ECS Southwest, LLP

Geotechnical Engineering Report

Dashwood Trails Apartments

Dashwood Drive and Jetty Lane
Houston, Harris County, Texas

ECS Project Number 43:3223

October 17, 2024

ECS SOUTHWEST, LLP
"One Firm. One Mission."
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October 17, 2024

Mr. Corey Orman
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Bartlett, Tennessee 38133

ECS Project No. 43:3223

Reference: Geotechnical Engineering Report
Dashwood Trails Apartments
Dashwood Drive and Jetty Lane
Houston, Harris County, Texas

Dear Mr. Orman:

ECS Southwest, LLP (ECS) has completed the subsurface exploration, laboratory testing, and geotechnical engineering analyses for the above-referenced project. Our services were performed in general accordance with our agreed scope of work. This report presents our understanding of the geotechnical aspects of the project along with the results of the field exploration and laboratory testing conducted, and our design and construction recommendations.

It has been our pleasure to be of service to Carlson Consulting Engineers, Inc. during the design phase of this project. We would appreciate the opportunity to remain involved during the continuation of the design phase, and we would like to provide construction phase observation and materials testing work. Should you have any questions concerning the information contained in this report, or if we can be of further assistance to you, please contact us.

Respectfully submitted,

ECS Southwest, LLP

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The *electronic seal in this document was authorized by Richard E. Webb, P.E. No 60460, on October 17, 2024.*

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EXECUTIVE SUMMARY

The following summarizes the main findings of the exploration, particularly those that may have a cost impact on the planned development. Further, our principal foundation recommendations are summarized. This Executive Summary is intended as a very brief overview of the principal geotechnical conditions that are expected to affect design and construction. Information gleaned from the executive summary should not be utilized in lieu of reading the entire geotechnical report.

- The subsurface soil conditions observed at the site generally consisted of approximately 2 feet of surficial Lean Clay Fill (CL FILL) and Fat Clay Fill (CH FILL) underlain by Fat Clay (CH) and Lean Clay (CL) extending up to the maximum explored depth of about 20 feet below the existing site grade.

- Groundwater was not observed in the borings during drilling and/or shortly after completion of drilling.

- The onsite soils are considered to have high expansion potential with Potential Vertical Movement (PVM) to be approximately 3½ inches for “dry” conditions for the proposed grade-supported structures. Therefore, we anticipate that subgrade improvements will be required to reduce the PVM. Subgrade improvement recommendations options are presented to reduce the PVM to about 1 inch.

- The planned building structures can be supported on a shallow spread footing foundation with a slab-on-grade floor slab or a monolithic slab-on-grade foundation. Detailed design and construction recommendations are outlined within this report.

- A below-grade detention vault is planned to be constructed in the northwestern portion of the project site. We assumed that the depth of the detention vault will be approximately 8 feet below the existing site grade.

- Rigid Concrete and/or Flexible Asphalt pavements can be used in conjunction with lime-treated clay and/or reworked onsite clay soils for light truck traffic for main drives and medium duty (drives) pavements to accommodate occasional heavier loadings due to fire trucks, delivery vehicles.

- It is recommended that ECS conduct a geotechnical review of the project plans (prior to issuance for construction) to check to see that ECS’ geotechnical recommendations have been properly interpreted and implemented.

- To prevent misinterpretation of ECS recommendations, we recommend ECS be retained to perform quality control testing and documentation during construction of the earthwork and foundations for the project.

1.0 INTRODUCTION

The purpose of this study was to provide geotechnical design and construction recommendations for an approximate 25,000-square foot, four-story residential apartment complex that will have 98 units, a below-grade detention vault, and 156 parking spaces for passenger vehicles. The recommendations developed for this report are based on project information supplied via an email on February 15, 2024.

Our services were provided in accordance with our Proposal No. 43:5364-GP, dated August 16, 2024. Mr. Dean L. Carlson, P.E. with Carlson Consulting Engineers, Inc. authorized our services by signing the "Professional Services Agreement Amendment #1" on August 29, 2024.

This report contains the procedures and results of our subsurface exploration and laboratory testing programs, review of existing site conditions, engineering analyses, and recommendations for the design and construction of the project.

The report includes the following items.

- A brief review and description of our field and laboratory test procedures and the results of testing conducted.
- A review of surface topographical features and site conditions.
- A review of area and site geologic conditions.
- A review of subsurface soil stratigraphy with pertinent available physical properties.
- A final copy of our soil test borings.
- Estimation for Potential Vertical Movement (PVM) in accordance with Tex-124-E.
- Recommended foundation types with pertinent design recommendations.
- Design and construction recommendations of detention vault.
- Recommendations for preparation of pavement subgrades and suggested pavement sections.
- Recommendations for site preparation and construction of compacted fills, including an evaluation of on-site soils for use as compacted fills.
- Evaluation and recommendations relative to groundwater control.
- An evaluation of soil excavation issues.

2.0 PROJECT INFORMATION

2.1 PROJECT LOCATION/CURRENT SITE USE

The project site is located near Dashwood Drive and Jetty Lane in Houston, Harris County, Texas. The location of the project site is presented below and on the Site Location Diagram in Appendix A.

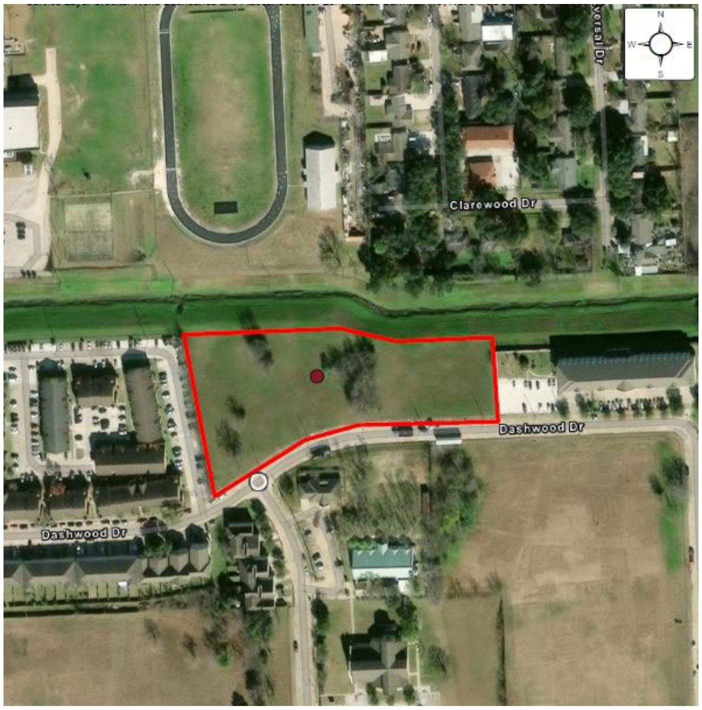


Figure 1: Site Location

The project site is generally flat with surface elevations between approximately 74.5 feet to 76 feet above MSL. The elevations and topographic variations were obtained from available Google Earth and may not be accurate enough for engineering purposes. While preparing this report, we reviewed available documents consisting of USGS topographic maps and USDA soil maps. The subject site is currently undeveloped and covered with light vegetative growth and scattered trees. We did not observe other noteworthy features within the project site during our review. A Topographic Map is presented in Appendix A.

We reviewed Historical Aerial Photographs (presented in Appendix A) to identify the past usage and location of the previously existing development within the project site. Our aerial photo review summary table is presented below:

Table 1: Historical Aerial Photography Summary Table

YEAR	SUBJECT PROPERTY USAGE	ADJACENT PROPERTY USAGE
1978	Generally undeveloped and covered with light vegetative growth.	Residential development to the north of the project site. The remaining site vicinity is generally undeveloped.
1989	No noteworthy improvements.	Residential development to the west of the project site. Track and field constructed north of the project site.
2005	No noteworthy improvements.	Commercial development to the south of the project site.
2009	No noteworthy improvements.	3-Story apartment building constructed east of the project site.
2024	No noteworthy improvements.	Gradual residential development to the southwest and commercial development to the east of the project site.

2.2 PROPOSED CONSTRUCTION

The following information explains our understanding of the planned development including the proposed buildings:

Table 2: General Project Information

SUBJECT	DESIGN INFORMATION / ASSUMPTIONS
Usage	Multifamily residential
Number of Stories	Four-story
Column Loads	50 kips Maximum (Assumed)
Wall Loads	3 kips/ft Maximum (Assumed)
Building Finish Floor Elevation	76.5 feet above MSL
Detention Vault	One, about 8 feet deep (Assumed)
Site work	General earthwork, detention vault, and pavement
Pavement	Rigid concrete and/or flexible asphalt

3.0 FIELD EXPLORATION

Our exploration procedures are explained in greater detail in Appendix B including the insert titled Subsurface Exploration Procedure. Our scope of work included drilling ten borings. Our borings were located with a handheld GPS unit and their approximate locations are shown on the Boring Location Diagram in Appendix A.

3.1 SUBSURFACE CHARACTERIZATION

Based on the Houston Sheet, Texas, Geologic Atlas of Texas (Bureau of Economic Geology, University of Texas, 1982), the site is located within the Beaumont Formation (Qb), which consists predominantly of clay and mud soils with silt. These soils can contain beds and lenses of fine sand and decayed organic matter and many buried organic-rich soil zones that contain calcareous and ferruginous nodules. This material includes plastic and potentially compressible clay that was deposited in flood basins, coastal lakes, and former stream channels on a deltaic plain. The thickness of this formation is approximately 5 to 10 feet along the north edge of the outcrop and thickens southward in the subsurface to more than 100 feet. A Regional Geology Map is presented in Appendix A.

The subsurface soil conditions observed at the site generally consisted of approximately 2 feet of surficial Lean Clay Fill (CL FILL) and Fat Clay Fill (CH FILL) underlain by Fat Clay (CH) and Lean Clay (CL) extending up to the maximum explored depth of about 20 feet below the existing site grade. Please refer to the boring logs in Appendix B. A Generalized Subsurface Profile is presented in Appendix A. Table 3 below summarizes the subsurface stratigraphy encountered at the project site.

Table 3: Subsurface stratigraphy

Approximate Depth to Bottom of Strata (feet)	Elevation of Bottom of Strata (feet)[1]	Stratum	description	Consistency / Density
0 to 2	EL. +72.5 to 76.0	I	(CL/CH FILL) LEAN CLAY/FAT CLAY FILL, dark gray, dark brown, with trace gravels, root fibers, and sand seams	Hard
2 to (6-20)	EL. +54.5 to 74.0	II	(CH) FAT CLAY, dark gray, dark brown, and reddish brown, with ferrous and calcareous nodules	Very Stiff to Hard
(12-17) to 20[2]	EL. +55.0 to 63.0	III	(CL) LEAN CLAY, dark gray, reddish brown, with ferrous nodules and sand seams	Hard

1. Ground surface elevations were not surveyed by a licensed surveyor. Elevations were obtained using Google EarthTM and are approximate.
2. Only encountered in Borings B-01 and B-06.

3.2 GROUNDWATER OBSERVATIONS

Groundwater level observations were made in the borings during and at completion of drilling operations. In auger drilling operations, water is not introduced into the borehole and the groundwater position can often be determined by observing water flowing into the excavation. Furthermore, visual observation of soil samples retrieved can often be used in evaluating the groundwater conditions. Groundwater was not observed during drilling of the borings. Shortly after completion of drilling the borings, the borings also remained dry.

Variations in groundwater can occur as a result of changes in precipitation, evaporation, surface water runoff, construction activities, and other factors. The highest groundwater observations are normally observed in the late winter and early spring. Therefore, the groundwater conditions at this site could be different at the time of construction. The possibility of groundwater level fluctuation should be considered when developing the design and construction plans for the project. Installation and monitoring of observation wells over a longer period of time would be required to assess true groundwater elevation.

3.3 LABORATORY TESTING

The laboratory testing consisted of selected tests performed on samples obtained during our field exploration operations. Classification and index property tests were performed on representative soil samples. The tests included moisture content (ASTM D2216), Atterberg limits (ASTM D4318), Passing No. 200 Sieve (ASTM D1140), and unconsolidated-undrained (UU) compressive strength (ASTM D2850).

The samples were visually classified on the basis of texture and plasticity in general accordance with ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) and ASTM D2487 Standard Practice for Classification for Engineering Purposes (Unified Soil Classification System (USCS). After classification, the samples were grouped in the major zones noted on the boring logs in Appendix B. The group symbols for each soil type are indicated in parentheses along with the soil descriptions. The stratification lines between strata on the logs are approximate; in situ, the transitions may be gradual.

4.0 DESIGN RECOMMENDATIONS

The following sections present more detailed recommendations regarding the proposed multifamily residential development. These include recommendations regarding building foundations, detention vault, drainage, earthwork, ground slabs, and pavement. The following recommendations have been developed based on the previously described project characteristics and subsurface conditions. If there are any changes to the project characteristics or if different subsurface conditions are encountered during construction, ECS should be consulted so that the recommendations of this report can be reviewed.

Based on the provided grading plan, we understand that the final site grade of the complex will be at 76.5 feet above MSL, about ½ to 2 feet above existing grade. Discussion of the factors affecting the building foundations for the proposed structures, as well as additional recommendations regarding design and construction at the project site are included below.

4.1 EXISTING FILL SOILS

Fill soils were observed to a depth of 2 feet below the existing grade within the project site. The depths of the fill soils may vary across the site and should be evaluated at the time of construction. Unless placed properly, compacted, and documented, fill can vary in composition, relative density, and consistency. Supporting foundations and floor slabs on undocumented fill can result in excessive foundation and floor slab movement and is not recommended. The fill soils in the proposed building area should be removed. Existing fill materials meeting select fill requirements can be reworked and reused in accordance with the recommendations presented within this report.

4.2 POTENTIAL VERTICAL MOVEMENTS

Based upon the laboratory test results performed on selected soil samples, the subsoils encountered at this site are considered to have high expansive potential. These soils generally have a greater potential to experience volumetric changes with fluctuations in moisture content also known as “Potential Vertical Movement (PVM)”. These soils can subject structures to movements (due to shrinking and swelling) with fluctuations in their moisture content, throughout the life of the structure and after construction is complete.

We have estimated potential heave for this site utilizing the TxDOT method (Tex-124-E). The Tex-124-E method provides an estimate of potential vertical movement (PVM) using the liquid limits, plasticity indices, and existing water contents for soils. The PVM is estimated in the seasonally active zone, which can be up to about 8 feet in the site vicinity.

Based on test method Tex-124-E in the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, and our experience with similar soils, we estimate potential vertical movements (PVM) to be approximately 3½ inches for “dry” conditions. The actual movements could be greater if poor drainage, ponded water, and/or other unusual sources of moisture are allowed to wet the soils beneath the structure after construction.

In this general area, most structural and geotechnical engineers consider a PVM of about 1 inch or less to be within acceptable tolerances for properly designed at-grade supported structures. However, this movement does not take into consideration the movement criteria required or perceived by the owner or occupants. These "operational" performance criteria may be, and often are, more restrictive than the structural criteria or tolerances.

4.2.1 Subgrade Improvements

To reduce the PVM to approximately 1 inch and reduce the risk associated with future movements, we are recommending the building pad subgrade improvement options noted in the following table:

Table 4: Subgrade Improvements

	DEPTH OF LOW-EXPANSIVE FILL(1) (FEET)	DEPTH OF MOISTURE CONDITIONING(2) (FEET)	TOTAL DEPTH OF IMPROVED ZONE (FEET)	PVM (INCH)
Option I	5	0	5	≈ 1
Option II	1	6	7	≈ 1
Note.	1. Low-expansive fill soils typically consist of "Select Fill" materials with properties outlined in the "Material Specifications" section of the report. The on-site clay soils may be treated with lime (outlined as "Lime-Treated On-Site Clay") and placed in lieu of Select Fill in accordance with the "Material Specifications" section of the report. 2. Depth of moisture conditioning will include removing, reworking, and recompacting on-site clays with proper engineering efforts outlined as "Moisture-Conditioned On-Site Clay Fill" in the "Material Specifications" section of the report.			

