



# Geotechnical Engineering Report

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**City of Huntsville – 17th Street Storm Sewer Replacement  
Huntsville, Texas**

October 19, 2022

Terracon Project No. 97225092

**Prepared for:**

LJA Engineering, Inc.  
Houston, Texas

**Prepared by:**

Terracon Consultants, Inc.  
Houston, Texas



October 19, 2022



LJA Engineering, Inc.  
11821 East Freeway, Suite 400  
Houston, Texas 77029

Attn: Mr. Jimmy Flowers, P.E.  
Senior Project Manager

Re: Geotechnical Engineering Report  
City of Huntsville – 17th Street Storm Sewer Replacement  
Huntsville, Texas  
Terracon Project No. 97225092

Dear Mr. Flowers:

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the project referenced above in Huntsville, Texas. We trust that this report is responsive to your project needs.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

**Terracon Consultants, Inc.**

(Texas Firm Registration No.: F-3272)

A handwritten signature in blue ink, appearing to read 'Blake R. Goblen'.

Blake R. Goblen, P.E.  
Project Engineer



A handwritten signature in blue ink, appearing to read 'Sheetal V. Gordon'.



## REPORT TOPICS

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**Note:** This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the **GeoReport** logo will bring you back to this page. For more interactive features, please view your project online at [client.terracon.com](http://client.terracon.com).

## ATTACHMENTS

**EXPLORATION AND TESTING PROCEDURES**

**SITE LOCATION AND EXPLORATION PLAN**

**EXPLORATION RESULTS** (Boring Logs and Laboratory Data)

**SUPPORTING INFORMATION** (General Notes, Unified Soil Classification System, City of Huntsville Standard Details, Tunnel Liner Loads, H20 Highway Load)

**Note:** Refer to each individual Attachment for a listing of contents.

**Geotechnical Engineering Report**  
**City of Huntsville – 17th Street Storm Sewer Replacement**  
**17th Street and Sam Houston Avenue**  
**Huntsville, Texas**  
**Terracon Project No. 97225092**  
**October 19, 2022**

## **INTRODUCTION**

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the proposed storm sewer improvements located in Huntsville, Texas. This project was authorized by Mr. Jimmy Flowers, P.E., Senior Project Manager for LJA Engineering through electronic correspondence on August 23, 2022. This project was performed in general accordance with Terracon Document No. P97225092, dated July 29, 2022.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Boring logs with field and laboratory data;
- Stratification based on visual soil classification;
- Groundwater levels observed during and after completion of drilling;
- Subsurface exploration procedures;
- Description of subsurface conditions;
- Temporary groundwater control;
- Utility construction considerations; and
- Bedding and backfill recommendations.

The geotechnical engineering Scope of Services for this project included the advancement of two test borings to a depth of approximately 10 feet below existing grade.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section.

## SITE CONDITIONS

The following description of site conditions was derived from our site visit in association with the field exploration.

Item	Description
<b>Project location</b>	The site is located along the south side of 17 <sup>th</sup> Street between Avenue M and Sam Houston Avenue in Huntsville, Texas. See <a href="#">Site Locations</a> .
<b>Existing improvements</b>	17 <sup>th</sup> street is a two-lane roadway with curb and gutter on both sides of the street at the time of our field program. Overhead power lines and underground utility lines traverse along the project alignment.
<b>Current ground cover</b>	Asphaltic concrete pavements.
<b>Existing topography</b>	Based on information from Google Earth, the ground surface elevations at the boring locations ranged from about 380 feet to 400 feet. The site generally slopes down from east to west.

## PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
<b>Project description</b> <sup>1</sup>	An approximate 400-foot-long, 18- to 24-inch diameter sewer line along the south side of 17 <sup>th</sup> Street between Avenue M and Sam Houston Avenue.
<b>Maximum utility depth</b> <sup>1</sup>	<ul style="list-style-type: none"> <li>■ Up to 7 feet.</li> <li>■ The sewer line will have about 5 feet of cover.</li> </ul>
<b>Installation method</b>	Open-cut construction methods. <sup>2</sup>

<sup>1.</sup> Based on information provided by the client.

<sup>2.</sup> Based on discussions with the client, we understand trenchless construction methods are also being considered.

## GEOTECHNICAL CHARACTERIZATION

### Geology

Based on the geologic maps published by the Bureau of Economic Geology, the site for the proposed improvements is located on the Fleming formation, a deltaic nonmarine Miocene deposit. The Fleming formation is a heterogeneous formation containing thick interbedded layers of clay and sandstone.

The clay fraction is commonly calcareous and locally forms brownish-black soils. The sandstone formation consists of medium to coarse grained sands, calcareous, thick bedded, some crossbedding, light yellowish gray to light gray and weathers light gray to medium gray.

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 detailed geologic fault investigation and study of the site geology are beyond the scope of this report.

### **Geomodel**

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

Pavements were observed at the ground surface at borings B-1 and B-2 and were measured to range from approximately 5½ to 6½ inches of asphaltic concrete overlying about 3 to 3½ inches of silty sand material overlying about 5½ to 6½ of concrete.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

<b>Model Layer</b>	<b>Layer Name</b>	<b>General Description</b>
1	<b>Fill: Clayey Sand</b>	Light gray, tan, and reddish brown, with scattered gravel
2	<b>Clayey Sand</b>	Light gray, tan, and reddish brown, loose to medium dense, with calcareous nodules
3	<b>Sandy Lean Clay</b>	Light gray, tan, and reddish brown, with sand pockets and calcareous nodules

### **Groundwater Conditions**

The borings were advanced using dry drilling techniques to their termination depths (about 10 feet below existing grade) in an effort to evaluate groundwater conditions at the time of our field program. Groundwater was not observed at borings B-1 and B-2 during or upon completion of drilling.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the sewer line may be present within the

depths explored. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project and should be evaluated prior to construction.

## **GEOTECHNICAL OVERVIEW**

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project. A summary of our findings and recommendations is provided below.

- The surficial soils at the site include an increased sand content which are extremely moisture-sensitive. These soils will become wet and weak with elevated moisture contents. Construction during and soon after wet weather periods may encounter difficulties due to wet and soft surficial soils becoming a general hindrance to equipment as a result of rutting and/or pumping of the soil surface. If wet and/or soft conditions are present at the time of construction, remedial efforts may be necessary to provide access to construction equipment. Remedial effort options are discussed in the **Wet Weather/Soft Subgrade** section of this report.
- The utility bedding and backfill should conform to the City of Huntsville or other appropriate standards on utility bedding and backfill details.
- Based on the soil and groundwater information obtained during our field activities and the maximum depth planned for the storm sewer, we anticipate that excavations within the surficial clayey sand and near-surface clay soils may occur without advanced dewatering. Groundwater seepage, if observed, from the clay soils is expected to be minor and likely be managed by pumping water collected within sumps positioned in the bottom of the excavation. However, excavations that extend into or through zones of sand soils such as observed at boring B-1 may require some form of advanced dewatering, such as vacuum wellpoints, depending on the groundwater conditions at the time of construction.

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 **General Comments** should be read for an understanding of the report limitations.

## **WET WEATHER/SOFT SUBGRADE CONSIDERATIONS**

The surficial soils at this site include an increased sand content which are extremely moisture-sensitive. These soils will become wet and weak with elevated moisture contents. Construction during and soon after wet weather periods may encounter difficulties due to wet and soft surficial soils becoming a general hindrance to equipment as a result of rutting and/or pumping of the soil

surface. This condition is primarily due to their lack of cohesion (low clay content) and little to no confining pressure near the ground surface. If the subgrade is wet and weak prohibiting access, one of the following methods should be used to improve the soils: 1) removal and replacement with select fill, 2) chemical treatment of the soil to dry the subgrade, or 3) drying by natural means if the schedule allows. Terracon should be contacted for additional recommendations if chemical treatment is required.

Based on our experience with similar soils, chemical treatment is an efficient and effective method to improve the condition of wet and soft subgrade such as that observed at this site. Chemical treatment may be necessary to depths of approximately one to 2 feet or greater of the surficial sand soils, depending on the condition of the subgrade at the time of construction. We suggest that a cost be included in the construction budget for chemical treatment of the soils using a lime-flyash mixture to aid drying and improve the condition of the soil if the soil is wet and/or soft at the time of construction. We recommend that this cost be in the form of a contingency or allowance to be used if needed.

