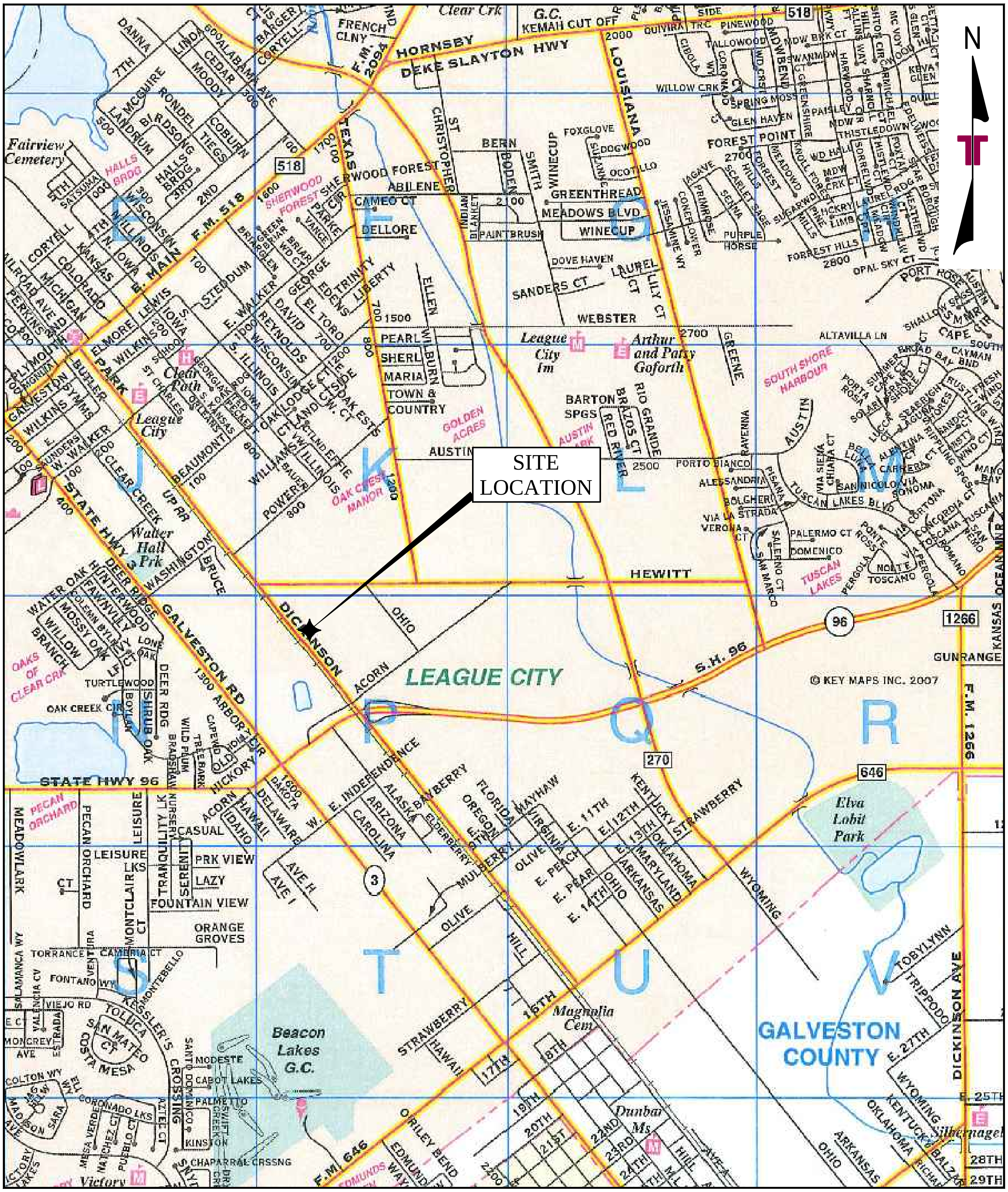
The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other services should be undertaken.