Specific recommendations for material requirements and installation procedures may be found in the 'Site Construction Recommendations' section of this report. The improved soil zone should extend at least 5 feet beyond the structure footprint and include flatwork sensitive to movements such as sidewalks or pavements.

Some of the risks associated with placing slabs or foundations on improved subgrades may include uneven floors, floor and wall cracking and sticking doors or windows. The higher the designed PVM, the higher the risk is for future performance issues. ECS should be contacted if a PVM other than 1 inch is required.

4.3 FOUNDATION RECOMMENDATIONS

Based on our subsurface exploration and laboratory testing, we are providing the following recommendations to support the proposed building structures on a shallow spread footing foundation with a slab-on-grade floor slab or a monolithic slab-on-grade foundation. The following section presents our detailed design and construction recommendations. The design team members (Owner/Developer/Architect and/or the Structural Engineer of Record) should discuss these options and select the appropriate foundation systems for the proposed structures.

4.3.1 Shallow Spread Footings

Upon mitigating the existing fill soils and reducing the PVM to 1 inch, the proposed building structures can be supported by shallow spread and/or continuous footings. We recommend the foundation design use the following parameters shown in Table 5 below:

Table 5: Shallow Foundation Design Parameters

DESIGN PARAMETER	COLUMN FOOTING	WALL FOOTING
Net Allowable Bearing Pressure[(1)]	3,000 psf	3,000 psf
Acceptable Bearing Soil Material	Stiff clay or compacted Select Fill	Stiff clay or compacted Select Fill
Minimum Width	24 inches	18 inches
Minimum Footing Embedment Depth (below finished grade)	2 Feet	2 Feet
Estimated Total Settlement [(2)]	Approx. 1 inch	Approx. 1 inch
Estimated Differential Settlement [(3)]	About ½ inch between columns	About ½ inch over a distance of 30 feet

Notes:

(1) Net allowable bearing pressure is the applied pressure in excess of the surrounding overburden soils above the base of the foundation.

(2) Based on our assumed structural loads. If final loads are different, ECS should be contacted to update foundation recommendations and estimated settlement values.

(3) Based on maximum column/wall loads and variability in borings. Differential settlement can be re-evaluated once the foundation plans are more complete.

The final footing and/or grade beam elevation should be evaluated by competent geotechnical engineering personnel to verify that the bearing soils are capable of supporting the recommended net allowable bearing pressure and are appropriate for foundation construction. These evaluations should include visual observations and may use the Dynamic Cone Penetration (DCP) testing (ASTM STP-399) or similar alternatives. If DCP testing is performed, the tests should be performed within each column footing excavation (minimum of 2 tests per column footing) and at intervals not greater than 25 feet in continuous footings. The DCP testing should extend at least 4 feet below the final foundation subgrade. A minimum DCP value of 12 blows/6” (Kessler 17.6-lb dual-mass hammer DCP) may be used for the evaluation of the foundations.

4.3.1.1 Potential Undercuts

The soils at the foundation bearing elevation are anticipated to be appropriate for support of the proposed structure. However, if soft or undesirable soils are observed at the footing bearing elevations, the soils should be undercut and removed. The undercut should be backfilled with lean concrete (f’c ≥ 1,000 psi at 28 days) up to the original design bottom of footing elevation; the original footing should be constructed on top of the hardened lean concrete.

4.3.1.2 Uplift Considerations

The ultimate uplift capacities of the shallow foundation can be obtained from the weight of the foundation and weight of the backfill soils directly above the spread footing. A minimum factor of safety of 1.2 should be used to compute allowable uplift capacity.

4.3.1.3 Lateral Considerations

Lateral loads on shallow footings are resisted by (a) soil friction at the base and (b) by the passive resistance along the side of the foundations. To compute the frictional resistance at the base, a friction coefficient of 0.33 may be used between the foundation bottom or concrete slabs and the supporting soils. A passive resistance of properly compacted fill of 225 psf per foot can be used along the foundation. The friction and passive resistance values are ultimate values and do not include factors of safety. The passive pressure and the frictional resistance of the soils can be combined in determining the total lateral resistance.

4.3.1.4 Slab-on-Grade

Upon mitigating the existing fill soils and reducing the PVM as recommended, the planned building structures can be supported on shallow foundations in conjunction with a slab-on-grade floor. A soil modulus of subgrade reaction (ks) of 100 pci can be used in the design of floor slab.

We recommend that floor slabs be isolated from the foundation footings so differential settlement of the structure may not induce shear stresses in the floor slab. To reduce the crack width of shrinkage cracks that may develop near the surface of the slab, we recommend reinforcement be included in the design of the floor slab. The reinforcement should be in the top half of the slab to be effective.

A bedding layer of sand, 4 inches in thickness, should be placed beneath the floor slab. If floor treatments that are sensitive to moisture are used, a 10-mil vapor retarder of polyethylene sheeting or similar material should be placed beneath the slab to reduce moisture migration through the slab. If a vapor retarder is considered to provide moisture protection, special attention should be given to the surface curing of the slabs to reduce uneven drying of the slabs and associated cracking and/or slab curling. The use of a blotter or cushion layer above the vapor retarder can also be considered for project specific reasons. Please refer to ACI 302.1R96 Guide for Concrete Floor and Slab Construction and ASTM E1643 Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs for additional guidance on this issue.

4.3.2 Monolithic Slab-on-Grade

Upon mitigating the existing fill soils and reducing the PVM as recommended, the planned building structures can be supported by a monolithic slab-on-grade/grade beam structural foundation system. This system may be designed with conventional reinforcing or by post-tensioning. The slab should be designed in accordance with WRI/CRSI “Design Slab-On-Ground Foundations” or PTI “Design and Construction of Post-Tensioned Slabs-On-Ground”. The following design parameters are recommended for the Post-Tensioning Institute's slab-on-grade design method (3rd Edition):

Table 6: Post-Tensioned Slab Parameters - PTI 3rd Edition with 2008 Supplements

DESIGN PARAMETERS	OPTION I; PVM ≈ 1 (INCH)	OPTION II; PVM ≈ 1 (INCH)
e_m Edge (feet)	4.8	4.8
y_m Edge (inches)	0.5	0.8
e_m Center (feet)	8.7	8.3
y_m Center (inches)	0.7	1.0
Effective PI	32	40
Design Suction Profile	Post-Equilibrium	
Thornthwaite Moisture Index	18	
Slab Subgrade Coefficient (Slab-on-Vapor Sheeting over Sand)	0.75	

As an alternative, the following design parameters are recommended for the WRI/CRSI "Design Slab-On-Ground Foundations (August, 1981)":

Table 7: BRAB/WRI Slab Parameters

DESIGN PARAMETERS	OPTION I; PVM ≈ 1.0 (INCH)	OPTION II; PVM ≈ 1.0 (INCH)
Allowable Bearing Capacity	2,000 psf	2,000 psf
Design PI	32	40
Climatic Rating (Cw)	26	26
Unconfined Compressive Strength	2,500 psf	2,500 psf
Soil-Climate Support Index (1-C)	0.12	0.18

Grade beams should have a minimum width of 12 inches to reduce the possibility of foundation bearing failure and excessive settlement due to local shear or "punching" failures. Additionally, the grade beams should extend at least 18 inches and 24 inches below final adjacent grades for interior and exterior beams, respectively. Fills should be sloped to drain surface water away from the structures. We anticipate that foundations, grade beams and slabs designed using the recommended allowable bearing pressures will experience settlements on the order of an inch.

The recommended differential movement values are based on climate-controlled soil conditions and are not valid when influenced by significant other conditions, such as trees, poor drainage, slope, cut and fill sections, etc. These design parameters also assume that positive drainage will be provided away from the structures. Moderate irrigation of surrounding lawn and planter areas may be performed without allowing excessive wetting or drying of soils adjacent to the foundations. Greater potential movements may occur with extreme wetting or drying of the soils due to ponding of water, plumbing leaks or lack of irrigation. In the event that sprinkler systems are used, we recommend that the sprinkler system be placed all around the structure to provide a relatively uniform moisture condition throughout the year. This will try to reduce fluctuations in subsoil moisture and corresponding movement.

If floor treatments that are sensitive to moisture are used, a 10-mil vapor retarder of polyethylene sheeting or similar material should be placed beneath the slab to reduce moisture migration through the slab. If a vapor retarder is considered to provide moisture protection, special attention should be given to the surface curing of the slabs to reduce uneven drying of the slabs and associated cracking and/or slab curling. The use of a blotter or cushion layer above the vapor retarder can also be considered for project specific reasons. Please refer to ACI 302.1R96 *Guide for Concrete Floor and Slab Construction* and ASTM E1643 *Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs* for additional guidance on this issue.

Based on the provided grading plan, the final site grade of the complex will be at 76.5 feet above MSL, which is about ½ to 2 feet above existing grade. Fill placed on the site should be in accordance with our recommendations given in the "Site Construction Recommendation" section.

4.4 PERIMETER CONDITIONS

Soils placed along the exterior of grade beams/perimeter walls should be on-site clay soils or lime-treated clay placed and compacted in accordance with this report. The purpose of this backfill is to reduce the opportunity for surface or subsurface water infiltration beneath the structure. The overbuild zone of select granular soils should be removed outside of the perimeter grade beams and backfilled with on-site clay or lime-treated soils. If lime-treated material is used as select, this overbuild removal is not required.

We recommend paving/sidewalks be placed adjacent to the structures to reduce seasonal drying of the near surface soils near the perimeter of the structures. Irrigation of lawn and landscaped areas should be moderate, without allowing excessive wetting or drying of soils around the perimeter of the structures. Sprinkler systems should be used around the perimeter of the structure to maintain a relatively uniform moisture distribution around the foundation slab.

Positive drainage away from the structures should be provided and strictly maintained during the life of the structures. Where flatwork is placed against or near the structure, a positive seal should be installed and adequately maintained to reduce water intrusion. Down spouts and gutters should be used to collect and distribute water at least 10 feet away from the structure.

Trees and taller bushes/shrubs planted near the perimeter of the structures can withdraw large amounts of water from the soils. We recommend trees not be planted or left in place (existing trees) closer than half the canopy diameter of mature trees from the grade beams, typically a minimum of 20 feet. If vegetation is planted closer than the anticipated mature height away from the buildings, then a root barrier should be installed to a depth of at least 5 feet below finished grade.

4.5 DETENTION VAULT DESIGN CONSIDERATIONS

4.5.1 Allowable Bearing Pressure

The proposed detention vault can be supported by shallow spread and/or continuous footings. We recommend the foundation design use the following parameters shown in Table 8 below:

Table 8: Shallow Foundation Design Parameters

DESIGN PARAMETER	COLUMN FOOTING	WALL FOOTING
Net Allowable Bearing Pressure(1)	3,000 psf	3,000 psf
Acceptable Bearing Soil Material	Stiff clay or compacted Select Fill	Stiff clay or compacted Select Fill
Minimum Width	24 inches	18 inches
Minimum Footing Embedment Depth (below finished grade)	2.0 Feet	2.0 Feet

Notes:

(1) Net allowable bearing pressure is the applied pressure in excess of the surrounding overburden soils above the base of the foundation.

4.5.2 Lateral Earth Pressure

Based on the conceptual site plan provided to us by the Client, a below-grade detention vault is planned to be constructed in the northwestern portion of the project site near Borings B-01 through B-03. We assumed that the depth of the detention vault will be approximately 8 feet below the existing site grade. Based on our subsurface exploration and laboratory test data near Borings B-01 through B-03, the generalized subsurface soils with corresponding depths are presented below:

Table 9: Generalized Subsurface Soils and Depths Observed within the Detention Vault

SOIL TYPE	DEPTH (FEET)	CONSISTENCY
Fat Clay Fill (CH FILL)	0 – 2	Hard
Fat Clay (CH)	2 – (17-20)	Very Stiff to Hard
Lean Clay (CL)	17 – 20	Hard

The detention vault will be subjected to lateral earth pressures from hydrostatic water pressure, soil pressure, and surcharge loads adjacent to the vault. Lateral earth pressures can be calculated by multiplying the equivalent fluid density of the surrounding soils and unit weight of water by the depth below the ground surface. ECS recommends the detention vault design assume the water table at the ground surface or a fully submerged condition due to hurricane storm surcharge. The following equivalent fluid densities and submerged unit weights of the soil located in Table 10 below can be used for design to resist lateral loading.

Table 10: Submerged Unit Weight and Equivalent Fluid Density

Soil Type	Depth of Layer (feet)	Drained Friction Angle (°)	Submerged Unit Weight (pcf)	At-Rest Earth Pressure Coefficient	Equivalent Fluid Density (psf/ft)
CH (FILL)	0 - 2	19	58	0.67	39
CH	2 – 17/20	19	63	0.67	42
CL	17 - 20	22	63	0.63	40

A triangular stress distribution can be assumed for design purposes. The equivalent fluid density does not include the hydrostatic pressure exerted on the structure. To calculate the hydrostatic water pressure against the structure, an additional triangular stress distribution should be utilized. The hydrostatic water pressure value should be considered additive to the fluid density. These hydrostatic water pressures can be calculated utilizing a unit weight of 63 pcf starting at the ground surface.

4.5.3 Uplift

The detention vault will be subjected to hydrostatic uplift pressures specifically during times of low water within the well or when the structure is experiencing minimal loading conditions. Provisions should be made to prevent the upward movement of the structure. During the end of construction and post construction while the sanitary lift station is in use, the following formula should be utilized to calculate a factor of safety against uplift.

All structures shall be designed to resist buoyancy to the finished top slab. Structural design and buoyancy calculations must show a minimum Factor of Safety (FOS) equal to or greater than 1.5 against flotation for an empty structure with the groundwater elevation at the surface. Groundwater used for uplift calculations (PU) should also consider anticipated flood levels for the site with a minimum FOS of 1.1 for extreme cases.

Uplift forces resisted by the dead weight of the detention vault structure should consider an empty condition. Dead loads from equipment and pumps should be neglected. We recommend the calculated ultimate uplift resistance due to the weight of the structure be reduced by a factor of 1.2 to compute the allowable uplift resistance. The structure weight should include only the concrete walls and slab and can be taken as 145 pcf. We recommend an allowable side skin friction of 550 psf when considering uplift resistance. The skin friction component should be neglected if a bentonite slurry is applied to the outside of the caisson during construction to facilitate excavation.

4.6 RETAINING WALL/BELOW-GRADE WALL CONSIDERATIONS

Retaining/below-grade walls should be placed on a slope no steeper than 3H:1V, as defined from the exterior lower footing edge, down to the limit of the slope upon which the retaining wall is built. This requirement is intended to prevent retaining/below-grade walls from being constructed on excessively steep slopes, threatening both the integrity of the retaining wall/below-grade wall, and the slope to be retained.

The values tabulated on the following page under “Active Conditions” pertain to retaining walls less than 6 feet tall and free to tilt outward as a result of lateral earth pressures. For rigid, non-yielding walls (such as detention vault walls) which are not allowed to rotate, the values under “At-Rest Conditions” should be used.