## **RECOMMENDATIONS FOR OPEN-CUT CONSTRUCTION**

Based on information provided by LJA Engineering, Inc., we understand that the maximum depth of the storm sewer is planned to be up to 7 feet below existing grade. The following paragraphs present our recommendations regarding the utility construction considerations based on the soil and groundwater conditions observed during our field and laboratory programs.

### **Excavation Considerations**

For open-cut excavations, either excavated side slopes or vertical cut excavations are feasible. For vertical sided excavations greater than 5 feet in depth, the excavations will require the use of shoring, bracing or some form of retention to prevent sloughing and caving of the soil into the excavation. The contractor should use a trench box or shoring and bracing as necessary to maintain a safe and clean excavation which meets with the Occupational Safety and Health Administration (OSHA) requirements.

In lieu of shoring, bracing, or trench boxes for excavations greater than 5 feet, OSHA standards provide recommendations for the design of temporary sloped excavations with a depth of less than 20 feet. The OSHA standards provide maximum allowable slopes contingent on three designated soil types: Type A, Type B, and Type C. According to OSHA standards, temporary sloped excavations should be no steeper than 0.75-horizontal on 1-vertical (0.75H:1V) for Type A soils, 1H:1V for Type B soils, and 1.5H:1V for Type C soils. The soils type should be evaluated by a contractor designated Competent Person at the time of construction. The surface soils should be protected from deterioration and weathering if they are left open for significant periods of time.

Excavations must be performed and inspected under the supervision of a contractor designated Competent Person. The Competent Person, as defined by the OSHA Standard, 29 CFR Part 1926.650 to .652, Subpart P – Excavations, must evaluate the excavations at the time of construction activity to safeguard workers.

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

As a safety measure, no equipment should be operated within 5 feet of the edge of the excavation and no materials should be stockpiled within 10 feet of the excavation. Excavations should not approach closer than 10 feet from existing structures/facilities without some form of protection for the facilities. Proper berming or ditching should be performed to divert any surface runoff away from the excavation.

The bearing surface should be protected against disturbance and deterioration by completing the waterline installation and backfilling operations as quickly as possible. The excavation bottom should be properly sloped to allow water infiltrating into the excavation to be collected at a convenient location along the edge of the excavation. Proper berming or ditching should be done to divert any surface runoff away from the excavations. Water should not be allowed to stand within the bearing area.

### **Temporary Groundwater Control**

Based on the soil and groundwater information obtained during our field activities (refer to section **Groundwater Conditions**), we anticipate that excavations for the proposed storm sewer that extend into the surficial clayey sand and near-surface clay soils may occur without advance dewatering. Seepage from the clay soils is expected to be minor and can likely be managed by pumping water collected with sumps positioned in the bottom of the excavation. Care should be taken to slope the excavation towards the sumps such that water can be collected and removed from the excavation.

However, excavations that extend into or through zones of sand soils such as observed at boring B-1, may require some form of advanced dewatering, such as vacuum wellpoints, depending on the groundwater conditions at the time of construction. Groundwater is typically controlled by the installation of vacuum wellpoints. However, vacuum wellpoints are generally less effective below a depth of about 15 feet beneath the top of the wellpoint. Deeper dewatering typically requires eductors or deep wells with submersible pumps or multi-stage wellpoint systems.

The suggested methods given above serve as a guideline for groundwater control; other appropriate means may be required for groundwater control during construction. Control of groundwater should be accomplished in a manner that will preserve the strength of the soils, will

not cause instability of the excavation, and will not result in damage to existing structures, if any. If necessary the water should be lowered in advance of excavation by wellpoint, deep wells, eductors, or similar methods. Open pumping should not be permitted if it results in boils, loss of fines, softening of the subgrade, or excavation instability. Wellpoints, deep wells, and eductors should be installed with suitable screen filter so that pumping of fines does not occur.

The dewatering of loose to medium dense sands might cause subsidence or compression of adjacent soils and adjacent structures, in spite of safeguards and methodology selected and used. Therefore, the dewatering operations must be performed and provided with great care to ensure caution and control of the potential subsidence resulting from the dewatering operations.

The well system should be in operation for at least several days prior to excavating to the design depth. We recommend that the groundwater head be lowered at least 3 feet below the bottom of the excavation to provide a working area with increased stability. In addition, dewatering should continue until the construction has been completed and the dewatering system should be turned off in stages to allow groundwater to recover to its original level gradually, over a period of about 3 to 5 days.

As stated previously, the groundwater levels will fluctuate with seasonal and climatic changes and should be evaluated just prior to construction. To evaluate the groundwater conditions in the area of the proposed improvements, piezometers may be installed, or trenches/test pits may be excavated to the planned excavation depth. Based on the observed water levels, the contractor should determine effective methods of groundwater management prior to starting excavation operations.

## **Uplift Pressures**

Uplift forces on below-grade structures such as manholes will be generated by a difference in water level in the soil adjacent to the structure and inside the structure. If the backfill around any buried structure is a sand or silt material, the backfill will approach saturation during periods of heavy rainfall and the effective static water level will be at the surface. The uplift pressures will be resisted by adhesion or skin friction of the soil to the wall and by the dead weight of the structure. An allowable skin friction for an engineered clay fill compacted to a minimum of 95 percent of the Standard Effort (ASTM D698) maximum dry density may be considered to be 300 psf. The upper 4 feet of skin friction should be neglected for a clay backfill due to potential for soil shrinkage away from the structure. Sand backfill, compacted to at least 70 percent of the maximum relative density (ASTM D4253 and 4254), may be considered to have an allowable skin friction of zero at the surface varying linearly to 50 psf at a depth of 7 feet below grade.

An alternate design method would be to place a heel extending out from the utility foundation into the backfill and rely on the weight of the soil above the heel on a 4-vertical to 1-horizontal slope to resist the uplift forces. The unit weight of soil above and below the water table for a properly

compacted backfill will be 120 pcf and 60 pcf, respectively. The preparation of the upper 3 feet of soil immediately above the heel is critical to reduce the possibility of an upward bearing failure. The entire thickness of fill should be compacted to the above recommended values.

If the lift station is installed by predrilling a hole and lowering the structure in the hole or by excavating from the inside and allowing the structure to sink under its own weight, the soil contact may be very low immediately after construction due to the annulus created during construction. In this case, the uplift pressure must be resisted by structural dead weight or by restoring the contact between the soil and the structure. If the annulus is open, grouting would be one means to restore skin frictional resistance. If grouted, a nominal allowable skin friction of 100 psf may be used to compute uplift resistance.

### **Lateral Earth Pressures**

Backfill around embedded structures will impose active to at-rest earth pressures against the embedded walls. Design lateral earth pressures for backfill are estimated to be equivalent to a fluid pressure of 90 pounds per cubic foot (pcf) for clean sand backfill and 110 pcf for in-situ native clay backfill. These pressures include hydrostatic pressures but do not include surcharge forces imposed by construction or vehicular loading. The lateral pressure produced by surcharge may be computed as 50 percent of the vertical surcharge pressure applied as a constant pressure over the full depth of the buried structure. A 2-foot compacted clay seal should be placed at the top of sand backfill to reduce the amount of infiltration of surface water.

### **Utility Bedding**

The subgrade and bedding for the underground utilities should conform to the City of Huntsville or other appropriate standards for utility line bedding details. For any excavations that penetrate into wet sand layers or terminate below groundwater, bedding details for wet ground conditions should be used. Since groundwater levels and subsurface conditions can vary, the decision should be made in the field based on actual conditions at the time of construction and the response of the soil and water to open trenching and to dewatering. City of Huntsville Drawings SS-28 and SS-30 for sanitary sewer lines may be utilized for dry and wet soil conditions, respectively. These drawings are included in **Supporting Information** for ease of reference.

The excavations should be monitored to detect any variation in soil condition from that found in our borings. Any changes noted in the soil stratigraphy should be brought to the attention of Terracon so that the conditions may be assessed and changes to the planned bedding requirements made, as necessary.