For any excavation construction activities at this site, all Occupational Safety and Health Administration (OSHA) guidelines and directives should be followed by the Contractor during construction to insure a safe working environment. In regards to worker safety, OSHA Safety and Health Standards require the protection of workers from excavation instability in trench situations.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION



SOURCE:
2007 GALVESTON COUNTY
KEY MAP
Page: 659 - P

1/2 0 1/4 1/2
SCALE IN MILES

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Mng.: DM	Project No.: 91145033	Terracon Consulting Engineers & Scientists	SITE LOCATION PLAN	Exhibit
Drawn By: CSI.INC	Scale: AS SHOWN	511 Link Road, Suite F League City, Texas 77573	Paving Improvements at Utility Line Repair Facility	A-1
Checked By: AM	File No.: 91145033	PH. (281) 557-2900 FAX. (281) 557-2990	1505 Dickinson Avenue	
Approved By: AM	Date: 05-15-2014		League City, Texas	

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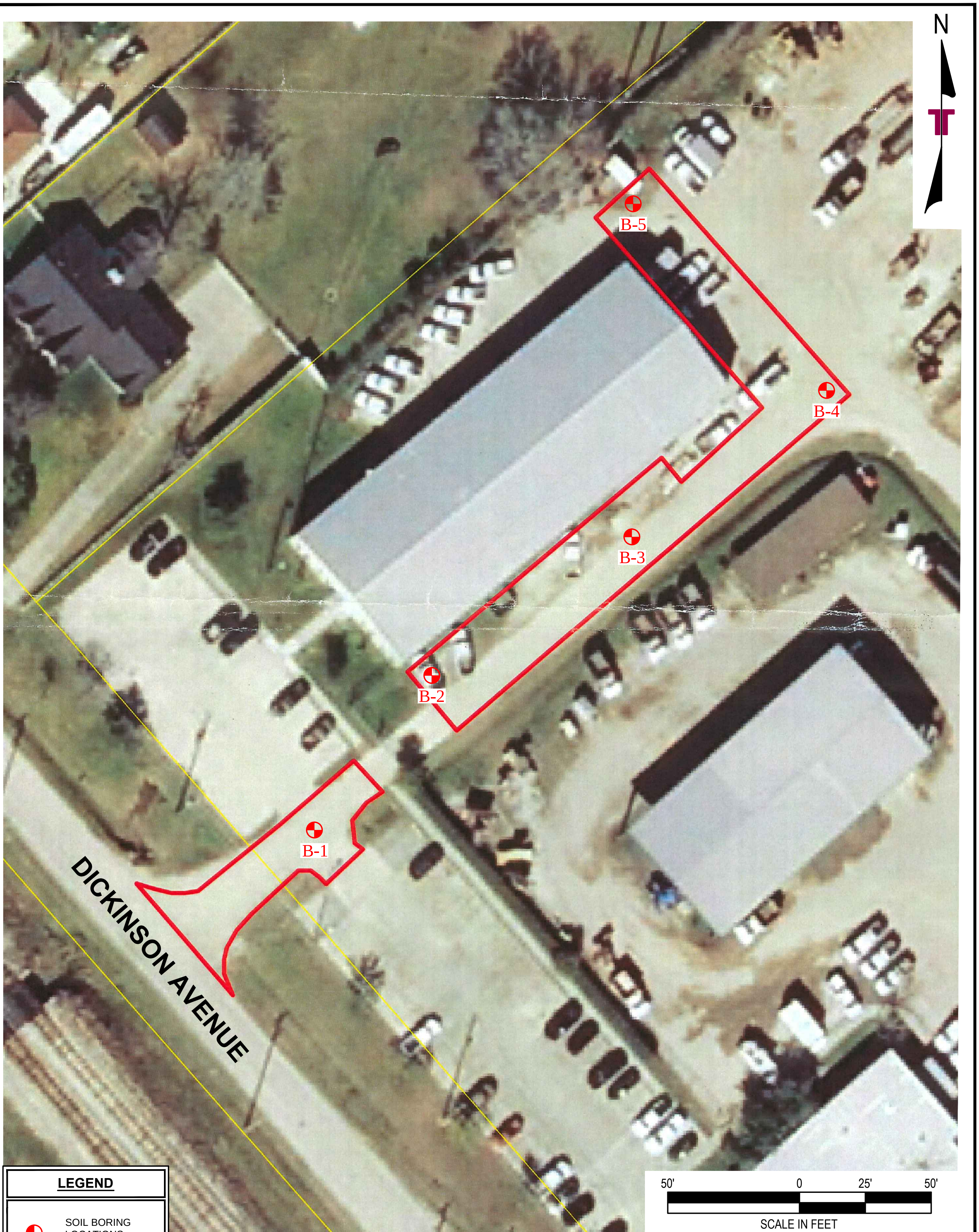