Table 11: Lateral Earth Pressure Design Values for Retaining Wall(s)/Below Grade Wall

BACKFILL TYPE (LEVEL BACKFILL)	ESTIMATED TOTAL UNIT WEIGHT (PCF)	ACTIVE CONDITION		AT REST CONDITION	
		EARTH PRESSURE COEFFICIENT, K_A	EQUIVALENT FLUID DENSITY (PCF)	EARTH PRESSURE COEFFICIENT, K_O	EQUIVALENT FLUID DENSITY (PCF)
Clayey/Silty SAND (SC/SM); PI < 21	120	0.33	40	0.5	60
Pit Run Clayey Gravels or Sands	135	0.32	45	0.48	65
On-Site Clays	120	0.59	70	0.74	90

Retaining/below grade walls, should also account for surcharge loads within a 45° slope from the base of the backside of the wall. In addition, the design pressure outlined above should be modified if a sloping backfill is required. The passive resistance should be neglected in the stability calculations if there is a possibility that the soil in front of the wall footing will be excavated in the future. The retaining wall should have a minimum factor of safety of 1.5 or greater against sliding and overturning. The depth of embedment should be at least 30 inches and a bearing capacity of 2,000 psf can be used for the design of the retaining wall.

The recommendations contained above assume that the backfill behind the wall is properly drained. Drainage of the backfill may be accomplished through the use of 3-inch diameter weep holes at 10-foot spacing, through the wall, immediately above the proposed grade in front of the wall. Alternatively, a longitudinal drain line may be placed behind the retaining wall and sloped to discharge by gravity or to a storm sewer.

Passive lateral pressures at the face of the footing, for resistance purposes, can be 225 psf per foot of soil height. The passive resistance should be ignored for the upper 1 foot of wall. The frictional resistance against sliding (N tan Ø) is 0.33N on natural or compacted soil.

Compaction of the materials placed for the wall should be conducted in accordance with this report and depends on the type of material used. If retaining walls are required as part of this development, we recommend that ECS be consulted during the design phase to evaluate that our recommendations are appropriately applied as well as to determine if a global stability analysis is required.

4.7 PAVEMENT SUBGRADE

Fill soils were encountered to a depth of 2 feet below the existing grade within the project site. Proposed paved areas should be proofrolled with heavy compaction equipment with load of at least 25 tons to identify soft or loose soils so they can be removed and replaced with properly placed and compacted soils. Pumping or rutting identified during proofroll should be conducted in accordance with TxDOT Standard Specification Item 216. The proofrolling operations should be observed by the representative of Geotechnical Engineer of Record.

For estimating purposes, we recommend that 6% hydrated lime (by dry weight of soil) can be considered for subgrade treatment. The application rate will be approximately 27 pounds per square yard for each 6-inch lift of compacted thickness. The actual amount of lime required should be determined by additional laboratory tests (lime series) during the construction phase. The lime treatment should conform TxDOT Item 260. The treated soil should be compacted to a minimum of 95% of its maximum standard Proctor dry density (ASTM D698) at a moisture content within ±2% of optimum moisture content value as determined by that test. Lime treatment should extend at least 1 foot beyond exposed pavement edges to reduce the effects of shrinkage and associated loss of subgrade support.

Density tests should be performed at a frequency of 1 test per 5,000 square feet of pavement. The actual amount of lime required should be confirmed by additional laboratory tests (lime series) during the construction phase.

4.7.1 Pavement Sections

Typical pavement sections are provided below. The Light-Duty and Medium-Duty asphalt pavements with lime treatment are adequate for design life of 50,000 and 100,000 ESAL, respectively. The Light-Duty and Medium-Duty concrete pavements without lime treatment are adequate for design life of 50,000 and 125,000 ESAL, respectively. If chemical treatment is performed beneath concrete pavements, the Standard-Duty and Medium-Duty concrete pavements are adequate for design life of 80,000 and 200,000 ESAL, respectively. Heavy-Duty pavements are recommended for frequent truck traffic areas and dumpster areas. Recommended pavement sections are provided below. Actual pavements sections and joint spacing should be designed based on actual traffic loads by the Civil Engineer of Record.

Table 12: Pavement Sections

MATERIAL DESCRIPTION	ASPHALTIC CONCRETE PAVEMENT		PORTLAND CEMENT CONCRETE (PCC) PAVEMENT		
	AUTOMOBILE LIGHT-DUTY	FIRE LANE MEDIUM-DUTY	AUTOMOBILE LIGHT-DUTY	FIRE LANE MEDIUM-DUTY	DUMPSTER AREA
Asphalt Surface Course	2 inches	2 inches	-	-	-
Asphalt Binder Course[1]	3 inches	4 inches	-	-	-
Portland Cement Concrete	-	-	5 inches	6 inches	7 inches
Lime-Treated Subgrade[2]	-	6 inches	-	6 inches	6 inches
Reworked Subgrade	6 inches	-	6 inches	-	-

[1] Flexible base material may be substituted for the asphalt binder using a substitute ratio of three inches of flexible base for each inch of asphalt binder.

[2] In lieu of lime-treated subgrade, the PCC pavement thickness may be increased by 1 inch.

An important consideration with the design and construction of pavements is surface and subsurface drainage. Where standing water develops, either on the pavement surface or within the base course layer, softening of the subgrade and other problems related to the deterioration of the pavement can be expected. Furthermore, good drainage should reduce the possibility of the subgrade materials becoming saturated during the normal service period of the pavement.

The recommended pavement sections provided above are considered the minimum necessary based on the traffic loading presented above. In some cases, jurisdictional minimum standards for pavement section construction may exceed those provided above. The Civil Engineer of Record and/or the Contractor should check with the local jurisdiction and therefore design and construct per the requirements.

Pavement should be specified, constructed, and tested to meet the following requirements:

1. Reinforcing Steel: Reinforcing steel may consist of #3 reinforcing steel bars placed at 18 inches on-center, each way. Reinforcing steel for trash pickup and dumpster areas may consist of #4 reinforcing steel bars placed at 18 inches on-center, each way. Saw cuts contraction joints should be spaced 15 feet on-center, each way. Expansion joints should be maintained 60 feet apart through the entire depth of pavement. Appropriate jointing should be incorporated into the design of the PCC pavement.

2. Hot Mix Asphaltic Concrete: Item 340 of the TxDOT Standard Specifications, Type A or B Base Course (binder), Type C or D Surface Course. The coarse aggregate in the surface course should be crushed limestone rather than gravel.

3. Portland Cement Concrete: Minimum compressive strength of 3,500 lbs per sq inch at 28 days. Concrete should be designed with 3 to 6 percent entrained air.

4. Flexible Base Material: Item 247 of the TxDOT Standard Specifications, Type A or B, Grade 1-2. The material should be compacted to a minimum 95 percent of standard Proctor maximum dry density (ASTM D698) and within three percentage points of the material's optimum moisture content.

Proper joint placement and design is critical to Portland cement pavement performance. Load transfer at joints and maintenance of watertight joints should be accomplished by use of proper joint seals and dowels. Control joints in new pavement should be sawed as soon as practical and preferably within 5 to 12 hours after placing concrete to control the location of cracks which form as the concrete cures. Longitudinal and transverse control joints should be sawed at spacings not exceeding 15 feet. The depth of the joint should extend at least ¼ of the slab thickness. Joints should be properly cleaned and sealed as soon as possible to avoid infiltration of water, small gravel, etc.

5.0 SITE CONSTRUCTION RECOMMENDATIONS

5.1 SUBGRADE PREPARATION

Good site drainage should be maintained during earthwork operations which will help maintain the integrity of the soil. The surface of the site should be kept properly graded to enhance drainage of the surface water away from the proposed building areas during the construction phase. We recommend that an attempt be made to enhance the natural drainage without interrupting its pattern.

The soils at the site are moisture and disturbance sensitive and contain fines which are considered moderately erodible. Therefore, the contractor should carefully plan his operation to prevent exposure of the subgrade to weather and construction equipment traffic and provide and maintain good site drainage during earthwork operations to help maintain the integrity of the surficial soils. Erosion and sedimentation should be controlled in accordance with sound engineering practice and current jurisdictional requirements.

We recommend that the upper six inches of subgrade soils beneath buildings, pavements, and concrete flatwork be compacted to at least 95% of standard density (ASTM D698) at a moisture content within 0 to +3% of optimum value. Positive drainage should always be maintained to drain surface water away from the structure.

5.1.1 Stripping and Grubbing

In preparing the site for construction, loose, existing pavement, poorly compacted existing soils, vegetation, organic soil, foundations or utilities (if encountered), poorly compacted soil or other yielding materials should be removed from proposed building and paving areas and areas receiving new fill. Tree trunks, tree roots, root balls/root mats should be removed during the clearing and grubbing. These areas should be backfilled with select fill soils. We recommend that the stripping depth be evaluated at the time of construction by a geotechnical professional.

5.1.2 Proofrolling

After stripping and removing inadequate surface materials, cutting to the proposed grade, and prior to the placement of fill or placing other construction materials, the exposed subgrade in building and pavement areas should be observed by ECS. The exposed subgrade should be proofrolled in accordance with TxDOT Standard Specification Item 216 with construction equipment having a minimum axle load of 25 tons (e.g., fully loaded tandem-axle dump truck). Proofrolling should traverse the areas by the equipment in two perpendicular (orthogonal) directions with overlapping passes of the vehicle under the observation of ECS. This procedure is intended to assist in identifying localized yielding materials. The proofrolling operations should be observed by the representative of Geotechnical Engineer of Record. If yielding or “pumping” subgrade is identified by the proofrolling, those areas should be marked for repair prior to the placement of subsequent fill or other construction materials. Subgrade repair methods, such as undercutting or moisture conditioning or chemical treatment, should be discussed with ECS to determine appropriate procedures to mitigate the conditions causing the yielding.

5.2 EARTHWORK OPERATIONS

If the onsite clays become wet, it may be difficult to access and perform earthwork and other construction activities. Should this condition develop, drying of the soils for support of pavement and floor slabs may be improved by the addition of 4% lime by dry weight, as a minimum. The application rate corresponding to this additive amount would be approximately 18 pounds per square yard for each six-inch lift of compacted thickness. Texas Department of Transportation (TxDOT) Specifications, Items 260, should be used as procedural guides for placing, mixing, and compacting lime and the soils.

Prior to placement of new fill, subgrades should be scarified to a minimum depth of 6 inches, moisture conditioned and compacted to at least 95% of maximum dry density as obtained by the standard Proctor method (ASTM D698) moisture conditioned within optimum and +3% above optimum value.

Soil moisture levels should be preserved (by various methods that can include covering with plastic, watering, etc.) until new fill, pavements or slabs are placed. Fill soils should be placed in maximum 8-inch loose lifts for mass grading operations and 4 inches for trench excavations where walk behind or “jumping jack” compaction equipment is used.

Upon completion of the filling operations, care should be taken to maintain the soil moisture content prior to construction of floor slabs and pavements. If the soil becomes desiccated, the affected material should be removed and replaced, or these materials should be scarified, moisture conditioned and recompacted.

Utility cuts should not be left open for extended periods of time and should be properly backfilled. Backfilling should be accomplished with properly compacted on-site soils, rather than granular materials. If granular materials are used, a utility trench cut-off at the building line is recommended to help prevent water from migrating through the utility trench backfill to beneath the proposed structure.

Field density and moisture tests should be performed on each lift as necessary to verify that adequate compaction is achieved. As a guide, one test per 2,500 square feet per lift is recommended in the foundation and slab area and one test per 5,000 square feet per lift in the paving areas (two tests minimum per lift). Utility trench backfill should be tested at a rate of one test per lift every 150 linear feet of trench (two tests minimum per lift). Certain jurisdictional requirements may require testing in addition to that noted previously. Therefore, these specifications should be reviewed, and the more stringent specifications should be followed.

5.3 MATERIAL SPECIFICATIONS

5.3.1 General Fill

General fill should consist of on-site or imported soils, provided they meet the requirements described below. General fill materials should be free of organics, construction debris, deleterious materials, and should be free of rocks larger than 4 inches in greatest dimension. Existing soils encountered in our soil borings can be used as general fill provided oversize materials, organics, debris, and deleterious materials are cleaned out. ECS should observe the cleaning of the existing soils on-site on a full-time basis prior to re-use. Proposed general fill should be evaluated and tested by ECS prior to placement in the field.

ECS recommends that general fill be placed in horizontal loose lifts of not more than 8 inches in thickness. Lift thickness should be decreased when using light compaction equipment. General fill should be compacted to at least 95% of the maximum dry density at moisture contents within the range of optimum to +4 percentage points of the optimum moisture content (ASTM D698).

5.3.2 Select Fill

For the purposes of this report, select fill soil may consist of imported material that is free of debris and organic matter and have a Plasticity Index (PI) of ranging 10 to 20 and liquid limit of less than 40. Based on the limited laboratory test results, the on-site soils should not meet the requirement to be used as select fill.

This material should be placed and compacted at workable moisture contents within optimum and +3% above optimum value and compacted to at least 95% of the maximum dry density as obtained using the standard Proctor method (ASTM D698).

5.3.3 Lime-Treated On-site Clay

In lieu of importing select fill, as defined above, the on-site clay soils may be lime treated. The advantage to lime treatment over untreated select fill is the nearly “weatherproof” nature of the soil and once placed and compacted the material essentially retains the virtually impermeable nature of the parent clay, minimizing water infiltration beneath the building.

A preliminary lime application rate of between 6% hydrated lime by dry weight of clay should be used for budgeting purposes. The application rate corresponding to this additive amount would be between approximately 27 pounds per square yard for each six inches of compacted thickness. The actual amount of lime required should be confirmed by additional laboratory tests (lime series) during the construction phase by the authorized representative of the Geotechnical Engineer of Record (GER).

The lime-treated clay should be mixed and appropriately mellowed for at least 48 hours and tested for gradation and lime solubility (pH) prior to final placement and compaction. Once appropriately mixed and mellowed, this material may then be placed and compacted at workable moisture contents above the optimum moisture content and compacted to at least 95% of the maximum dry density as obtained using the standard Proctor method (ASTM D698).

5.3.4 Moisture-Conditioned On-Site Clay Fill

Within the planned building pad, and flatwork sensitive to movements, moisture conditioning should be performed as outlined in this report. Reworking of the existing clays, clay soils from the excavation areas, and new clayey fill, is performed to increase the moisture of the clays to a level that reduces their ability to absorb additional water that could result in post-construction heave in these soils.

The moisture conditioning should consist of undercutting, scarifying and/or reworking, as required to achieve the required subgrade improvement. During this process, the clay should receive adequate amounts of water to ensure a uniform moisture content of at least 4% or higher above the optimum moisture content. During the addition of water, the soils should be adequately mixed, and re-mixed, to ensure a uniform distribution of the moisture throughout the soil mass. Once appropriately mixed, the material should be compacted to 92% to 96% of the maximum dry density as obtained using the standard Proctor method (ASTM D698).

Outside of the moisture-conditioned zone and where clay is used to establish site grades, we recommend that this material may be placed and compacted to at least 95% of the maximum dry density as obtained using the standard Proctor method (ASTM D698). These soils should be free of deleterious materials and be reworked to ensure a consistent distribution of water to achieve a consistent moisture content distribution above the optimum value.

Care should be taken to verify and preserve the specified moisture levels in the reworked clays prior to placement of low-expansive fill.

5.4 CONSTRUCTION GROUNDWATER CONTROL

Groundwater was not observed during the field exploration. However, these conditions should be anticipated and can be handled through the use of trenching and pumping. One of the more cost-effective techniques is the prudent utilization of spot drains, and in planning utility installations. For example, utility installation that requires a gravity feed can be effectively converted into a drainage line to help assist in groundwater control during construction.

If groundwater is observed during construction of footings or buried utilities, an ECS geotechnical engineer should be consulted to determine if additional permanent drainage provisions are necessary in the design and construction. Groundwater levels should be maintained no higher than 3 feet below subgrade levels to provide relatively dry working conditions and firm bedding. Sump pumping and surface runoff ditches may be adequate for temporary control of surface runoff and groundwater during construction.