### **Utility Backfill**

The type of fill placed above the utility bedding will depend on whether the surface above the utility line is covered with pavement or will consist of unpaved ground. If the surface is to be

unpaved ground then the backfill may consist of the excavated, in-situ soils. The in-situ soils used as backfill should be placed in thin lifts, moisture conditioned to within 3 percent of optimum moisture content, and compacted to at least 85 percent of the material's maximum dry density as determined by the Modified Effort (ASTM D1557). Within pavement areas, the backfill should consist of cement treated sand to within 12 inches of the top of the subgrade compacted to at least 85 percent of the material's Modified Effort (ASTM D1557) maximum dry density. The upper 12 inches may consist of clean soils compacted to at least 95 percent of the material's Standard Effort (ASTM D 698) maximum dry density within 2 percent of optimum moisture content.

Prior to any filling operations, samples of the proposed borrow 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 verify that proper levels of compaction are being attained.

## **DESIGN CONSIDERATIONS FOR TRENCHLESS METHODS**

In addition to open-cut construction, we understand trenchless construction methods are also being considered. Trenchless construction methods may be utilized for the sewer line at street crossings. Pipe insertion into the trenchless hole will generate stresses on the pipe. The pipe should be selected considering the construction equipment to be used.

### **Geotechnical Properties**

Loose to medium dense sand soils and very stiff lean clay soils are anticipated at the depths of trenchless construction.

Recommended engineering design soil parameters for the sands are as follows:

Moist Unit Weight	120 pcf
Submerged Unit Weight	60 pcf
Coefficient of Earth Pressure, $K_o$	0.5
Coefficient of Earth Pressure, $K_a$	0.36
Angle of Internal Friction	28° to 30°
Poisson's Ratio	0.25 to 0.4
Young's Modulus	150 to 375 ksf

Recommended engineering design soil parameters for the clay soils are as follows:

Moist Unit Weight	125 pcf
Submerged Unit Weight	65 pcf
Coefficient of Earth Pressure, $K_o$	0.7
Coefficient of Earth Pressure, $K_a$	0.53

Undrained Shear Strength	1,500 to 2,000 psf
Poisson's Ratio	0.4 to 0.5
Young's Modulus	450 to 600 ksf

## Pipe Design

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

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

When tunneling near adjacent structures, we recommend that a preconstruction survey, as well as monitoring program during and soon after construction, be established for existing structures located immediately adjacent to the proposed project site to help observe and evaluate any potential impact resulting from the construction activities. Information regarding the types, dimensions, and embedment depths of the foundation systems for the adjacent existing structures was not available at the time of this report.

Access shafts and manhole excavations should be shored or laid back to a stable slope to provide safety for workers and adjacent structures. The bracing and sheeting should be designed using the parameters presented in **Geotechnical Properties**. Groundwater control will be required for access shafts extending into and through sand layers as discussed in **Temporary Groundwater Control**.

## Pressures on Primary Pipe and Permanent Liners

Pipe liner design is largely dependent upon the depth of the liner beneath the ground surface and additional surface loads. Surface loads may include traffic loads, foundations in proximity of the sewer line, and other such loading conditions.

We recommend the vertical and horizontal pressures be taken as the following (using pressures on buried rigid pipes from “Structural Mechanics on Buried Pipes” by Reynold K. Watkins and Loren R. Anderson):

Total Liner Pressure =  $W + W''$

$$W = \gamma H K_a$$

where,

- $W''$  = Traffic allowance;
- $\gamma$  = design unit weight of soil;
- H = depth of pipe from the ground surface to the top of the tunnel liner; and
- $K_a$  = active lateral earth pressure coefficient, use values given in **Geotechnical Properties**

Tunnel liner loading equations along street alignments are shown on the **Tunnel Liner Loads** Figure 1. Based on the planned earth cover on the sewer line, an additional traffic loading should also be considered based upon a design chart adopted from “Principles of Structural Performance of Buried Pipes”, by Reynold K. Watkins. This adapted chart is shown on the **Tunnel Liner Loads - H20 Highway Load** Figure 1.

The pipe liner can be expected to deform under load from its original circular shape. The liner should be designed for the bending stresses associated with the elliptically distorted shape. In general, we recommend a maximum design distortion of:

- About 0.5 percent of the diameter for shortening in the vertical axis; and
- About 0.5 percent of the diameter for lengthening in the horizontal axis.

In addition, the pipe section should be designed to withstand the calculated installation stresses with an appropriate factor of safety.

## **GENERAL COMMENTS**

Our work is conducted with the understanding of the project as described in the proposal and incorporates collaboration with the design team as we completed our services to verify assumptions. Revision of our understanding to reflect actual conditions important to our work was based on these verifications and it is reflected in this report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

## Geotechnical Engineering Report

City of Huntsville – 17th Street Storm Sewer Replacement ■ Huntsville, Texas

October 19, 2022 ■ Terracon Project No. 97225092



Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from our site exploration and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, 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.

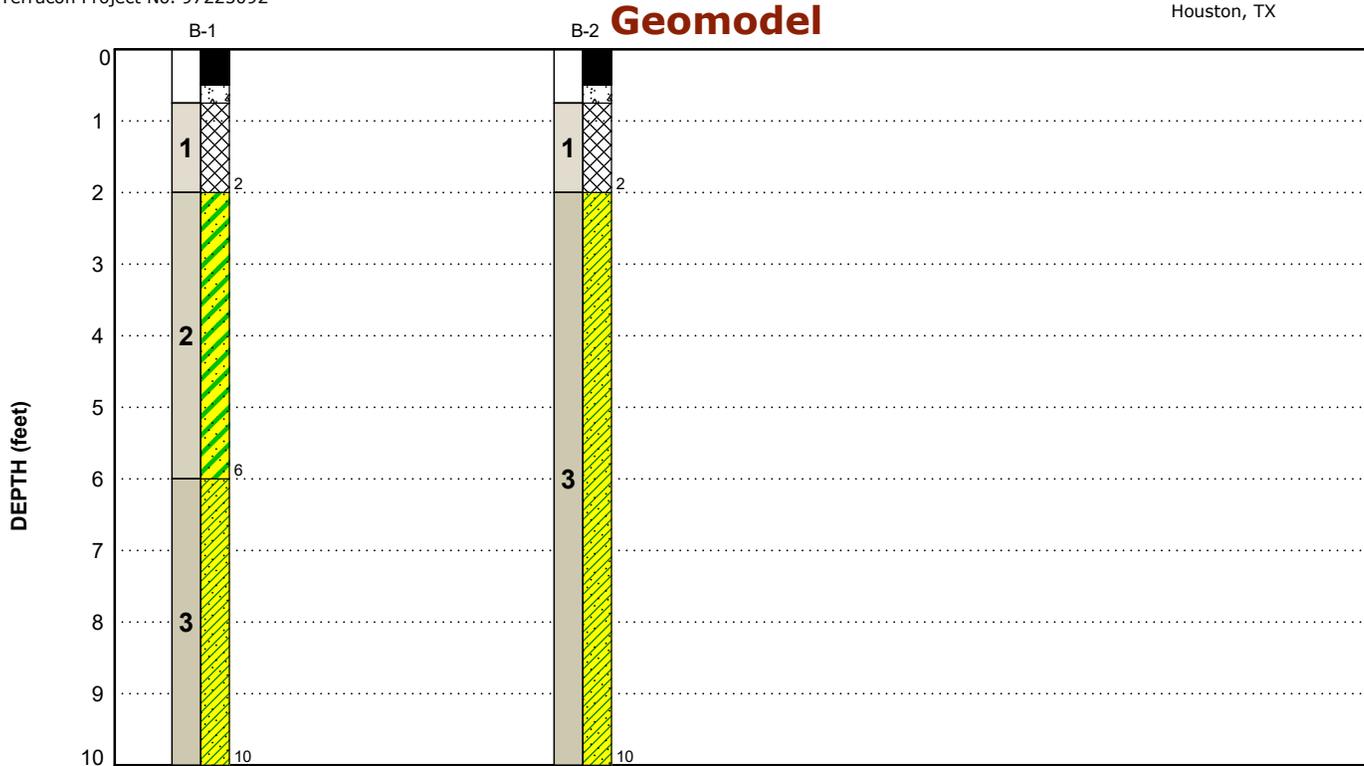
Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes only. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing

## FIGURES

### Contents:

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Fill: Clayey Sand	light gray, tan, and reddish brown, with scattered gravel
2	Clayey Sand	light gray, tan and reddish brown, loose to medium dense, with calcareous nodules
3	Sandy Lean Clay	light gray, tan and reddish brown, very stiff, with sand pockets and calcareous nodules

**LEGEND**

- Asphalt
- Concrete
- Fill
- Clayey Sand
- Sandy Lean Clay

**NOTES:**  
 Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below existing grade.

## **ATTACHMENTS**

## EXPLORATION AND TESTING PROCEDURES

### Field Exploration

Number of Borings	Boring Depth (feet) <sup>1,2</sup>	Approximate Boring Location
2 (B-1 and B-2)	10	Along the alignment of the proposed storm sewer

<sup>1.</sup> Below existing grade (at the time of our field program).