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

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Project Mng.: DM	Project No.: 91145033
Drawn By: CSI.INC	Scale: AS SHOWN
Checked By: AM	File No: 91145033
Approved By: AM	Date: 05-15-2014

Terracon
Consulting Engineers & Scientists

511 Link Road, Suite F League City, Texas 77573
PH. (281) 557-2900 FAX. (281) 557-2990

BORING LOCATION PLAN

Paving Improvements at Utility Line Repair Facility
1505 Dickinson Avenue
League City, Texas

Exhibit
A-2

Field Exploration Description

Subsurface conditions were evaluated by drilling five test borings, designated B-1 through B-5, to depths that ranged from about 6 to 10 feet within the proposed pavement areas. The borings were drilled using standard truck-mounted drilling equipment at the approximate locations shown on the Boring Location Plan, Exhibit A-2 of Appendix A. The borings were located by measuring from existing site features shown on the drawing provided to us without the use of surveying equipment. Boring depths were measured from existing grade at the time of our field program. Upon completion of our field program, the borings were backfilled with soil cuttings.

The Boring Logs, presenting the subsurface soil descriptions, type of sampling used, and additional field data, are presented on Exhibits A-4 through A-8 of Appendix A. The General Notes, which defines the terms used on the logs, are presented on Exhibit C-1 of Appendix C. The Unified Soil Classification System is presented on Exhibit C-2 of Appendix C.

Soil samples were recovered using open-tube samplers. Pocket penetrometer tests were performed on samples of cohesive soils in the field to serve as a general measure of consistency.

Samples were removed from samplers in the field, visually classified, and appropriately sealed in sample containers to preserve their in-situ moisture contents. Samples were then transported to our laboratory in League City, Texas.

BORING LOG NO. B-1

PROJECT: Paving Improvements at Utility Line Repair Facility

CLIENT: City of League City, League City, Texas

SITE: 1505 Dickinson Avenue, League City, Texas

LOCATION See Exhibit A-2

Depth	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
0.3	**FILL - CRUSHED STONE**, Approximately 3 inches of crushed stone											
2.0	**FILL - LEAN CLAY WITH SAND (CL)**, dark gray, with ferrous nodules, crushed stone, and scattered roots				4.0 (HP)		2.82	7.3	19	110	47-17-30	
4.0	**FILL - SANDY LEAN CLAY (CL)**, gray, with ferrous and calcareous nodules, crushed stone, and sand seams				2.0 (HP)				21			
6.0	**LEAN CLAY WITH SAND (CL)**, light gray and tan, very stiff, with ferrous and calcareous nodules, and sand pockets/seams	5			2.25 (HP)							
	Boring Terminated at 6 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 6 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 West League City Pkwy., Suite F
League City, Texas

Boring Started: 5/5/2014	Boring Completed: 5/5/2014
Drill Rig: Standard Truck	Driller:
Project No.: 91145033	Exhibit: A-4