The surface of the site should be kept property graded to enhance drainage of surface water away from the proposed construction area during construction. We recommend that an attempt be made to enhance the natural drainage without interrupting its pattern.

5.5 EXCAVATIONS

Based on soils strength data, temporary (less than 24 hours), open trenched, non-surcharged and unsupported excavations should be built on a slope flatter than 1.5(h):1(v) provided this will not impact the stability of the existing/nearby structures. Flatter slopes may be required in the areas where soft soils or large amounts of sands are encountered. Vertical cuts can be used, provided shoring and bracing is used for excavation wall stability. Benched excavation can also be used with average slopes of about 1(h):1(v) and steps should not be higher than four feet. Excavation construction should conform to OSHA (Occupational Safety and Health Administration) guidelines.

Excavations and slopes should be constructed and maintained in accordance with OSHA excavation safety standards. The contractor is solely responsible for designing, constructing, and maintaining stable temporary excavations and slopes. The contractor’s responsible person, as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor’s safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. ECS is providing this information solely as a service to our client. ECS is not assuming responsibility for construction site safety or the contractor’s activities; such responsibility is not being implied and should not be inferred.

Excavations should be performed with equipment capable of providing a relatively clean bearing area. Excavation equipment should not disturb the soil beneath the design excavation bottom and should not leave large amounts of loose soil in the excavation. Foundation excavations should be protected against significant change in soil moisture content and disturbance by construction activity and require that water not be allowed to pond in excavations.

6.0 CLOSING

ECS has prepared this report to guide the geotechnical-related design and construction aspects of the project. We performed these services in accordance with the standard of care expected of professionals in the industry performing similar services on projects of like size and complexity at this time in the region. No other representation expressed or implied, and no warranty or guarantee is included or intended in this report.

The description of the proposed project is based on information provided to ECS by Carlson Consulting Engineers, Inc. If any of this information is inaccurate or changes, either because of our interpretation of the documents provided or site or design changes that may occur later, ECS should be contacted so we can review our recommendations and provide additional or alternate recommendations that reflect the proposed construction.

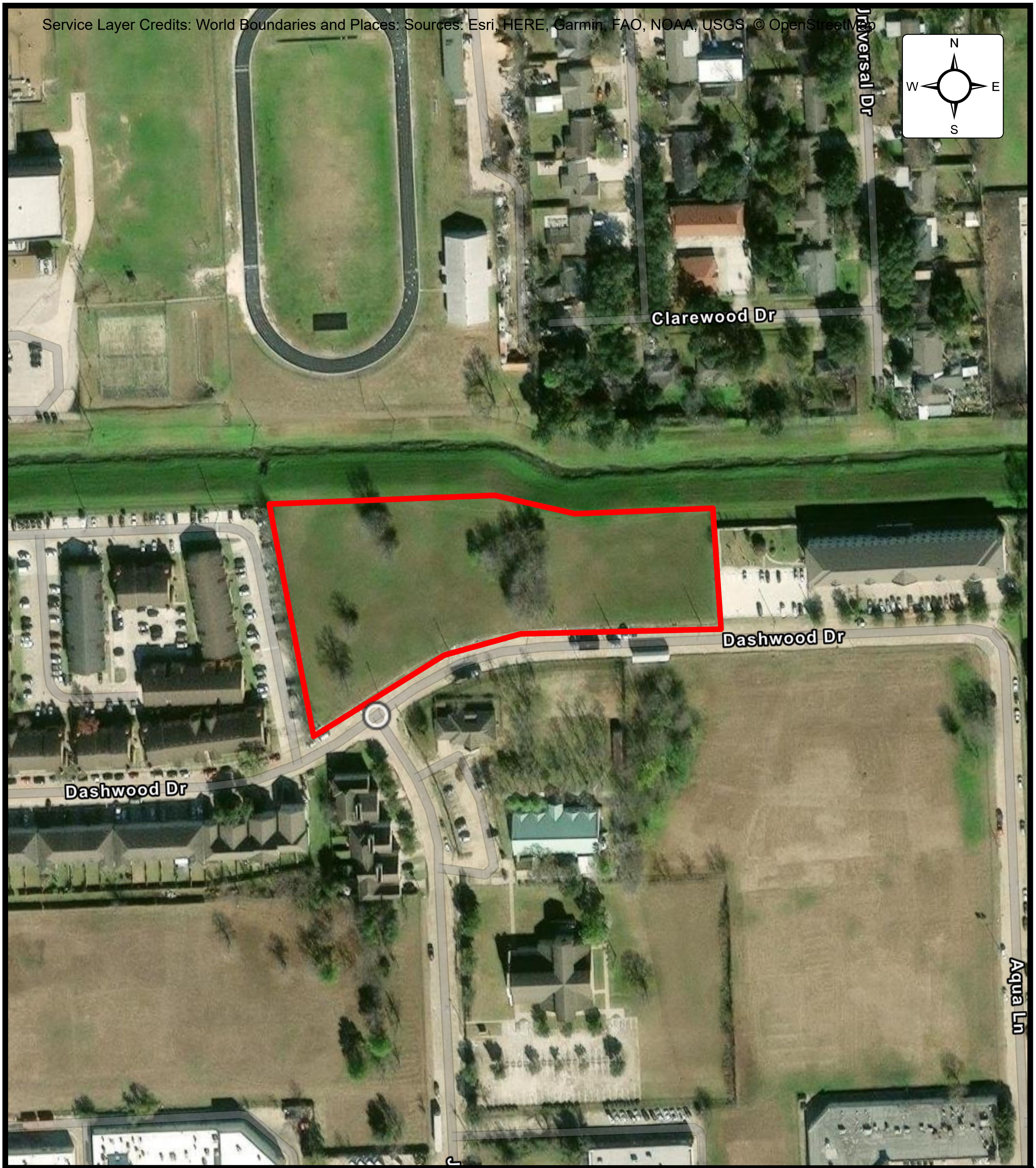
We recommend that ECS be retained to review the project plans and specifications so we can confirm that those plans/specifications are in accordance with the recommendations of this geotechnical report.

Field observations, and quality assurance testing during earthwork and foundation installation are an extension of, and integral to, the geotechnical design. We recommend that ECS be retained to apply our expertise throughout the geotechnical phases of construction, and to provide consultation recommendations should issues arise.

ECS is not responsible for the conclusions, opinions, or recommendations of others based on the data in this report.

APPENDIX A – Drawings and Reports

Site Location Diagram
Boring Location Diagram
Subsurface Cross-Section
Historic Aerials
Geological Survey Map
Topographic Map



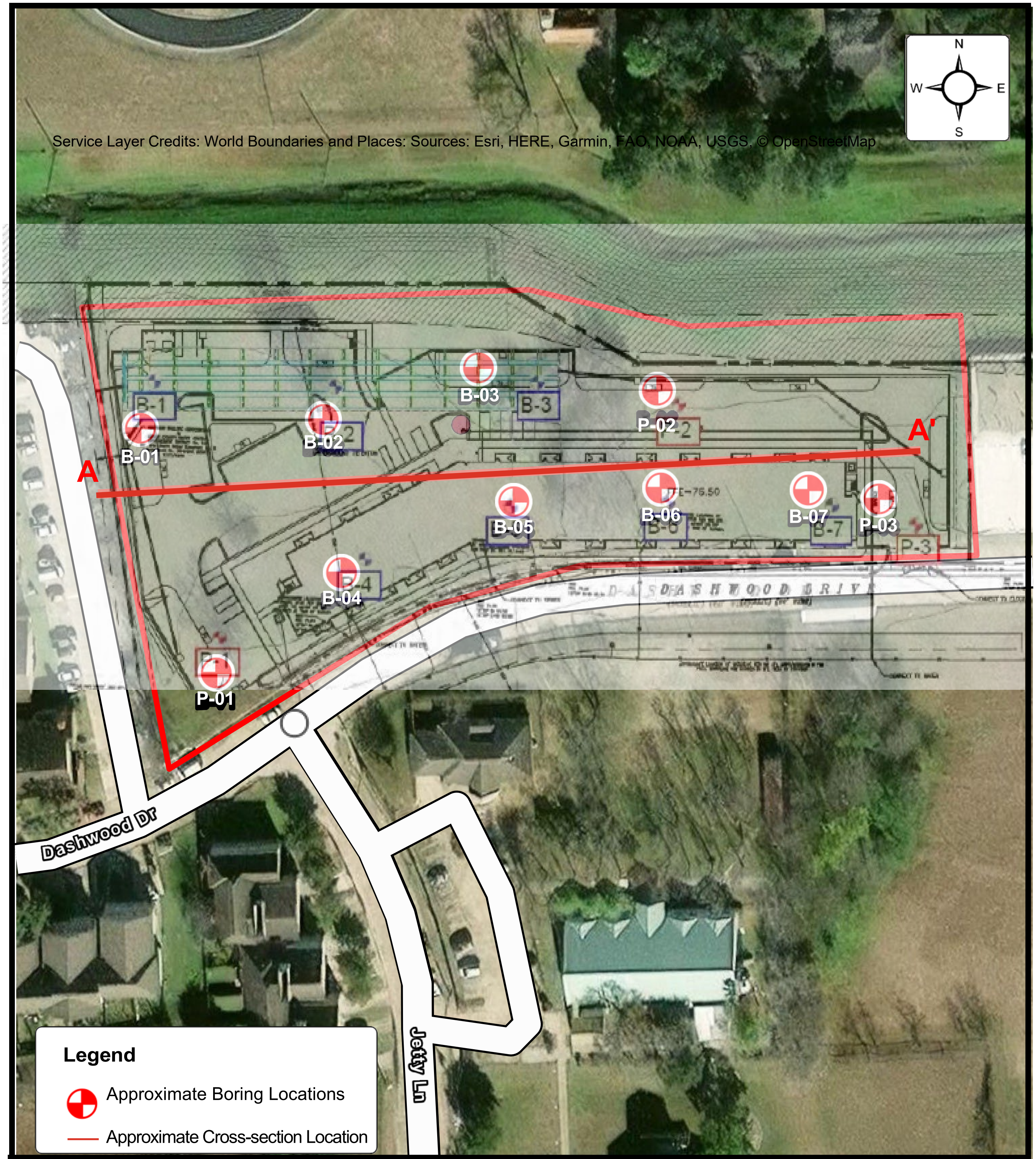
SITE LOCATION DIAGRAM

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER	VY
SCALE	1" = 200'
PROJECT NO.	43:3223
SHEET	
DATE	10/17/2024



Service Layer Credits: World Boundaries and Places: Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap

BORING LOCATION DIAGRAM

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

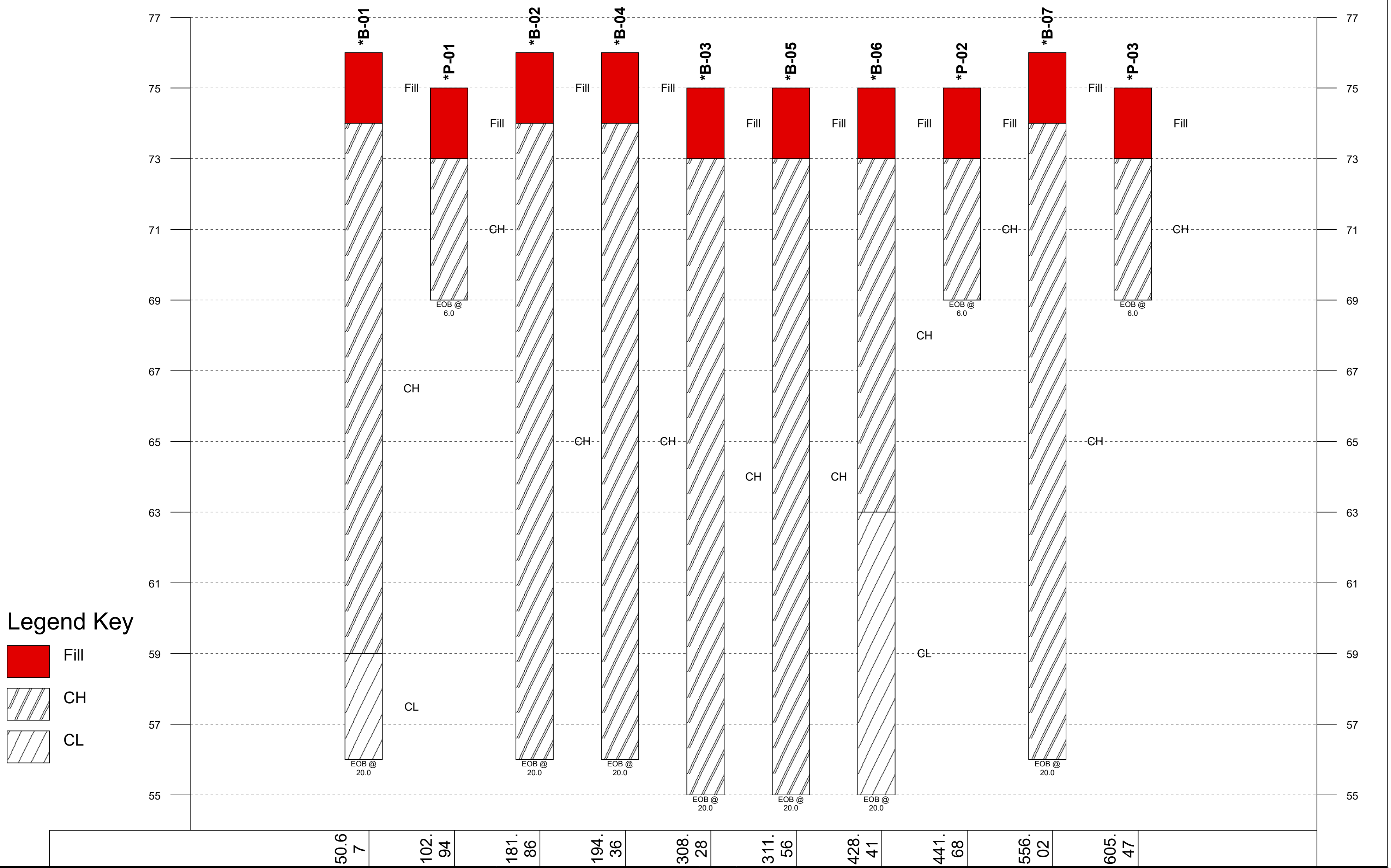
ENGINEER
VY

SCALE
1" = 100'

PROJECT NO.
43:3223

SHEET

DATE
10/17/2024



Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit X——●——△	▽	WL (First Encountered)	🟥	Fill
[Fines Content %]	▼	WL (Completion)	🟪	Possible Fill
Bottom of Casing	▽	WL (Estimated Seasonal High Water)	🟥	Probable Fill
Loss of Circulation	▽	WL (Stabilized)	🟩	Rock
○ Calibrated Penetrometer				

ECS

GENERALIZED SUBSURFACE SOIL PROFILE Section Line AA'

Dashwood Trails Apartments

Carlson Consulting Engineers, Inc.