**Boring Layout and Elevations:** We used handheld Global Positioning System (GPS) equipment to locate the approximate latitude and longitude of the borings with an accuracy of +/-25 feet. The boring depths were measured from the existing ground surface at the time of our field activities.

**Subsurface Exploration Procedures:** We advanced soil borings with a standard truck-mounted mounted drill rig using solid stem continuous flight augers. Samples were obtained at 2-foot intervals in the upper 10 feet of each boring. Soil samples were recovered using open-tube samplers. Hand penetrometer tests were performed on samples of cohesive soils in the field to serve as a general measure of consistency.

The samples were placed in appropriate containers, taken to our soil laboratory for testing, and classified by a geotechnical engineer. In addition, we observed and recorded groundwater levels during drilling and sampling.

Our exploration team prepared field boring logs as part of standard drilling operations including sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials observed during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent an interpretation of the field logs by a geotechnical engineer and include modifications based on laboratory observation and tests on select samples.

**Property Disturbance:** We augered through the existing pavement in order to access the underlying subgrade soils. We backfilled the borings with auger cuttings and patched at the surface with asphaltic concrete upon completion. Excess auger cuttings were dispersed in the general vicinity of the boring. Our services do not include repair of the site beyond backfilling our borings, and cold patching the existing pavements. Because backfill material often settles below the surface after a period, we recommend borings be periodically checked and backfilled, if necessary. We can provide this service, or grout the borings for additional fees, at your request.

### Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural

## Geotechnical Engineering Report

City of Huntsville – 17th Street Storm Sewer Replacement ■ Huntsville, Texas

October 19, 2022 ■ Terracon Project No. 97225092



standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D7263 Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D2166/D2166M Standard Test Method for Unconfined Compressive Strength of Cohesive Soil

The laboratory testing program included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we describe and classify the soil samples in accordance with the Unified Soil Classification System.

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.

## **SITE LOCATION AND EXPLORATION PLAN**

### **Contents:**

Site Location

Exploration Plan

**SITE LOCATION**

City of Huntsville - 17th Street Storm Sewer Replacement ■ Huntsville, Texas  
October 19, 2022 ■ Terracon Project No. 97225092

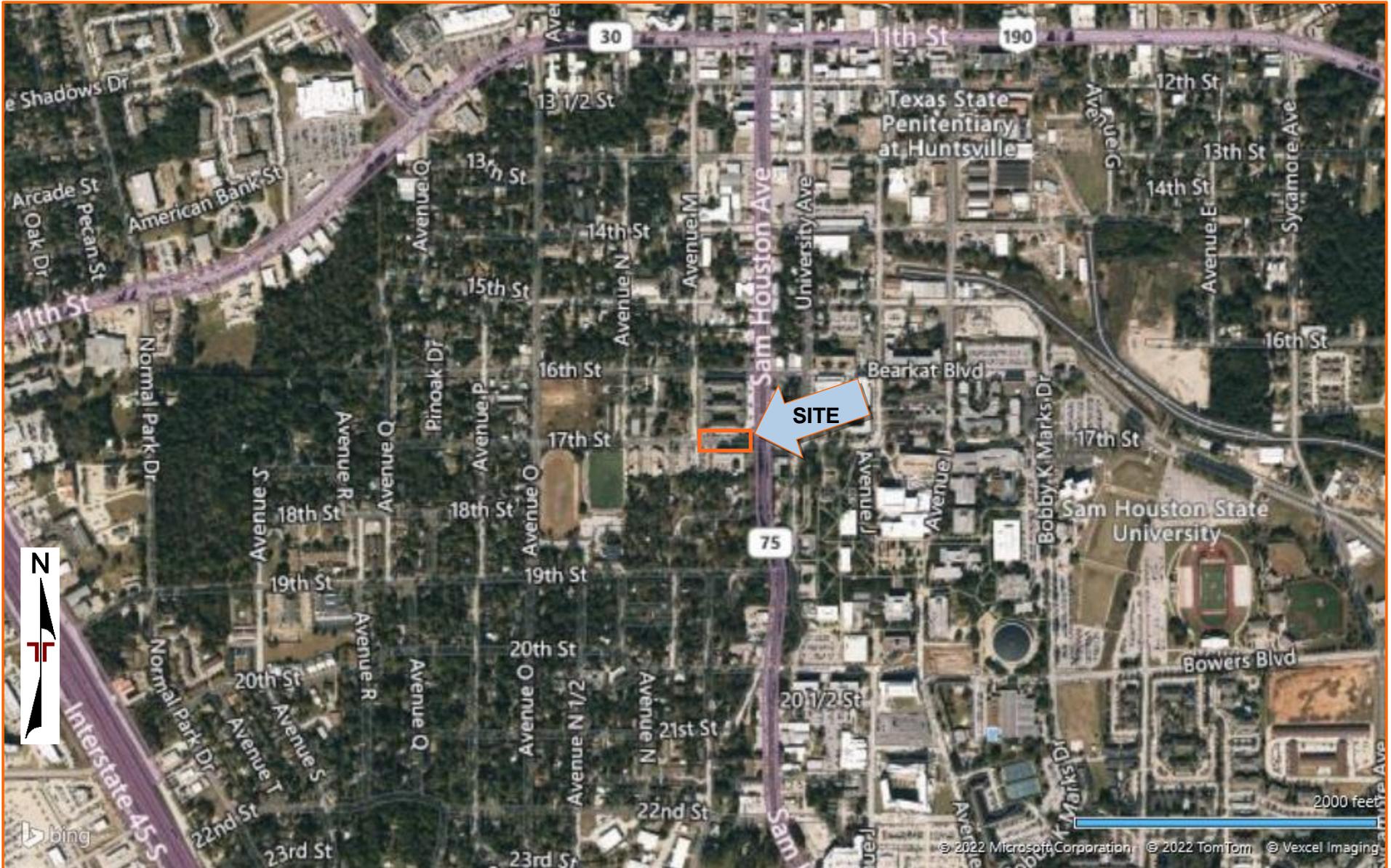


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY  
QUADRANGLES INCLUDE: HUNTSVILLE, TX (11/1997).

**EXPLORATION PLAN**

City of Huntsville - 17th Street Storm Sewer Replacement ■ Huntsville, Texas  
October 19, 2022 ■ Terracon Project No. 97225092