BORING LOG NO. B-2

PROJECT: Paving Improvements at Utility Line Repair Facility

CLIENT: City of League City, League City, Texas

SITE: 1505 Dickinson Avenue, League City, Texas

LOCATION See Exhibit A-2

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**FILL - CRUSHED STONE**, Approximately 4 inches of crushed stone											
	FILL - LEAN CLAY WITH SAND (CL), dark gray, with ferrous nodules - with crushed stone and debris, 0.3 to 2 feet				2.5 (HP)		1.39	9.8	20	108	41-22-19	
4.0	- with calcareous nodules, 2 to 4 feet				4.0 (HP)		2.51	10.8	16	114		
6.0	**LEAN CLAY WITH SAND (CL)**, light gray and tan, very stiff, with ferrous and calcareous nodules, and sand pockets/seams	5			3.5 (HP)							
	Boring Terminated at 6 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 6 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 West League City Pkwy., Suite F
League City, Texas

Boring Started: 5/5/2014	Boring Completed: 5/5/2014
Drill Rig: Standard Truck	Driller:
Project No.: 91145033	Exhibit: A-5

BORING LOG NO. B-3

PROJECT: Paving Improvements at Utility Line Repair Facility

CLIENT: City of League City, League City, Texas

SITE: 1505 Dickinson Avenue, League City, Texas

LOCATION See Exhibit A-2

DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**FILL - CRUSHED STONE**, Approximately 4 inches of crushed stone											
2.0	**FILL - SANDY LEAN CLAY (CL)**, dark gray, with ferrous and calcareous nodules, and scattered roots				4.0 (HP)		1.96	12.8	14	114	38-18-20	
4.0	**FILL - LEAN CLAY WITH SAND (CL)**, gray, with ferrous nodules, shell fragments, and scattered roots				2.75 (HP)		1.72	15	18	109		
6.0	**LEAN CLAY WITH SAND (CL)**, light gray and tan, very stiff, with ferrous and calcareous nodules, and sand pockets/seams	5			3.0 (HP)							

Boring Terminated at 6 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 6 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 West League City Pkwy., Suite F
League City, Texas

Boring Started: 5/5/2014	Boring Completed: 5/5/2014
Drill Rig: Standard Truck	Driller:
Project No.: 91145033	Exhibit: A-6

BORING LOG NO. B-4

PROJECT: Paving Improvements at Utility Line Repair Facility

CLIENT: City of League City, League City, Texas

SITE: 1505 Dickinson Avenue, League City, Texas

LOCATION See Exhibit A-2

Depth	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
0.3	**FILL - CRUSHED STONE**, Approximately 4 inches of crushed stone											
2.0	**FILL - SANDY LEAN CLAY (CL)**, dark gray, with ferrous nodules, crushed stone, sand seams, and scattered roots				2.5 (HP)				19		46-23-23	
	FILL - LEAN CLAY WITH SAND (CL), dark gray, with ferrous and calcareous nodules, and scattered roots				2.0 (HP)		1.81	14.8	20	106		
	- with shell fragments, 4 to 6 feet	5			2.5 (HP)							
8.0					2.0 (HP)							
10.0	**LEAN CLAY WITH SAND (CL)**, gray and tan, medium stiff, with ferrous and calcareous nodules	10			1.0 (HP)							

Boring Terminated at 10 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 10 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 West League City Pkwy., Suite F
League City, Texas

Boring Started: 5/5/2014	Boring Completed: 5/5/2014
Drill Rig: Standard Truck	Driller:
Project No.: 91145033	Exhibit: A-7