Dashwood Drive and Jetty Lane, Houston, Harris County, Texas 77027

Project No: 43:3223 Date: 10/17/2024

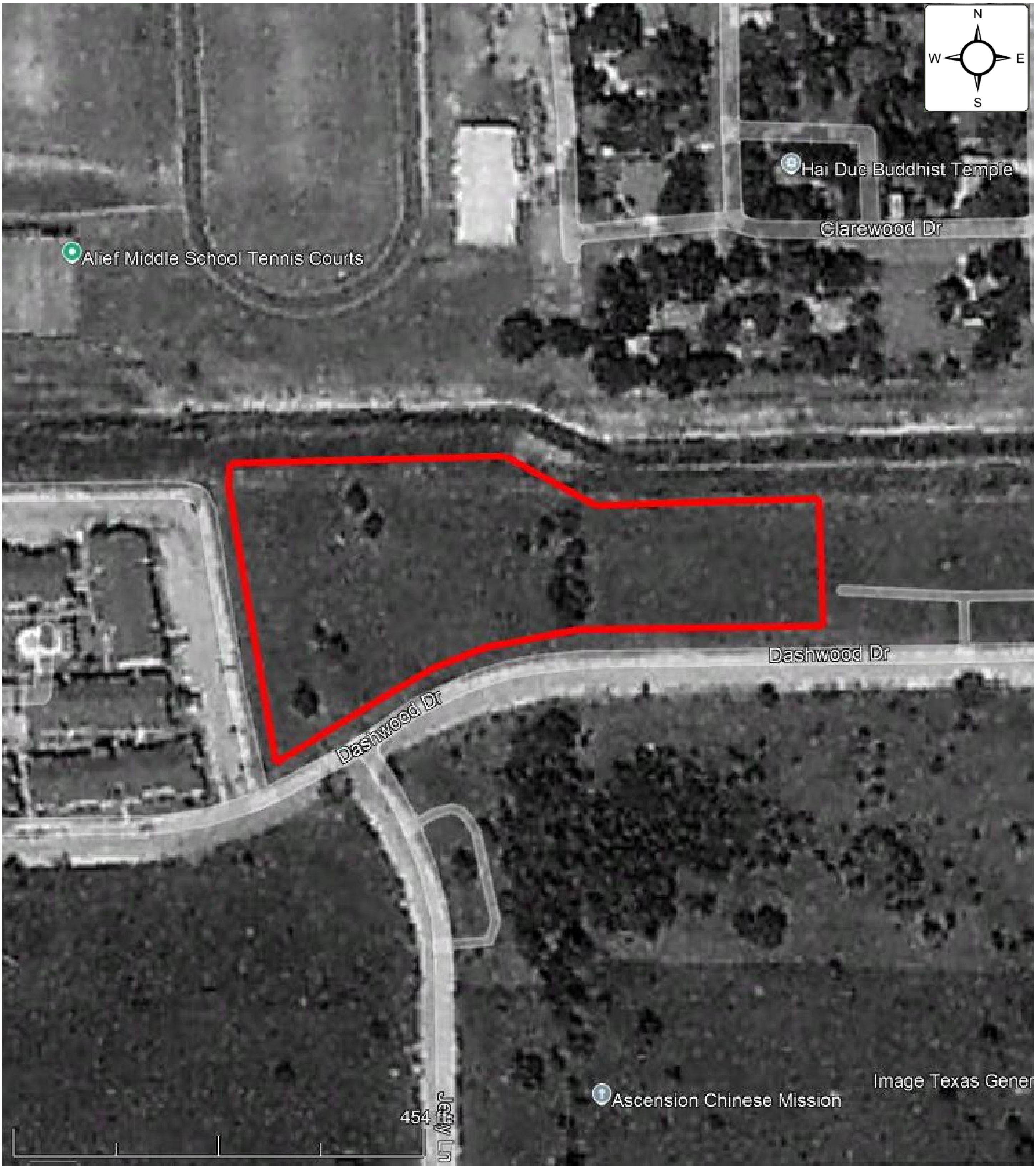
AERIAL PHOTOGRAPH - 1978

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER	VY
SCALE	AS NOTED
PROJECT NO.	43:3223
DATE	10/17/2024



AERIAL PHOTOGRAPH - 1989

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER
VY

SCALE
AS NOTED

PROJECT NO.
43:3223

DATE
10/17/2024

AERIAL PHOTOGRAPH - 2005

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER
VY

SCALE
AS NOTED

PROJECT NO.
43:3223

DATE
10/17/2024

AERIAL PHOTOGRAPH - 2009

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER	VY
SCALE	AS NOTED
PROJECT NO.	43:3223
DATE	10/17/2024

AERIAL PHOTOGRAPH - 2024

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER
VY

SCALE
AS NOTED

PROJECT NO.
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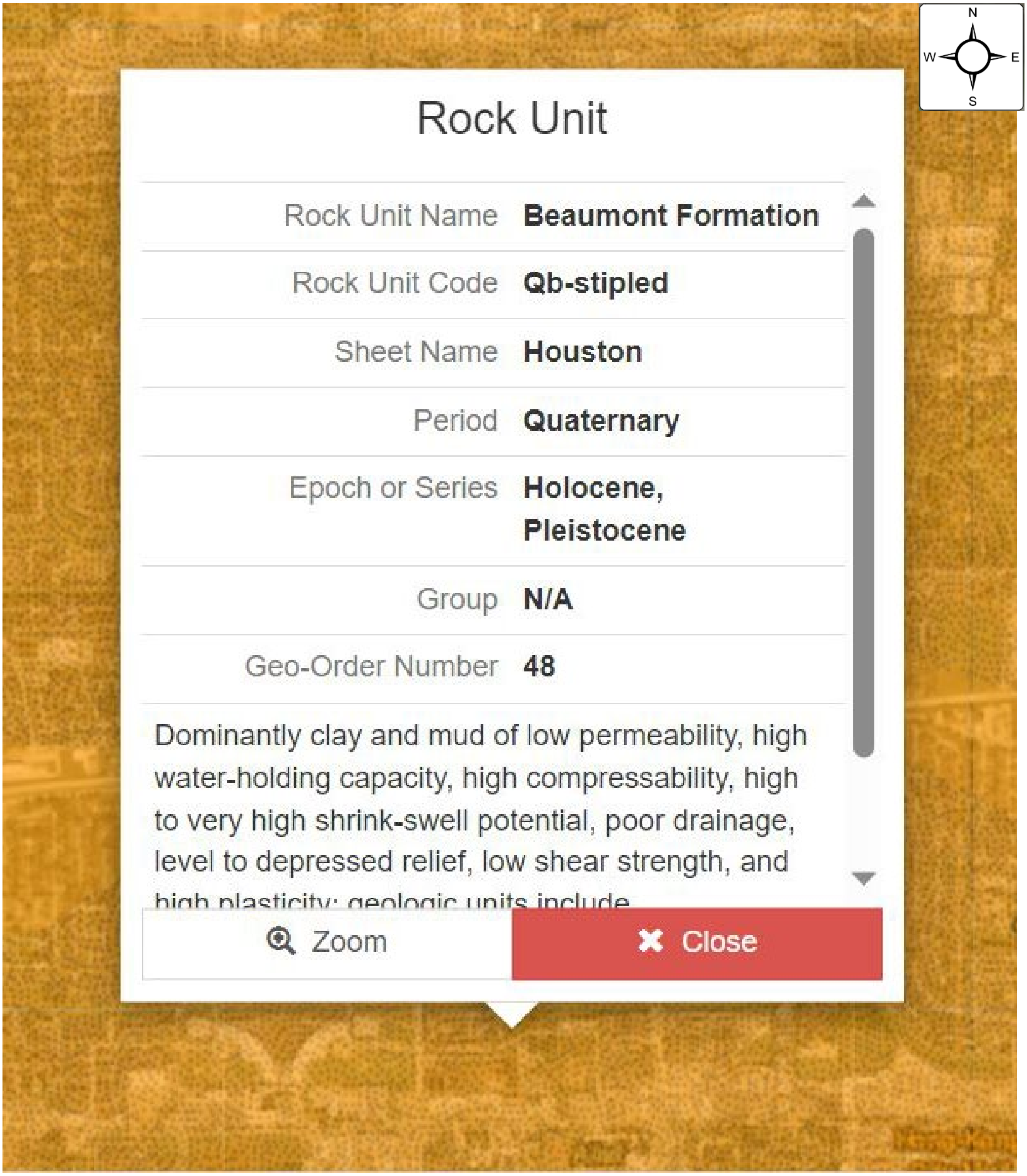
10/17/2024



Rock Unit

Rock Unit Name	**Beaumont Formation**
Rock Unit Code	**Qb-stipled**
Sheet Name	**Houston**
Period	**Quaternary**
Epoch or Series	**Holocene, Pleistocene**
Group	**N/A**
Geo-Order Number	**48**

Dominantly clay and mud of low permeability, high water-holding capacity, high compressability, high to very high shrink-swell potential, poor drainage, level to depressed relief, low shear strength, and high plasticity; geologic units include

REGIONAL GEOLOGY MAP

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

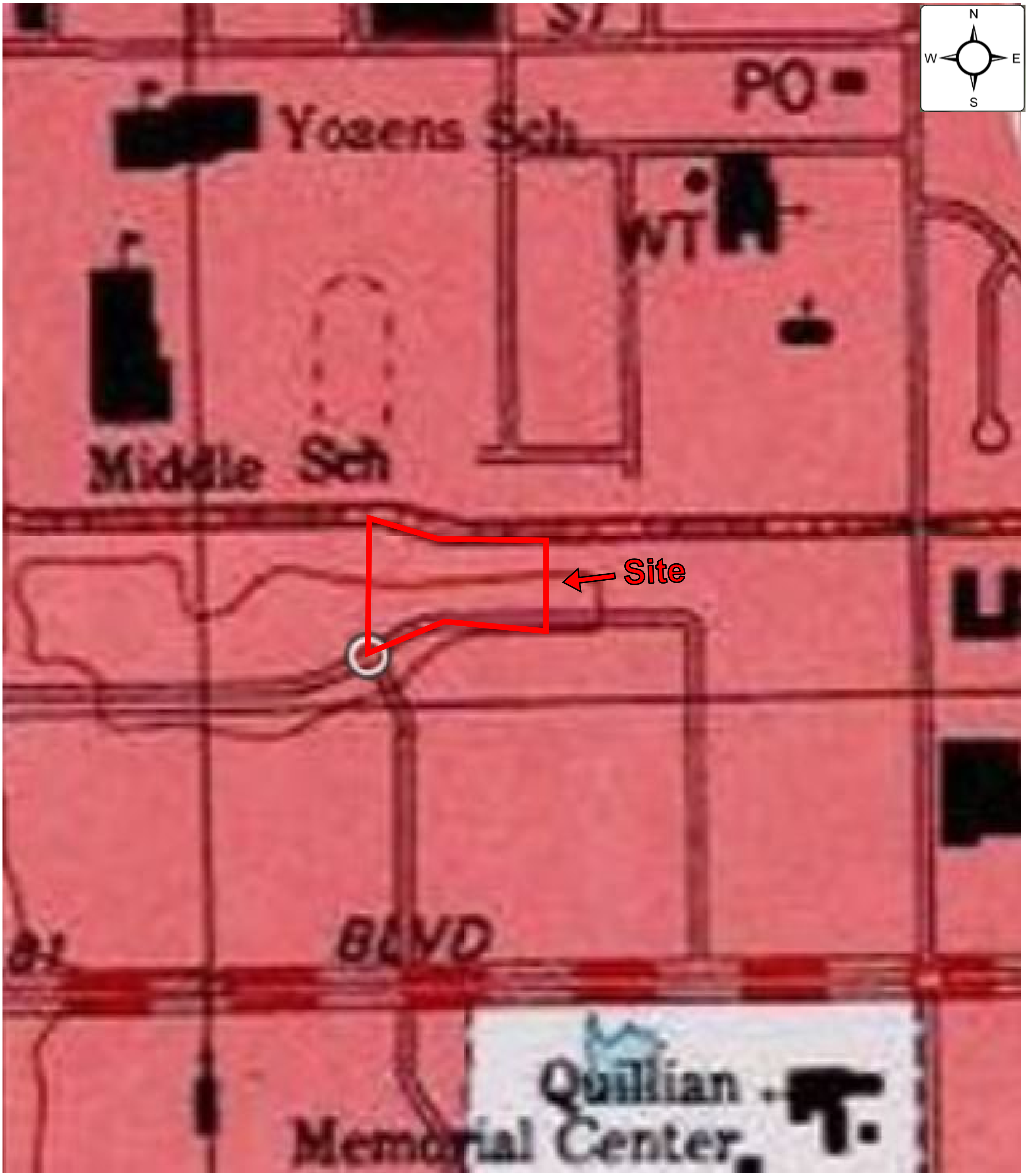
CARLSON CONSULTING ENGINEERS, INC.

ENGINEER
VY

SCALE
NTS

PROJECT NO.
43:3223

DATE
10/17/2024



TOPOGRAPHIC MAP

DASHWOOD TRAILS APARTMENTS

DASHWOOD DRIVE AND JETTY LANE
HOUSTON, HARRIS COUNTY, TEXAS

CARLSON CONSULTING ENGINEERS, INC.

ENGINEER	VY
SCALE	NTS
PROJECT NO.	43:3223
DATE	10/17/2024

APPENDIX B – Field Operations

Reference Notes for Boring Logs
Subsurface Exploration Procedure
Boring Logs

REFERENCE NOTES FOR BORING LOGS

MATERIAL[1,2]

■		**ASPHALT**
▨		**CONCRETE**
▨		**GRAVEL**
▨		**TOPSOIL**
□		**VOID**
▨		**BRICK**
▨		**AGGREGATE BASE COURSE**
▨	**GW**	**WELL-GRADED GRAVEL** **gravel-sand mixtures, little or no fines**
▨	**GP**	**POORLY-GRADED GRAVEL** **gravel-sand mixtures, little or no fines**
▨	**GM**	**SILTY GRAVEL** **gravel-sand-silt mixtures**
▨	**GC**	**CLAYEY GRAVEL** **gravel-sand-clay mixtures**
▨	**SW**	**WELL-GRADED SAND** **gravelly sand, little or no fines**
▨	**SP**	**POORLY-GRADED SAND** **gravelly sand, little or no fines**
▨	**SM**	**SILTY SAND** **sand-silt mixtures**
▨	**SC**	**CLAYEY SAND** **sand-clay mixtures**
▨	**ML**	**SILT** **non-plastic to medium plasticity**
▨	**MH**	**ELASTIC SILT** **high plasticity**
▨	**CL**	**LEAN CLAY** **low to medium plasticity**
▨	**CH**	**FAT CLAY** **high plasticity**
▨	**OL**	**ORGANIC SILT or CLAY** **non-plastic to low plasticity**
▨	**OH**	**ORGANIC SILT or CLAY** **high plasticity**
▨	**PT**	**PEAT** **highly organic soils**

DRILLING SAMPLING SYMBOLS & ABBREVIATIONS

SS	Split Spoon Sampler	PM	Pressuremeter Test
ST	Shelby Tube Sampler	RD	Rock Bit Drilling
WS	Wash Sample	RC	Rock Core, NX, BX, AX
BS	Bulk Sample of Cuttings	REC	Rock Sample Recovery %
PA	Power Auger (no sample)	RQD	Rock Quality Designation %
HSA	Hollow Stem Auger		

PARTICLE SIZE IDENTIFICATION

DESIGNATION		PARTICLE SIZES
Boulders		12 inches (300 mm) or larger
Cobbles		3 inches to 12 inches (75 mm to 300 mm)
Gravel:	Coarse	¾ inch to 3 inches (19 mm to 75 mm)
	Fine	4.75 mm to 19 mm (No. 4 sieve to ¾ inch)
Sand:	Coarse	2.00 mm to 4.75 mm (No. 10 to No. 4 sieve)
	Medium	0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)
	Fine	0.074 mm to 0.425 mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")		<0.074 mm (smaller than a No. 200 sieve)

COHESIVE SILTS & CLAYS

UNCONFINED COMPRESSIVE STRENGTH, QP[4]	SPT[5] (BPF)	CONSISTENCY[7] (COHESIVE)
<0.25	<2	Very Soft
0.25 - <0.50	2 - 4	Soft
0.50 - <1.00	5 - 8	Firm
1.00 - <2.00	9 - 15	Stiff
2.00 - <4.00	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

RELATIVE AMOUNT[7]	COARSE GRAINED (%)[8]	FINE GRAINED (%)[8]
Trace	≤5	≤5
With	10 - 20	10 - 25
Adjective *(ex: "Silty")*	25 - 45	30 - 45

GRAVELS, SANDS & NON-COHESIVE SILTS

SPT[5]	DENSITY
<5	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
>50	Very Dense

WATER LEVELS[6]

▽	WL (First Encountered)
▼	WL (Completion)
▽	WL (Seasonal High Water)
▽	WL (Stabilized)

FILL AND ROCK

🟥	🟪	⬜	🟩
FILL	**POSSIBLE FILL**	**PROBABLE FILL**	**ROCK**

[1] Classifications and symbols per ASTM D 2488-17 (Visual-Manual Procedure) unless noted otherwise.