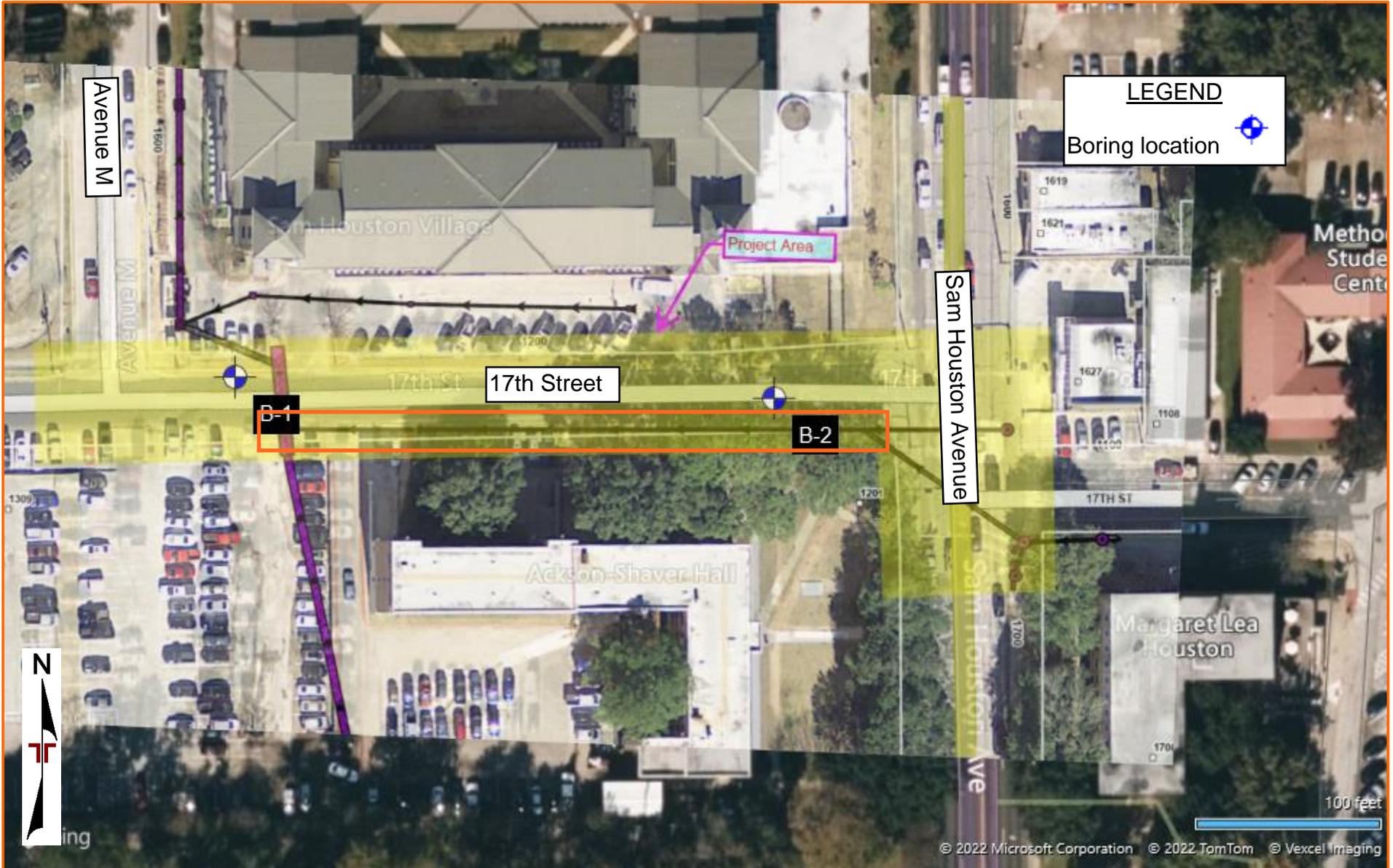


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

## EXPLORATION RESULTS

### Contents:

Boring Logs (B-1 and B-2)

## Boring Log No. B-1

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 30.7166° Longitude: -95.5527° Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
							Test Type	Compressive Strength (tsf)	Strain (%)				
	0.5	<b>PAVEMENT</b> , approximately 2 inches of asphaltic concrete overlying about 3 inches of sand											
	1.0	<b>PAVEMENT</b> , approximately 6½ inches of concrete											
1	2.0	<b>FILL - CLAYEY SAND (SC)</b> , light gray, tan and reddish brown, with sand pockets and seams				1.5 (HP)			17.8	107			
2	6.0	<b>CLAYEY SAND (SC)</b> , light gray and tan, loose to medium dense				1.25 (HP)							
	5		5			0.75 (HP)	UC	0.46	14.1	19.6	107		
3	10.0	<b>SANDY LEAN CLAY (CL)</b> , light gray and tan, very stiff, with sand pockets and calcareous nodules  - reddish brown below 8 feet				2.5 (HP)			15.7		30-14-16		
	10	<b>Boring Terminated at 10 Feet</b>	10			4.25 (HP)							

<p>See <a href="#">Exploration and Testing Procedures</a> for a description of field and laboratory procedures used and additional data (If any).          See <a href="#">Supporting Information</a> for explanation of symbols and abbreviations.</p>	<p><b>Water Level Observations</b> No free water observed.</p>	<p><b>Drill Rig</b> Truck</p>
<p><b>Notes</b></p>	<p><b>Advancement Method</b> Dry augered to 10 feet.</p> <p><b>Abandonment Method</b> Dry augered to 10 feet.</p>	<p><b>Driller</b> Herman</p> <p><b>Logged by</b> Ted Y</p> <p><b>Boring Started</b> 09-09-2022</p> <p><b>Boring Completed</b> 09-09-2022</p>

## Boring Log No. B-2

Model Layer	Graphic Log	Location: See <a href="#">Exploration Plan</a> Latitude: 30.7166° Longitude: -95.5518° Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
							Test Type	Compressive Strength (tsf)	Strain (%)				
	0.5	<b>PAVEMENT</b> , approximately 2½ inches of asphaltic concrete overlying about 3½" inches sand											
	1.0	<b>PAVEMENT</b> , approximately 5½ inches of concrete											
1	2.0	<b>CLAYEY SAND (SC)</b> , gray, with scattered gravel				1.75 (HP)			12.8		30-14-16		
		<b>SANDY LEAN CLAY (CL)</b> , light gray and tan, very stiff, with sand pockets and calcareous nodules				2.5 (HP)			17.7	113			
			5			2.75 (HP)			14.5		26-14-12		
3						3.5 (HP)							
		- reddish brown below 8 feet				4.25 (HP)							
		10.0	10										
		<b>Boring Terminated at 10 Feet</b>											

<p>See <a href="#">Exploration and Testing Procedures</a> for a description of field and laboratory procedures used and additional data (If any).          See <a href="#">Supporting Information</a> for explanation of symbols and abbreviations.</p>	<p><b>Water Level Observations</b> No free water observed.</p>	<p><b>Drill Rig</b> Truck</p>
<p><b>Notes</b></p>	<p><b>Advancement Method</b> Dry augered to 10 feet.</p> <p><b>Abandonment Method</b> Dry augered to 10 feet.</p>	<p><b>Driller</b> Herman</p> <p><b>Logged by</b> Ted Y</p> <p><b>Boring Started</b> 09-09-2022</p> <p><b>Boring Completed</b> 09-09-2022</p>

## **SUPPORTING INFORMATION**

### **Contents:**

General Notes  
Unified Soil Classification System  
City of Huntsville Standard Details  
Tunnel Liner Loads  
H2O Highway Load

# GENERAL NOTES

## DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

City of Huntsville - 17th Street Storm Sewer Replacement ■ Huntsville, Texas

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SAMPLING	WATER LEVEL	FIELD TESTS
 Auger Cuttings  Shelby Tube	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered  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.	<b>N</b> Standard Penetration Test Resistance (Blows/Ft.)  <b>(HP)</b> Hand Penetrometer  <b>(T)</b> Torvane  <b>(DCP)</b> Dynamic Cone Penetrometer  <b>UC</b> Unconfined Compressive Strength  <b>(PID)</b> Photo-Ionization Detector  <b>(OVA)</b> Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION
Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES
Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See <a href="#">Exploration and Testing Procedures</a> in the report for the methods used to locate the exploration points for this project. 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		CONSISTENCY OF FINE-GRAINED SOILS		
(More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		(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.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (tsf)	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG
The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests <sup>A</sup>				Soil Classification		
				Group Symbol	Group Name <sup>B</sup>	
<b>Coarse-Grained Soils:</b> More than 50% retained on No. 200 sieve	<b>Gravels:</b> More than 50% of coarse fraction retained on No. 4 sieve	<b>Clean Gravels:</b> Less than 5% fines <sup>C</sup>	$Cu \geq 4$ and $1 \leq Cc \leq 3$ <sup>E</sup>	GW	Well-graded gravel <sup>F</sup>	
			$Cu < 4$ and/or $[Cc < 1$ or $Cc > 3.0]$ <sup>E</sup>	GP	Poorly graded gravel <sup>F</sup>	
		<b>Gravels with Fines:</b> More than 12% fines <sup>C</sup>	Fines classify as ML or MH	GM	Silty gravel <sup>F, G, H</sup>	
			Fines classify as CL or CH	GC	Clayey gravel <sup>F, G, H</sup>	
	<b>Sands:</b> 50% or more of coarse fraction passes No. 4 sieve	<b>Clean Sands:</b> Less than 5% fines <sup>D</sup>	$Cu \geq 6$ and $1 \leq Cc \leq 3$ <sup>E</sup>	SW	Well-graded sand <sup>I</sup>	
			$Cu < 6$ and/or $[Cc < 1$ or $Cc > 3.0]$ <sup>E</sup>	SP	Poorly graded sand <sup>I</sup>	
		<b>Sands with Fines:</b> More than 12% fines <sup>D</sup>	Fines classify as ML or MH	SM	Silty sand <sup>G, H, I</sup>	
			Fines classify as CL or CH	SC	Clayey sand <sup>G, H, I</sup>	
<b>Fine-Grained Soils:</b> 50% or more passes the No. 200 sieve	<b>Silts and Clays:</b> Liquid limit less than 50	<b>Inorganic:</b>	$PI > 7$ and plots on or above "A"	CL	Lean clay <sup>K, L, M</sup>	
			$PI < 4$ or plots below "A" line <sup>J</sup>	ML	Silt <sup>K, L, M</sup>	
		<b>Organic:</b>	Liquid limit - oven dried	$< 0.75$	OL	Organic clay <sup>K, L, M, N</sup>
			Liquid limit - not dried			Organic silt <sup>K, L, M, O</sup>
	<b>Silts and Clays:</b> Liquid limit 50 or more	<b>Inorganic:</b>	$PI$ plots on or above "A" line	CH	Fat clay <sup>K, L, M</sup>	
			$PI$ plots below "A" line	MH	Elastic Silt <sup>K, L, M</sup>	
		<b>Organic:</b>	Liquid limit - oven dried	$< 0.75$	OH	Organic clay <sup>K, L, M, P</sup>
			Liquid limit - not dried			Organic silt <sup>K, L, M, Q</sup>
	<b>Highly organic soils:</b>	Primarily organic matter, dark in color, and organic odor			PT	Peat