BORING LOG NO. B-5

PROJECT: Paving Improvements at Utility Line Repair Facility

CLIENT: City of League City
League City, Texas

SITE: 1505 Dickinson Avenue
League City, Texas

LOCATION See Exhibit A-2

GRAPHIC LOG	DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5	**FILL - CRUSHED STONE**, Approximately 6 inches of crushed stone											
		FILL - LEAN CLAY WITH SAND (CL), gray, with ferrous nodules and scattered roots				3.0 (HP)		1.70	6	23	96	48-19-29	
	4.0	- gray and tan, with calcareous nodules, 2 to 4 feet				4.0 (HP)		1.84	7	18	108		
	6.0	**LEAN CLAY WITH SAND (CL)**, light gray and tan, very stiff, with ferrous and calcareous nodules, and sand pockets/seams	5			2.5 (HP)							
		Boring Terminated at 6 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 6 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 West League City Pkwy., Suite F
League City, Texas

Boring Started: 5/5/2014	Boring Completed: 5/5/2014
Drill Rig: Standard Truck	Driller:
Project No.: 91145033	Exhibit: A-8

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Soil samples were tested in the laboratory to measure their dry unit weight and natural water content. Unconfined compression tests were performed on selected samples and a calibrated hand penetrometer was used to estimate the approximate unconfined compressive strength of some cohesive samples. The calibrated hand penetrometer values have been correlated with unconfined compression tests and provide a better estimate of soil consistency than visual examination alone. Selected samples were also classified using the results of Atterberg Limits testing. The test results are provided on the Boring Logs included in Appendix A and in **"3.2 Typical Profile"** section of this report.

Descriptive classifications of the soils indicated on the Boring Logs are in general accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. Classification of the soil samples was generally determined by visual manual procedures.

Samples not tested in the laboratory will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless we are notified otherwise.

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	**Split Spoon**
Shelby Tube	**Macro Core**
Ring Sampler	**Rock Core**
Grab Sample	**No Recovery**

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	**Hand Penetrometer**
(T)	**Torvane**
(b/f)	**Standard Penetration Test (blows per foot)**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

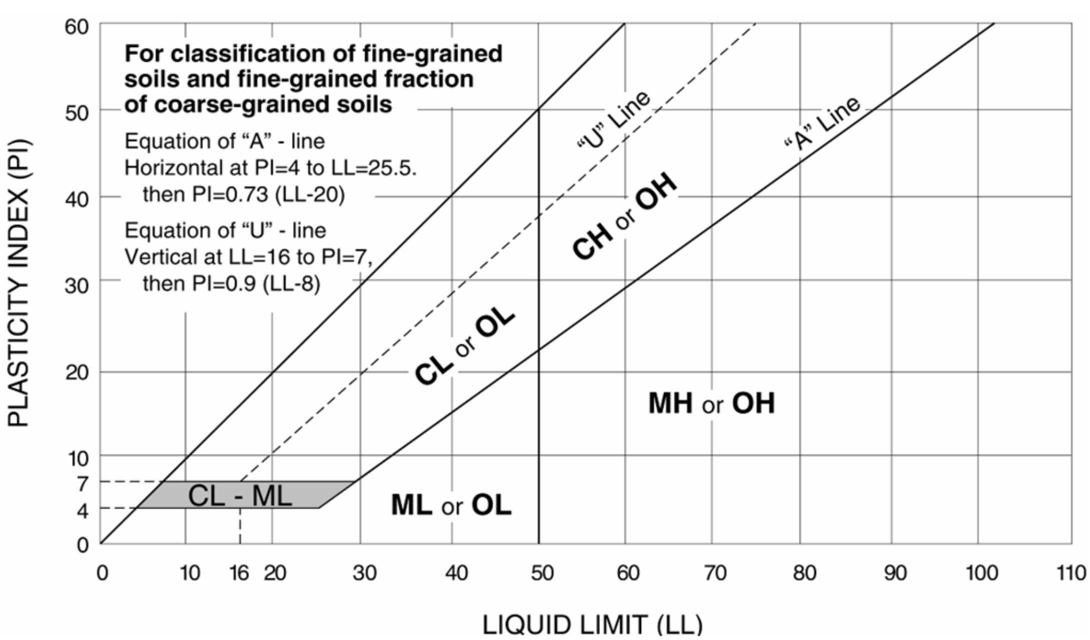

Exhibit C-2