[2] To be consistent with general practice, "POORLY GRADED" has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.

[3] Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-FILL)].

[4] Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).

[5] Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf). SPT correlations per 7.4.2 Method B and need to be corrected if using an auto hammer.

[6] The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.

[7] Minor deviation from ASTM D 2488-17 Note 14.

[8] Percentages are estimated to the nearest 5% per ASTM D 2488-17.

SUBSURFACE EXPLORATION PROCEDURE

The field exploration was planned with the objective of characterizing the project site in general geotechnical and geological terms and to evaluate subsequent field and laboratory data to assist in the determination of geotechnical recommendations.

The subsurface conditions were explored by ten borings drilled to completion depths between 6 feet to 20 feet below the existing site grade. A truck-mounted drill rig with solid-stem, continuous-flight augers was utilized to drill the borings.

The approximate as-drilled boring locations are shown on the Boring Location Diagram in Appendix A. The ground surface elevations noted in this report were obtained from the available public data sources and may not be accurate enough for engineering purposes.

Representative soil samples were obtained by means of the Shelby tube sampling procedures in general accordance with ASTM D1587. In the Shelby tube sampling procedure, a thin walled, steel, seamless tube with sharp cutting edges is pushed hydraulically into the soil, and a relatively undisturbed sample is obtained.

Field logs of the soils encountered in the borings were maintained by the drill crew. After recovery, each geotechnical soil sample was removed from the sampler and visually classified. Representative portion of the soil samples were then wrapped in plastic and transported to our laboratory for further visual examination and laboratory testing. After completion of the drilling operations, the boreholes were backfilled with auger cuttings to the existing ground surface.

CLIENT: **Carlson Consulting Engineers, Inc.**

PROJECT NO.: **43:3223**

BORING NO.: **B-01**

SHEET: **1 of 1**

PROJECT NAME: **Dashwood Trails Apartments**

DRILLER/CONTRACTOR: **Herman Drilling Corporation**

SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**

LOSS OF CIRCULATION: 100%

BOTTOM OF CASING

LATITUDE: **29.706871**

LONGITUDE: **-95.593212**

STATION:

SURFACE ELEVATION: **76.0' MSL**

⊕ STANDARD PENETRATION BLOWS/FT: 10 20 30 40 50

ROCK QUALITY DESIGNATION & RECOVERY: 20 40 60 80 100

🟥 RQD

— REC

☒ MC SAMPLER BLOWS/FT: 10 20 30 40 50

▼ TEXAS CONE PENETRATION BLOWS/FT

△ LIQUID LIMIT

✕ PLASTIC LIMIT

○ CALIBRATED PENETROMETER TSF: 1 2 3 4 5

● WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*	CALIBRATED PENETROMETER TSF	PLASTIC LIMIT	WATER CONTENT %	LIQUID LIMIT	[FINES CONTENT] %
	S-1	ST	24		(CH FILL) FAT CLAY FILL, Dark Gray and Dark Brown, Hard, Trace Root Fibers and Gravel				4.50				
	S-2	ST	24		(CH) FAT CLAY WITH SAND, Dark Gray, Dark Brown and Reddish Brown, Hard, with Ferrous and Calcareous Nodules				4.50				
5	S-3	ST	24				71		4.50				
	S-4	ST	24						4.50	20	24.9	60	[95.6%]
	S-5	ST	24						4.00				
10							66						
	S-6	ST	24						4.50				
15							61						
					(CL) LEAN CLAY WITH SAND, Dark Gray and Reddish Brown, Hard, with Ferrous Nodules and Sand Seams								
	S-7	ST	24						4.00	16	15.3	35	[79.0%]
20					**END OF BORING AT 20.0 FT**		56						

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**Dry**
▼ WL (Completion)	**Dry**
WL (Seasonal High Water)	
WL (Stabilized)	

BORING STARTED: **Sep 05 2024**

CAVE IN DEPTH: **N/A**

BORING COMPLETED: **Sep 05 2024**

HAMMER TYPE: **Auto**

EQUIPMENT: **Truck**

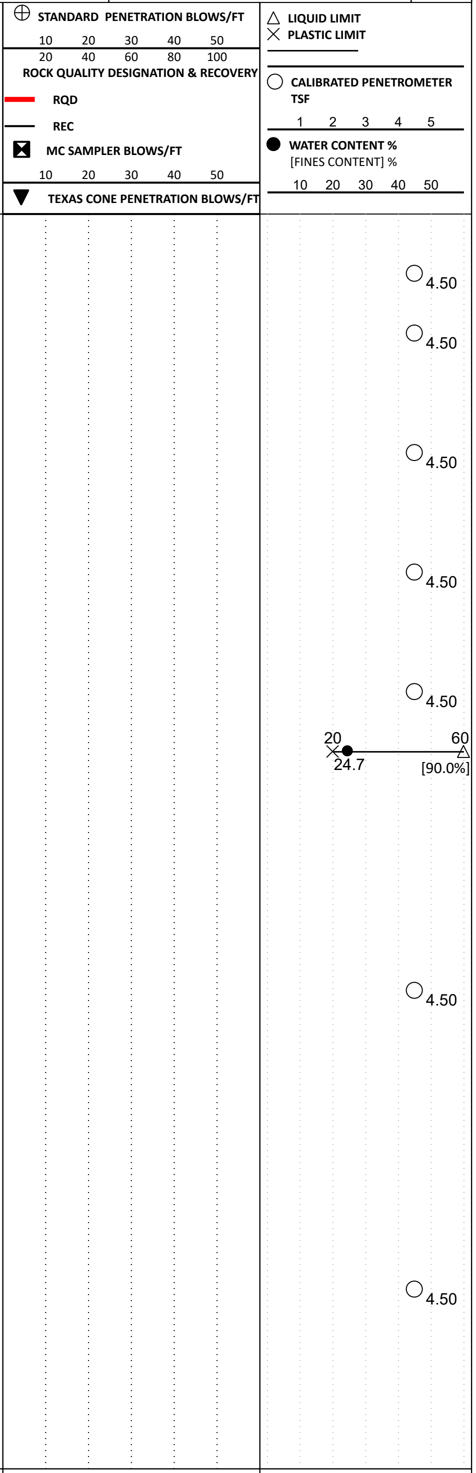
LOGGED BY: **HDC**

DRILLING METHOD: **ASTM D1587**

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**
PROJECT NO.: **43:3223**
BORING NO.: **B-02**
SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**
DRILLER/CONTRACTOR: **Herman Drilling Corporation**
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**
LOSS OF CIRCULATION
BOTTOM OF CASING
LATITUDE: **29.706847**
LONGITUDE: **-95.592797**
STATION:
SURFACE ELEVATION: **76.0' MSL**

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	ST	24		(CH FILL) FAT CLAY FILL, Dark Gray and Dark Brown, Hard, Trace Root Fibers and Gravel			
	S-2	ST	24		(CH) FAT CLAY WITH SAND, Dark Gray, Dark Brown and Reddish Brown, Hard, with Ferrous and Calcareous Nodules			
5	S-3	ST	24				71	
	S-4	ST	24					
	S-5	ST	24					
10							66	
	S-6	ST	24					
15							61	
	S-7	ST	24					
20					**END OF BORING AT 20.0 FT**		56	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered) **Dry**	BORING STARTED: **Sep 05 2024**	CAVE IN DEPTH: **N/A**
WL (Completion) **Dry**	BORING COMPLETED: **Sep 05 2024**	HAMMER TYPE: **Auto**
WL (Seasonal High Water)	EQUIPMENT: **Truck** LOGGED BY: **HDC**	DRILLING METHOD: **ASTM D1587**
WL (Stabilized)		

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**

PROJECT NO.: **43:3223**

BORING NO.: **B-03**

SHEET: **1 of 1**

PROJECT NAME: **Dashwood Trails Apartments**

DRILLER/CONTRACTOR: **Herman Drilling Corporation**

SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**

LOSS OF CIRCULATION

BOTTOM OF CASING

LATITUDE: **29.706938**

LONGITUDE: **-95.592405**

STATION:

SURFACE ELEVATION: **75.0' MSL**

⊕ STANDARD PENETRATION BLOWS/FT 10 20 30 40 50

ROCK QUALITY DESIGNATION & RECOVERY 20 40 60 80 100

RQD

REC

MC SAMPLER BLOWS/FT 10 20 30 40 50

▼ TEXAS CONE PENETRATION BLOWS/FT

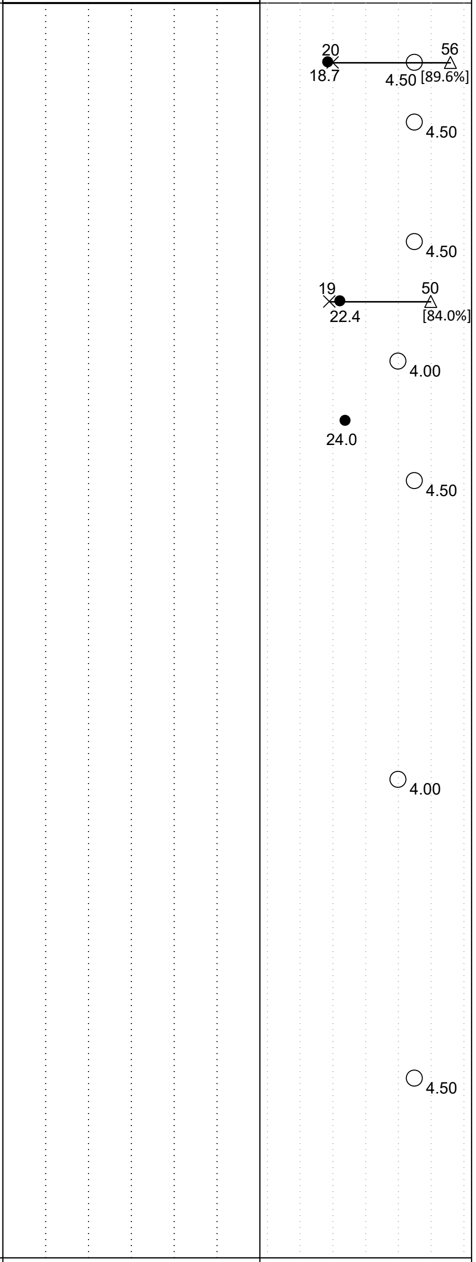
△ LIQUID LIMIT

× PLASTIC LIMIT

○ CALIBRATED PENETROMETER TSF 1 2 3 4 5

● WATER CONTENT % [FINES CONTENT] % 10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	ST	24		(CH FILL) FAT CLAY WITH SAND FILL, Dark Gray and Dark Brown, Hard, Trace Root Fibers and Gravel			
	S-2	ST	24		(CH) FAT CLAY WITH SAND, Dark Gray, Dark Brown and Reddish Brown, Very Stiff to Hard, with Ferrous and Calcareous Nodules			
5	S-3	ST	24				70	
	S-4	ST	24		**- Dry Unit Weight = 100.0 pcf & Su = 1.72 tsf**			
	S-5	ST	24					
10							65	
	S-6	ST	24					
15							60	
	S-7	ST	24					
20					**END OF BORING AT 20.0 FT**		55	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered) **Dry**

▼ WL (Completion) **Dry**

▽ WL (Seasonal High Water)

▽ WL (Stabilized)

BORING STARTED: **Sep 05 2024**

BORING COMPLETED: **Sep 05 2024**

EQUIPMENT: **Truck**

LOGGED BY: **HDC**

CAVE IN DEPTH: **N/A**

HAMMER TYPE: **Auto**

DRILLING METHOD: **ASTM D1587**

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**	PROJECT NO.: **43:3223**	BORING NO.: **B-04**	SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**	DRILLER/CONTRACTOR: **Herman Drilling Corporation**		
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**	LOSS OF CIRCULATION	100%	
LATITUDE: **29.706550**	LONGITUDE: **-95.592737**	STATION:	SURFACE ELEVATION: **76.0' MSL**
BOTTOM OF CASING			

⊕ STANDARD PENETRATION BLOWS/FT: 10 20 30 40 50
ROCK QUALITY DESIGNATION & RECOVERY: 20 40 60 80 100
RQD
REC
☒ MC SAMPLER BLOWS/FT: 10 20 30 40 50
▼ TEXAS CONE PENETRATION BLOWS/FT

△ LIQUID LIMIT
× PLASTIC LIMIT
○ CALIBRATED PENETROMETER TSF: 1 2 3 4 5
● WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*	LIQUID LIMIT / PLASTIC LIMIT / CALIBRATED PENETROMETER TSF / WATER CONTENT % [FINES CONTENT] %
	S-1	ST	24		(CH FILL) FAT CLAY WITH SAND FILL, Dark Gray and Dark Brown, Hard, Trace Root Fibers and Gravel				19 17.9 4.50 52 [89.2%]
	S-2	ST	24		(CH) FAT CLAY, Dark Gray, Dark Brown and Reddish Brown, Hard, with Ferrous and Calcareous Nodules				4.50
5	S-3	ST	24				71		4.50
	S-4	ST	24						4.00
	S-5	ST	24						4.00
10							66		
	S-6	ST	24						4.50
15							61		
	S-7	ST	24						4.50
20					**END OF BORING AT 20.0 FT**		56		

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered) **Dry**	BORING STARTED: **Sep 05 2024**		CAVE IN DEPTH: **N/A**
▼ WL (Completion) **Dry**	BORING COMPLETED: **Sep 05 2024**		HAMMER TYPE: **Auto**
▽ WL (Seasonal High Water)	EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD: **ASTM D1587**
▽ WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**	PROJECT NO.: **43:3223**	BORING NO.: **B-05**	SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**	DRILLER/CONTRACTOR: **Herman Drilling Corporation**		
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**		LOSS OF CIRCULATION	100%
LATITUDE: **29.706669**	LONGITUDE: **-95.592376**	STATION:	SURFACE ELEVATION: **75.0' MSL**
		BOTTOM OF CASING	

⊕ STANDARD PENETRATION BLOWS/FT 10 20 30 40 50
20 40 60 80 100 ROCK QUALITY DESIGNATION & RECOVERY
RQD
REC
☒ MC SAMPLER BLOWS/FT 10 20 30 40 50
▼ TEXAS CONE PENETRATION BLOWS/FT