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve.

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup> 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.

<sup>D</sup> 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.

$$E \quad Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

<sup>F</sup> If soil contains  $\geq 15\%$  sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains  $\geq 30\%$  plus No. 200 predominantly sand, add "sandy" to group name.

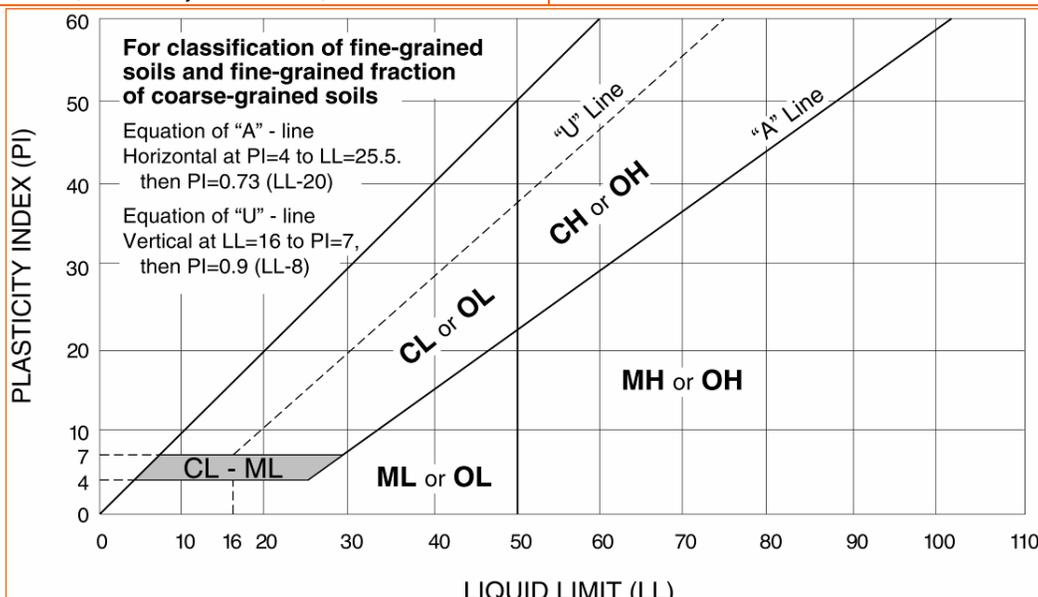
<sup>M</sup> If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.

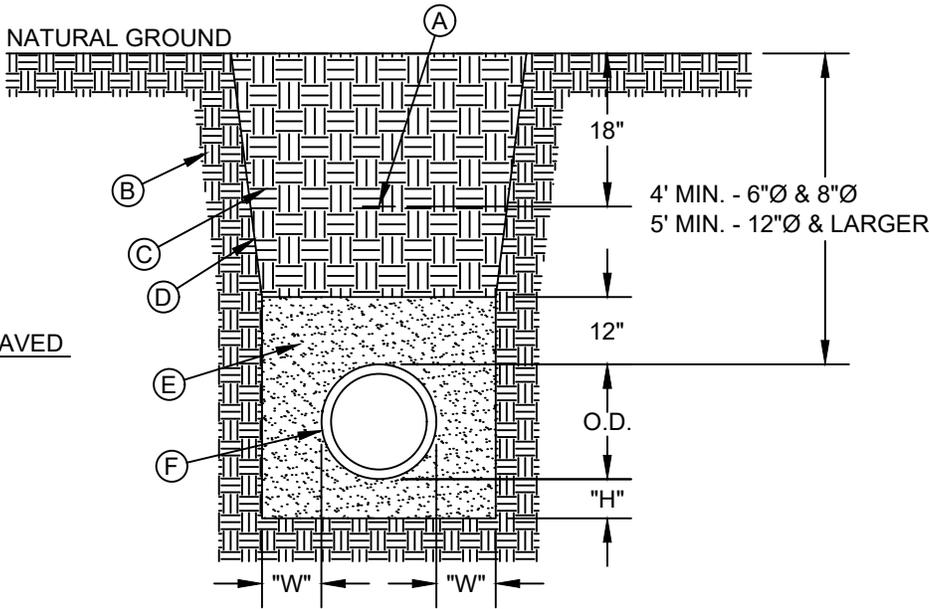
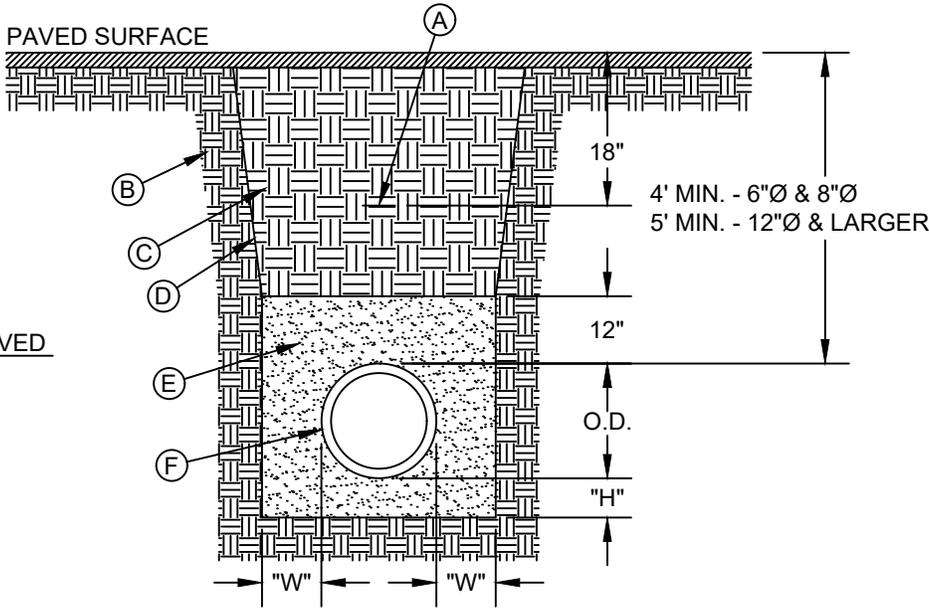
<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>O</sup>  $PI < 4$  or plots below "A" line.

<sup>P</sup>  $PI$  plots on or above "A" line.

<sup>Q</sup>  $PI$  plots below "A" line.