△ LIQUID LIMIT
✕ PLASTIC LIMIT
○ CALIBRATED PENETROMETER TSF 1 2 3 4 5
● WATER CONTENT % [FINES CONTENT] % 10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL		WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*		
	S-1	ST	24		(CH FILL) FAT CLAY FILL, Dark Gray and Dark Brown, Hard, Trace Root Fibers and Gravel	🟥					○ 4.50 ○ 4.50
	S-2	ST	24		(CH) FAT CLAY WITH SAND, Dark Gray, Dark Brown and Reddish Brown, Very Stiff to Hard, with Ferrous and Calcareous Nodules	▨					✕ 21 ● 23.2 △ 61 [94.5%] ○ 4.50
5	S-3	ST	24			▨		70			○ 4.50
	S-4	ST	24			▨					✕ 21 ● 24.8 △ 66 [93.5%] ○ 4.50
	S-5	ST	24		*- Dry Unit Weight = 98.2 pcf & Su = 1.37 tsf*	▨					● 25.9
10						▨		65			
	S-6	ST	24			▨					○ 4.50
15						▨		60			
	S-7	ST	24			▨					○ 4.50
20					**END OF BORING AT 20.0 FT**			55			

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered) **Dry**	BORING STARTED: **Sep 05 2024**		CAVE IN DEPTH: **N/A**
▼ WL (Completion) **Dry**	BORING COMPLETED: **Sep 05 2024**		HAMMER TYPE: **Auto**
WL (Seasonal High Water)	EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD: **ASTM D1587**
▽ WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**
PROJECT NO.: **43:3223**
BORING NO.: **B-06**
SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**
DRILLER/CONTRACTOR: **Herman Drilling Corporation**
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**
LOSS OF CIRCULATION 100%
BOTTOM OF CASING
LATITUDE: **29.706671**
LONGITUDE: **-95.592008**
STATION:
SURFACE ELEVATION: **75.0' MSL**

⊕ STANDARD PENETRATION BLOWS/FT 10 20 30 40 50
ROCK QUALITY DESIGNATION & RECOVERY 20 40 60 80 100
🟥 RQD
— REC
☒ MC SAMPLER BLOWS/FT 10 20 30 40 50
▼ TEXAS CONE PENETRATION BLOWS/FT

△ LIQUID LIMIT
✕ PLASTIC LIMIT
○ CALIBRATED PENETROMETER TSF 1 2 3 4 5
● WATER CONTENT % [FINES CONTENT] % 10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*	CALIBRATED PENETROMETER TSF / WATER CONTENT % / LIQUID LIMIT / PLASTIC LIMIT
0–2	S-1	ST	24		(CL FILL) LEAN CLAY FILL, Dark Gray and Dark Brown, Hard, Trace Gravel and Sand Seams		75		4.50
2–4	S-2	ST	24		(CH) FAT CLAY, Dark Gray, Dark Brown and Reddish Brown, Very Stiff to Hard, with Ferrous and Calcareous Nodules				4.00
5	S-3	ST	24				70		3.50
	S-4	ST	24						3.50
	S-5	ST	24						4.00
10							65		
					(CL) LEAN CLAY WITH SAND, Dark Gray and Reddish Brown, Hard, with Ferrous Nodules and Sand Seams				
	S-6	ST	24						4.50 18 / 19.3 / 47 [79.0%]
15							60		
	S-7	ST	24						4.50
20					**END OF BORING AT 20.0 FT**		55		

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**Dry**	BORING STARTED:	**Sep 05 2024**	CAVE IN DEPTH:	**N/A**
▼ WL (Completion)	**Dry**	BORING COMPLETED:	**Sep 05 2024**	HAMMER TYPE:	**Auto**
▽ WL (Seasonal High Water)		EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD:	**ASTM D1587**
▽ WL (Stabilized)					

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**	PROJECT NO.: **43:3223**	BORING NO.: **B-07**	SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**	DRILLER/CONTRACTOR: **Herman Drilling Corporation**		
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**		LOSS OF CIRCULATION	
LATITUDE: **29.706672**	LONGITUDE: **-95.591606**	STATION:	SURFACE ELEVATION: **76.0' MSL**
		BOTTOM OF CASING	

⊕ STANDARD PENETRATION BLOWS/FT 10 20 30 40 50

20 40 60 80 100 ROCK QUALITY DESIGNATION & RECOVERY

RQD

REC

MC SAMPLER BLOWS/FT 10 20 30 40 50

▼ TEXAS CONE PENETRATION BLOWS/FT

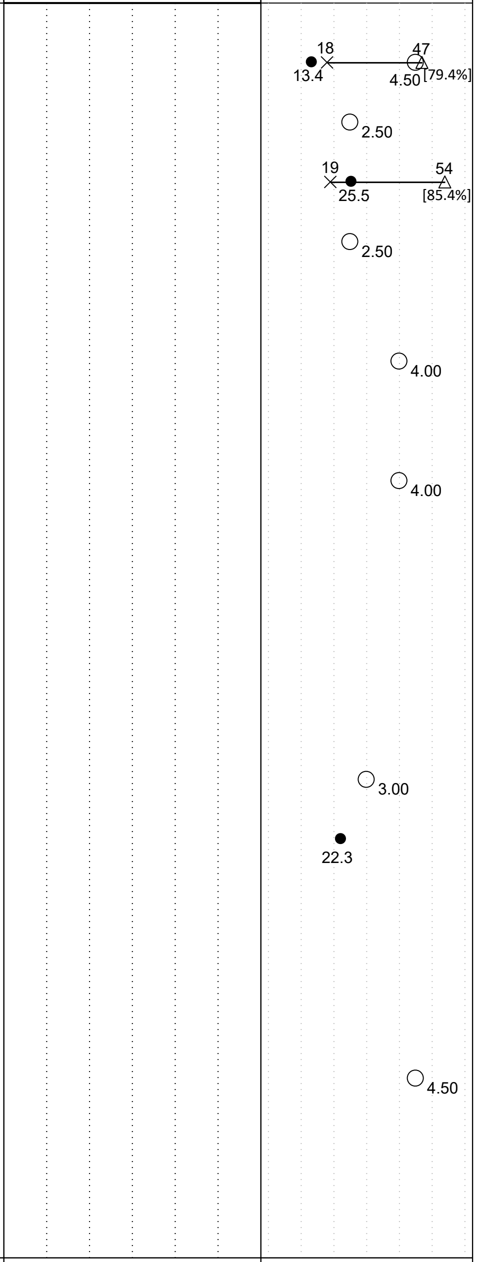
△ LIQUID LIMIT

✕ PLASTIC LIMIT

○ CALIBRATED PENETROMETER TSF 1 2 3 4 5

● WATER CONTENT % [FINES CONTENT] % 10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	ST	24		(CL FILL) LEAN CLAY WITH SAND FILL, Dark Gray and Dark Brown, Hard, Trace Gravel and Sand Seams			
	S-2	ST	24		(CH) FAT CLAY WITH SAND, Dark Gray, Dark Brown and Reddish Brown, Very Stiff to Hard, with Ferrous and Calcareous Nodules			
5	S-3	ST	24				71	
	S-4	ST	24					
	S-5	ST	24					
10							66	
	S-6	ST	24		*- Dry Unit Weight = 105.6 pcf & Su = 0.66 tsf*			
15							61	
	S-7	ST	24					
20					**END OF BORING AT 20.0 FT**		56	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Sep 05 2024**	CAVE IN DEPTH:	**N/A**
WL (Completion)	**Dry**	BORING COMPLETED:	**Sep 05 2024**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD:	**ASTM D1587**
WL (Stabilized)					

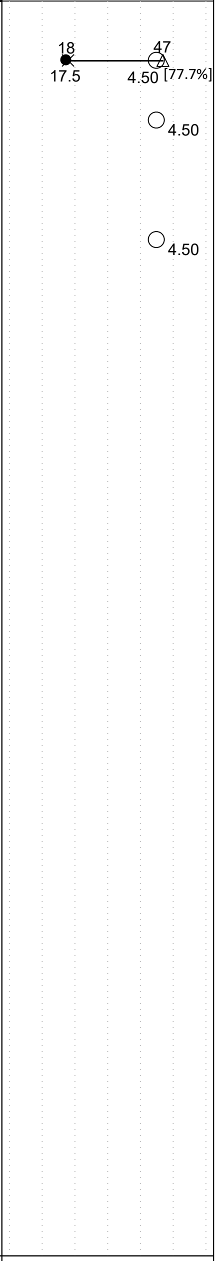
GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**	PROJECT NO.: **43:3223**	BORING NO.: **P-01**	SHEET: **1 of 1**	ECS
PROJECT NAME: **Dashwood Trails Apartments**	DRILLER/CONTRACTOR: **Herman Drilling Corporation**			
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**			LOSS OF CIRCULATION	100%
LATITUDE: **29.706333**	LONGITUDE: **-95.593010**	STATION:	SURFACE ELEVATION: **75.0' MSL**	BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL		WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	ST	24		(CL FILL) LEAN CLAY WITH SAND FILL, Dark Gray and Dark Brown, Hard, Trace Gravel and Sand Seams	🟥			
	S-2	ST	24		(CH) FAT CLAY, Dark Gray and Dark Brown, Hard, with Ferrous and Calcareous Nodules	▨			
5	S-3	ST	24			▨		70	
					END OF BORING AT 6.0 FT				
10								65	
15								60	
20								55	

⊕ STANDARD PENETRATION BLOWS/FT
10 20 30 40 50
20 40 60 80 100
ROCK QUALITY DESIGNATION & RECOVERY
RQD
REC
MC SAMPLER BLOWS/FT
10 20 30 40 50
▼ TEXAS CONE PENETRATION BLOWS/FT

△ LIQUID LIMIT
✕ PLASTIC LIMIT
○ CALIBRATED PENETROMETER TSF
1 2 3 4 5
● WATER CONTENT %
[FINES CONTENT] %
10 20 30 40 50



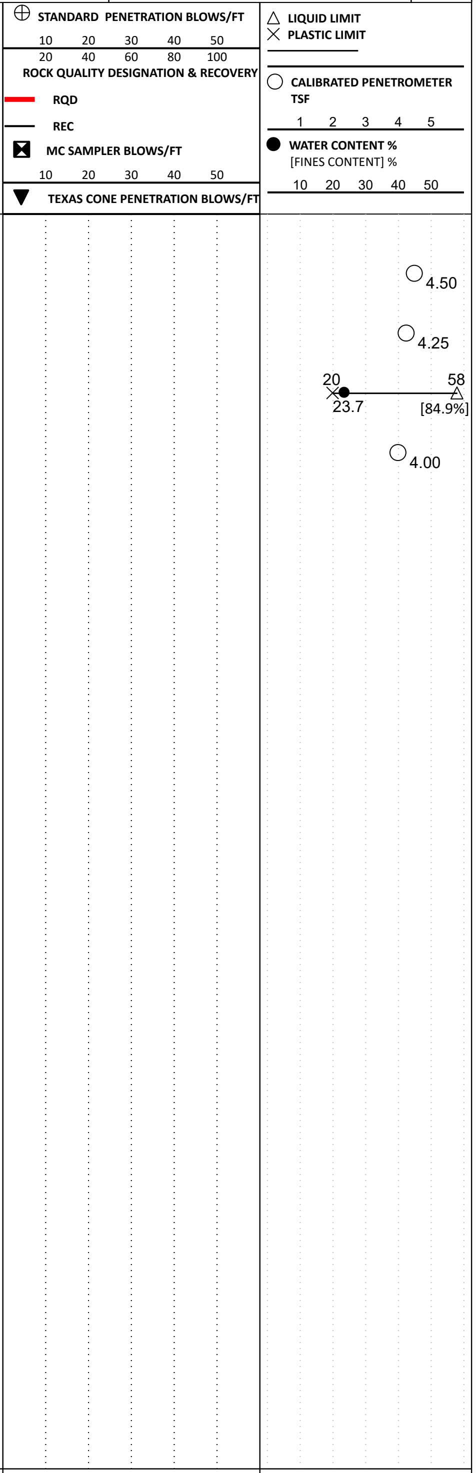
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**Dry**	BORING STARTED:	**Sep 05 2024**	CAVE IN DEPTH:	**N/A**
▼ WL (Completion)	**Dry**	BORING COMPLETED:	**Sep 05 2024**	HAMMER TYPE:	**Auto**
▼ WL (Seasonal High Water)		EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD:	**ASTM D1587**
▽ WL (Stabilized)					

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**	PROJECT NO.: **43:3223**	BORING NO.: **P-02**	SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**	DRILLER/CONTRACTOR: **Herman Drilling Corporation**		
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**		LOSS OF CIRCULATION	
LATITUDE: **29.706856**	LONGITUDE: **-95.591979**	STATION:	SURFACE ELEVATION: **75.0' MSL**
		BOTTOM OF CASING	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*	CALIBRATED PENETROMETER TSF	WATER CONTENT % [FINES CONTENT] % / PLASTIC LIMIT / LIQUID LIMIT
	S-1	ST	24		(CL FILL) LEAN CLAY FILL, Dark Gray and Dark Brown, Hard, Trace Gravel and Sand Seams				4.50	
	S-2	ST	24		(CH) FAT CLAY WITH SAND, Dark Gray and Dark Brown, Hard, with Ferrous and Calcareous Nodules				4.25	20 / 23.7 / 58 [84.9%]
5	S-3	ST	24				70		4.00	
					END OF BORING AT 6.0 FT					
10							65			
15							60			
20							55			



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**Dry**	BORING STARTED:	**Sep 05 2024**	CAVE IN DEPTH:	**N/A**
▼ WL (Completion)	**Dry**	BORING COMPLETED:	**Sep 05 2024**	HAMMER TYPE:	**Auto**
▽ WL (Seasonal High Water)		EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD:	**ASTM D1587**
▽ WL (Stabilized)					

GEOTECHNICAL BOREHOLE LOG

CLIENT: **Carlson Consulting Engineers, Inc.**	PROJECT NO.: **43:3223**	BORING NO.: **P-03**	SHEET: **1 of 1**
PROJECT NAME: **Dashwood Trails Apartments**	DRILLER/CONTRACTOR: **Herman Drilling Corporation**		
SITE LOCATION: **Dashwood Drive and Jetty Lane, Houston, Texas 77072**			

LOSS OF CIRCULATION 100%

BOTTOM OF CASING

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:
29.706626	**-95.591447**		**75.0' MSL**

⊕ STANDARD PENETRATION BLOWS/FT
10 20 30 40 50

ROCK QUALITY DESIGNATION & RECOVERY
20 40 60 80 100

🟥 RQD
— REC

☒ MC SAMPLER BLOWS/FT
10 20 30 40 50

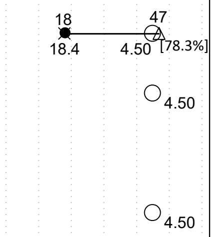
▼ TEXAS CONE PENETRATION BLOWS/FT

△ LIQUID LIMIT
✕ PLASTIC LIMIT

○ CALIBRATED PENETROMETER TSF
1 2 3 4 5

● WATER CONTENT %
[FINES CONTENT] %
10 20 30 40 50

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL		WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	ST	24		(CL FILL) LEAN CLAY WITH SAND FILL, Dark Gray and Dark Brown, Hard, Trace Gravel and Sand Seams	🟥			
	S-2	ST	24		(CH) FAT CLAY, Dark Gray and Dark Brown, Hard, with Ferrous and Calcareous Nodules	▨			
5	S-3	ST	24			▨		70	
					END OF BORING AT 6.0 FT				
10								65	
15								60	
20								55	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered) **Dry**	BORING STARTED: **Sep 05 2024**		CAVE IN DEPTH: **N/A**
▼ WL (Completion) **Dry**	BORING COMPLETED: **Sep 05 2024**		HAMMER TYPE: **Auto**
WL (Seasonal High Water)	EQUIPMENT: **Truck**	LOGGED BY: **HDC**	DRILLING METHOD: **ASTM D1587**
WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