**CONSTRUCTION KEY NOTES**

- A. APPROVED MARKING TAPE.
- B. UNDISTURBED STABLE MATERIAL
- C. BACKFILL
  - 1. PAVED CONDITION: STABILIZED SAND
  - 2. UNPAVED CONDITION: NATIVE MATERIAL, COMPACT TO 85% DENSITY PER ASTM D-1557 MODIFIED PROCTOR. (SEE NOTE # 4 IF THESE PREVIOUS CONDITIONS CANNOT BE MET.)
- D. SLOPE TRENCH IN SANDY SOIL CONDITIONS.
- E. PRESSURE PIPE: USE CLASS II OR CLASS III SAND PER ASTM D-2487. NATIVE MATERIAL OR IMPORTED SELECT MATERIAL MEETING OR EXCEEDING THIS REQUIREMENT MAY BE USED. COMPACT TO 85% DENSITY PER ASTM D-1557 MODIFIED PROCTOR (OR 90% D-698 STANDARD PROCTOR). GRAVITY PIPE: USE CLASS I GRAVEL PER ASTM D-2321 AND D-2487. NO COMPACTION REQUIRED. USE MINIMAL TAMPING, RODDING OR HAUNCH SLICING CAREFULLY IN THE EMBEDMENT ZONE. IF REQUIRED BY THE ENGINEER, TEST PER ASTM D-4254 PERCENT OF RELATIVE DENSITY.
- F. APPROVED PIPE.
- G. TRENCH DIMENSIONS AS FOLLOWS:

<u>PIPE DIAMETER</u>	<u>"H"</u>
6"-30"	6"
>30"	6"
<u>PIPE DIAMETER</u>	<u>"W"</u>
6"-30"	12"
>30"	12"

**NOTES:**

- BEDDING FOR PRESSURE AND GRAVITY PIPE IN DRY CONDITIONS.
- PROVIDE TRENCH SAFETY SYSTEM FOR TRENCH DEPTHS GREATER THAN 5 FEET.
- IF THE NATIVE MATERIAL EXCAVATED FROM THE TRENCH IS UNSUITABLE AS BACKFILL MATERIAL, OR THE REQUIRED COMPACTION IS UNATTAINABLE, THE CONTRACTOR SHALL, AT HIS EXPENSE, IMPORT SELECT MATERIAL TO BE MIXED WITH OR USED IN PLACE OF THE NATIVE MATERIAL. SELECT MATERIAL MUST BE APPROVED BY THE CITY OF HUNTSVILLE. SUBSTITUTE SOIL CEMENT SLURRY (1-SACK) IF REQUIRED IN SPECS.

ENGINEERING DEPARTMENT  
CITY OF HUNTSVILLE, TEXAS

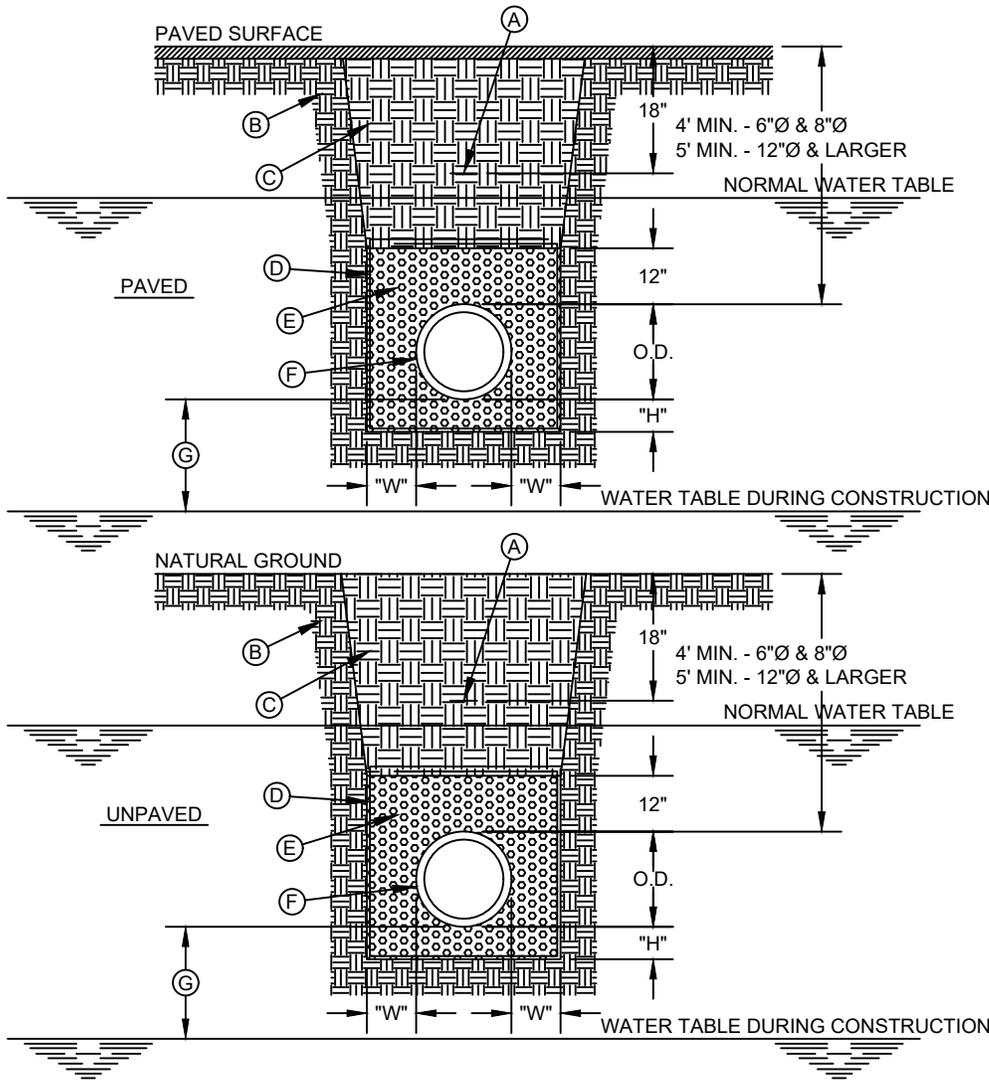
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NAME: EMBEDMENT CLASS "A" - DRY  
CATEGORY: SEWER  
DRAWN DATE: 11/07/2016  
DRAWN BY: WLSIII  
SCALE: N.T.S.  
APPROVED BY: YSR



CITY OF HUNTSVILLE STANDARD DETAILS  
EMBEDMENT CLASS "A" FOR  
PRESSURE AND GRAVITY PIPE - DRY CONDITIONS

REV#	ISSUER	DATE	APPROVER	SHEET 1 OF 1
0	MAM	08/10/2018		
1	MAM	10/16/2019	RAM	
				<b>SS-28</b>



**CONSTRUCTION KEY NOTES**

- A. APPROVED MARKING TAPE.
- B. UNDISTURBED STABLE MATERIAL
- C. BACKFILL
  1. PAVED CONDITION: STABILIZED SAND
  2. UNPAVED CONDITION: NATIVE MATERIAL, COMPACT TO 85% DENSITY PER ASTM D-1557 MODIFIED PROCTOR. (SEE NOTE # 4 IF THESE PREVIOUS CONDITIONS CANNOT BE MET.)
- D. APPROVED GEOTECHNICAL FABRIC WITH A STANDARD OVERLAP THAT IS 2 FEET EXCEPT WHERE TRENCH WIDTH EXCEEDS 3 FEET. THE OVERLAP AT TOP SHALL BE 3 FEET.
- E. USE CLASS I GRAVEL PER ASTM D-2321 AND D-2487. NO COMPACTION REQUIRED. USE MINIMAL TAMPING, RODDING OR HAUNCH SLICING CAREFULLY IN THE EMBEDMENT ZONE. IF REQUIRED BY THE ENGINEER, TEST PER ASTM D-4254 PERCENT OF RELATIVE DENSITY.
- F. APPROVED PIPE.
- G. 18" MINIMUM UNLESS OTHERWISE SPECIFIED.
- H. TRENCH DIMENSIONS AS FOLLOWS:

<u>PIPE DIAMETER</u>	<u>"H"</u>
6"-30"	6"
>30"	6"
<u>PIPE DIAMETER</u>	<u>"W"</u>
6"-30"	12"
>30"	12"

**NOTES:**

1. BEDDING FOR PRESSURE PIPE IN WET CONDITIONS.
2. PROVIDE TRENCH SAFETY SYSTEM FOR TRENCH DEPTHS GREATER THAN 5 FEET.
3. A DRY TRENCH MUST BE MAINTAINED WHILE PLACING BEDDING AND GEOTECHNICAL FABRIC.
4. IF THE NATIVE MATERIAL EXCAVATED FROM THE TRENCH IS UNSUITABLE AS BACKFILL MATERIAL, OR THE REQUIRED COMPACTION IS UNATTAINABLE, THE CONTRACTOR SHALL, AT HIS EXPENSE, IMPORT SELECT MATERIAL TO BE MIXED WITH OR USED IN PLACE OF THE NATIVE MATERIAL. SELECT MATERIAL MUST BE APPROVED BY THE CITY OF HUNTSVILLE. SUBSTITUTE SOIL CEMENT SLURRY (1-SACK) IF REQUIRED IN SPECS.

ENGINEERING DEPARTMENT  
CITY OF  
HUNTSVILLE, TEXAS



City Service Center  
448 State Highway 75  
Huntsville, TX 77320

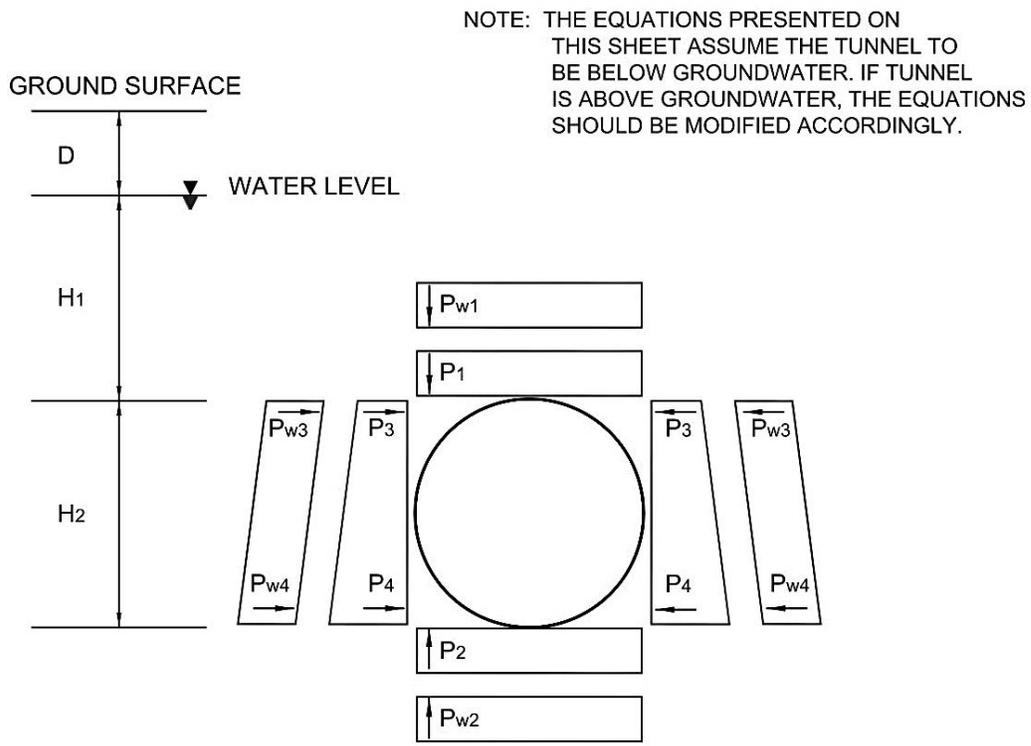
CITY OF HUNTSVILLE STANDARD DETAILS  
EMBEDMENT CLASS "C" FOR  
GRAVITY PIPE - WET CONDITIONS

REV#	ISSUER	DATE	APPROVER	SHEET 1 OF 1
0	MAM	08/10/2018		
1	MAM	10/16/2019	RAM	<b>SS-30</b>

NAME: EMBEDMENT CLASS "C" - WET  
CATEGORY: SEWER  
DRAWN DATE: 11/07/2016  
DRAWN BY: WLSIII  
SCALE: N.T.S.  
APPROVED BY: YSR

**FIGURE 1 – TUNNEL LINER LOADS**

City of Huntsville - 17th Street Storm Sewer Replacement ■ Huntsville, Texas  
 October 19, 2021 ■ Terracon Project No. 97225092

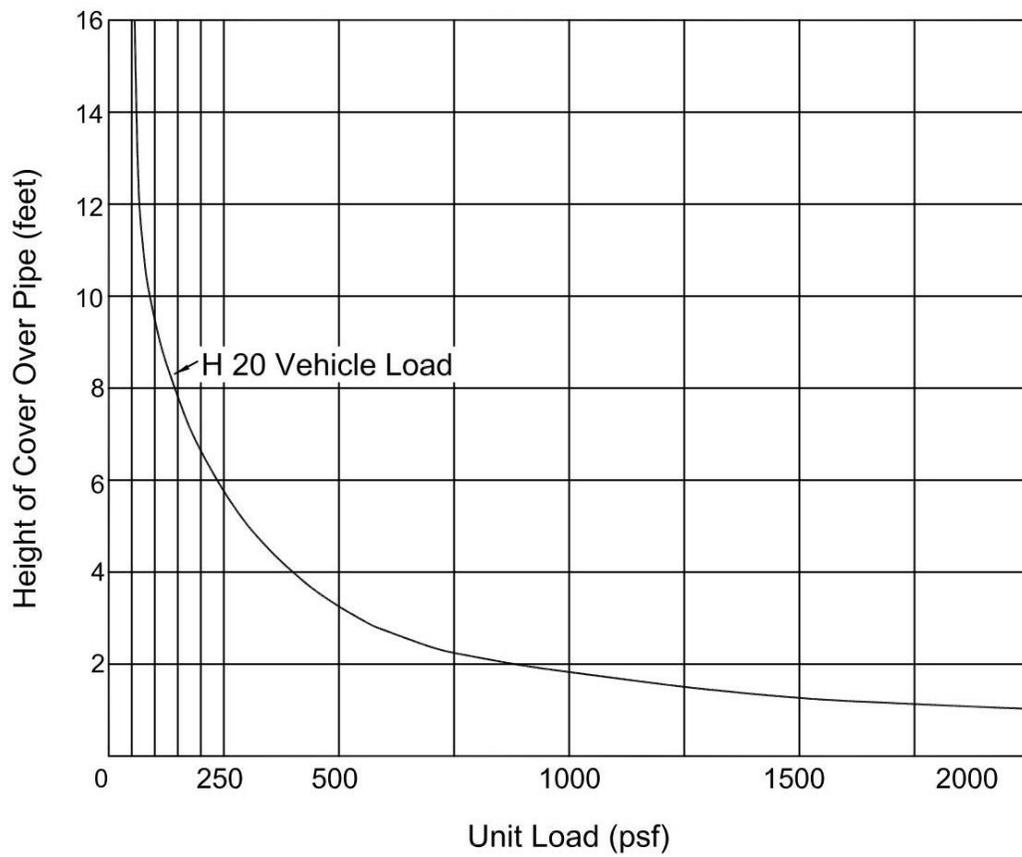


- $\gamma_b$  = Soil Buoyant Density (pcf)
- $\gamma_d$  = Soil Dry Density (pcf)
- $\gamma_t$  = Soil Wet Density (pcf)
- $\gamma_{water}$  = Water Density (pcf)
- $K_a$  = Coefficient of Active Earth Pressure
- $D$  = Depth to Water Table (ft)
- $q$  = Surcharge Load

Vertical Pressure	$P_1 = \gamma_t D + (\gamma_t - \gamma_{water})H_1 + q$
Water Pressure (top)	$P_{w1} = H_1 \gamma_{water}$
Over Burden Pressure	$= P_1 + P_{w1}$
Soil Pressure (bottom)	$P_2 = P_1 + (\gamma_t - \gamma_{water})H_2$
Water Pressure (bottom)	$P_{w2} = P_{w1} + \gamma_{water} H_2$
	$P_{w2} = P_{w4}$
$P_{w1} = P_{w3}$	
Lateral Soil Pressure (top)	$P_3 = K_a P_1$
Lateral Soil Pressure (bottom)	$P_4 = K_a P_2$
Total Lateral Pressure (top)	$= P_{w3} + P_3$
Total Lateral Pressure (bottom)	$= P_{w4} + P_4$

**FIGURE 2 - TUNNEL LINER LOADS – H20 HIGHWAY LOAD**

City of Huntsville - 17th Street Storm Sewer Replacement ■ Huntsville, Texas  
October 19, 2021 ■ Terracon Project No. 97225092



REFERENCE: PRINCIPLES OF STRUCTURAL PERFORMANCE OF BURIED PIPES  
REYNOLD K. WATKINS (1977)