APPENDIX C – Laboratory Testing

Laboratory Testing Summary
Unconsolidated-Undrained (UU) Compressive Strength

Laboratory Testing Summary

Page 1 of 1

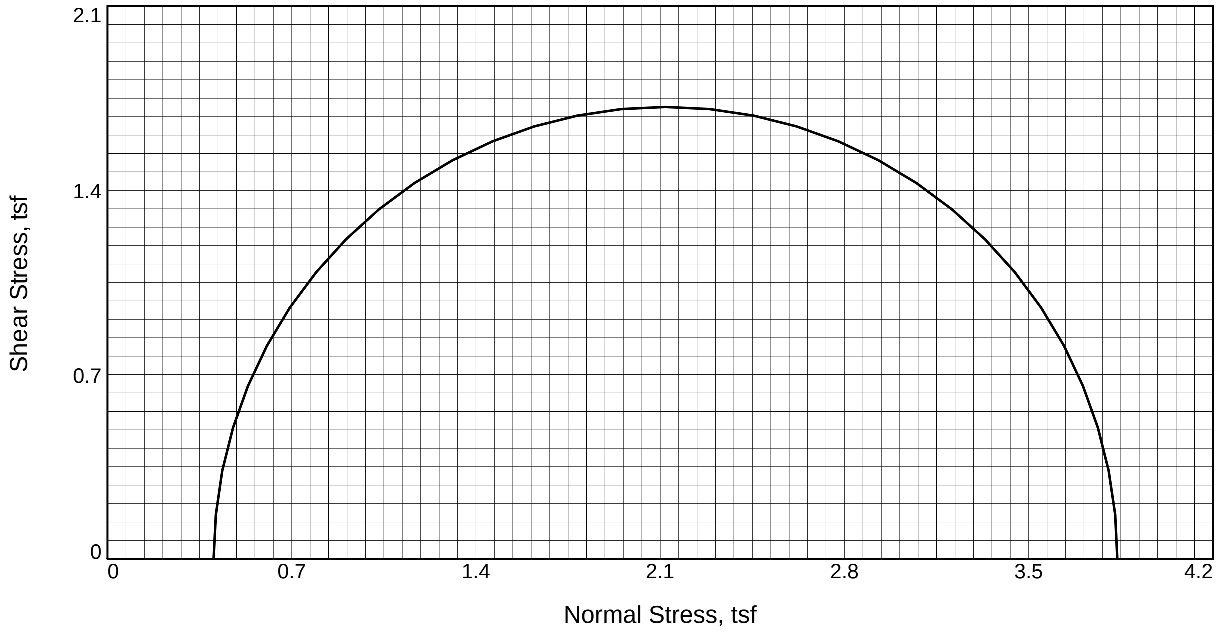
Sample Source	Sample Number	Start Depth (feet)	End Depth (feet)	Sample Distance (feet)	MC[1] (%)	Soil Type[2]	Atterberg Limits[3]			Percent Passing No. 200 Sieve[4]	UC[5]		CBR Value[6]	Organic Content (%)
							LL	PL	PI		Dry Density (pcf)	Su (tsf)		
B-01	S-4	6.0	8.0	2.0	24.9	CH	60	20	40	95.6				
B-01	S-7	18.0	20.0	2.0	15.3	CL	35	16	19	79.0				
B-02	S-5	8.0	10.0	2.0	24.7	CH	60	20	40	90.0				
B-03	S-1	0.0	2.0	2.0	18.7	CH FILL	56	20	36	89.6				
B-03	S-3	4.0	6.0	2.0	22.4	CH	50	19	31	84.0				
B-03	S-4	6.0	8.0	2.0	24.0	CH					100.0	1.72		
B-04	S-1	0.0	2.0	2.0	17.9	CH FILL	52	19	33	89.2				
B-05	S-2	2.0	4.0	2.0	23.2	CH	61	21	40	94.5				
B-05	S-4	6.0	8.0	2.0	24.8	CH	66	21	45	93.5				
B-05	S-5	8.0	10.0	2.0	25.9	CH					98.2	1.37		
B-06	S-6	13.0	15.0	2.0	19.3	CL	47	18	29	79.0				
B-07	S-1	0.0	2.0	2.0	13.4	CL FILL	47	18	29	79.4				
B-07	S-2	2.0	4.0	2.0	25.5	CH	54	19	35	85.4				
B-07	S-6	13.0	15.0	2.0	22.3	CH					105.6	0.66		
P-01	S-1	0.0	2.0	2.0	17.5	CL FILL	47	18	29	77.7				
P-02	S-2	2.0	4.0	2.0	23.7	CH	58	20	38	84.9				
P-03	S-1	0.0	2.0	2.0	18.4	CL FILL	47	18	29	78.3				

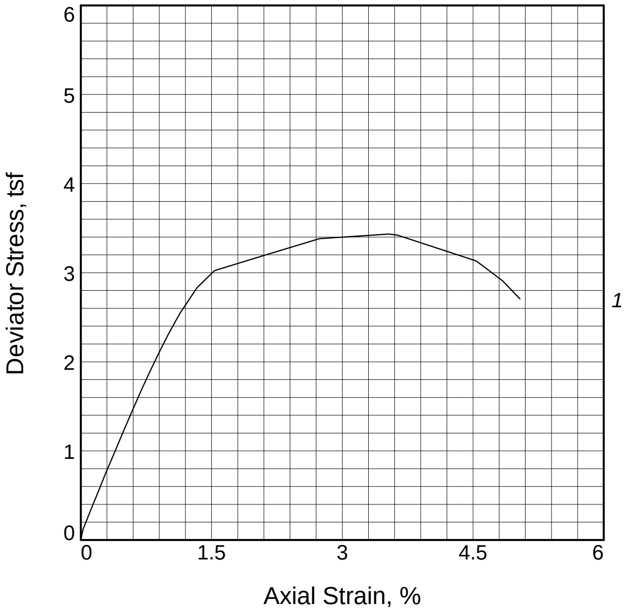
Notes: 1. ASTM D 2216, 2. ASTM D 2487, 3. ASTM D 4318, 4. ASTM D 1140, 5. ASTM D 2850, 6. See test reports for test method

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ration, OC: Organic Content (ASTM D 2974)

Project No.: **43:3223**
Project Name: **Dashwood Trails Apartments**
PM: **Vincent Yin**
PE: **Richard E. Webb**
Printed On: **October 17, 2024**

ECS Southwest, LLP - Houston
1000 North Post Oak Road, Suite 240
Houston, TX 77055
Phone: 713-955-1980
Fax: 281-520-4637





Sample No.		1
Initial	Water Content, %	24.0
	Dry Density, pcf	100.0
	Saturation, %	
	Void Ratio	0.6542
	Diameter, in.	2.76
	Height, in.	5.59
At Test	Water Content, %	0.0
	Dry Density, pcf	0.0
	Saturation, %	0.0
	Void Ratio	N/A
	Diameter, in.	2.76
	Height, in.	5.59
Strain rate, in./min.		0.028
Back Pressure, psi		0.00
Cell Pressure, psi		5.60
Fail. Stress, tsf		3.43
Ult. Stress, tsf		
σ_1 Failure, tsf		3.84
σ_3 Failure, tsf		0.40

Type of Test:
Unconsolidated Undrained

Sample Type: Shelby Tube

Description:

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: ECS

Project:

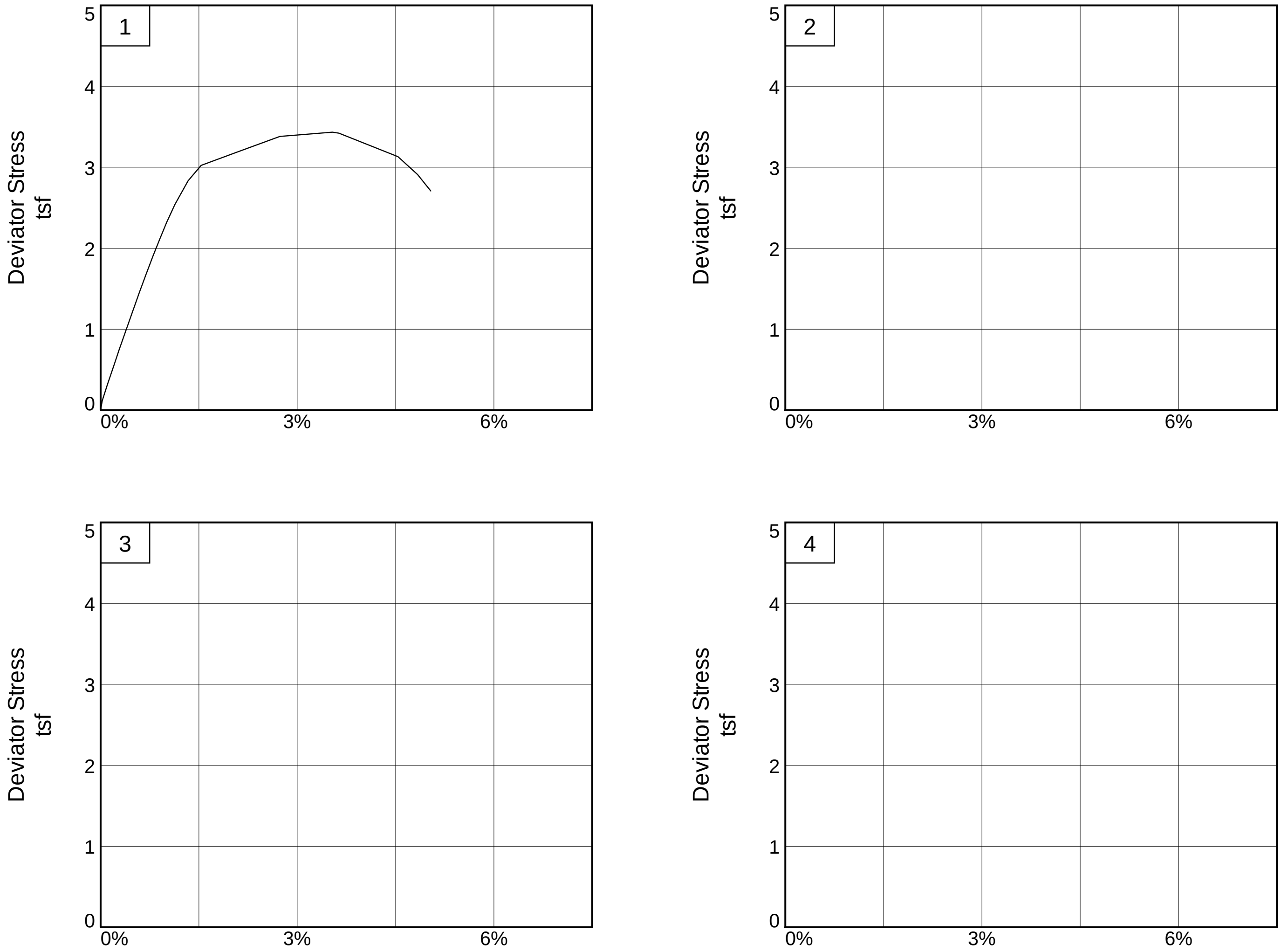
Source of Sample: B-3 **Depth:** 6'-8'

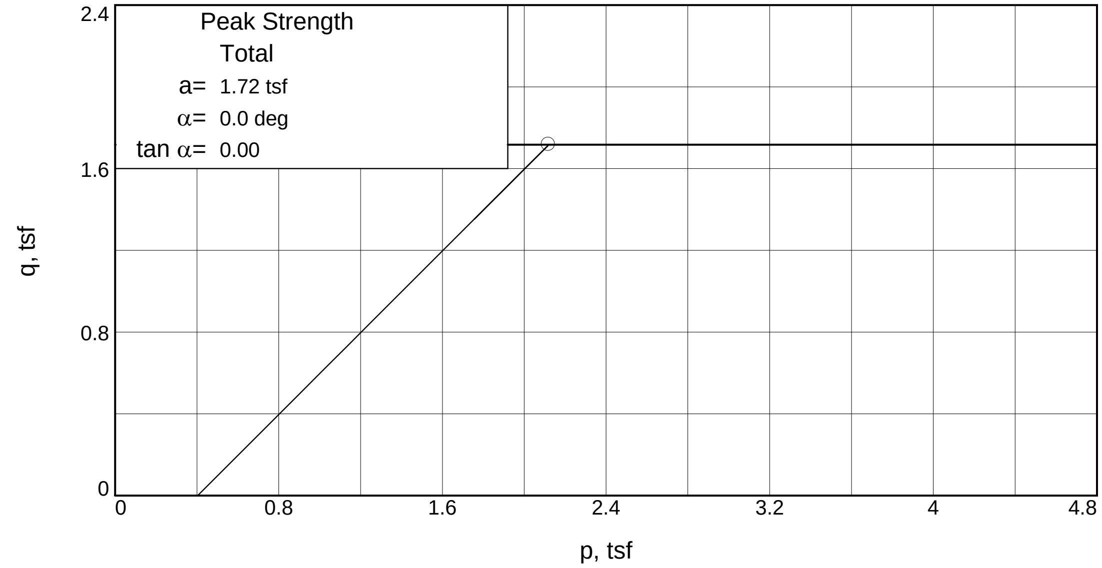
Sample Number: 4

Proj. No.: KG24-027(3223) **Date Sampled:**

Kenallgeo

Tested By: FA **Checked By:** VC





Stress Paths: o indicates peak

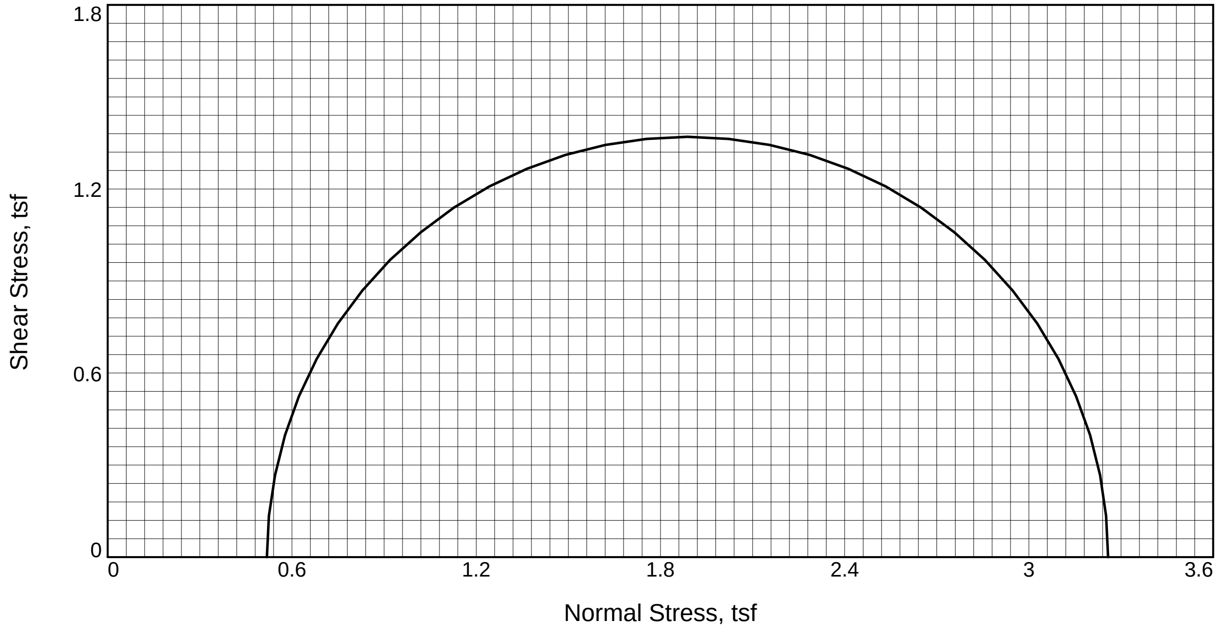
Client: ECS

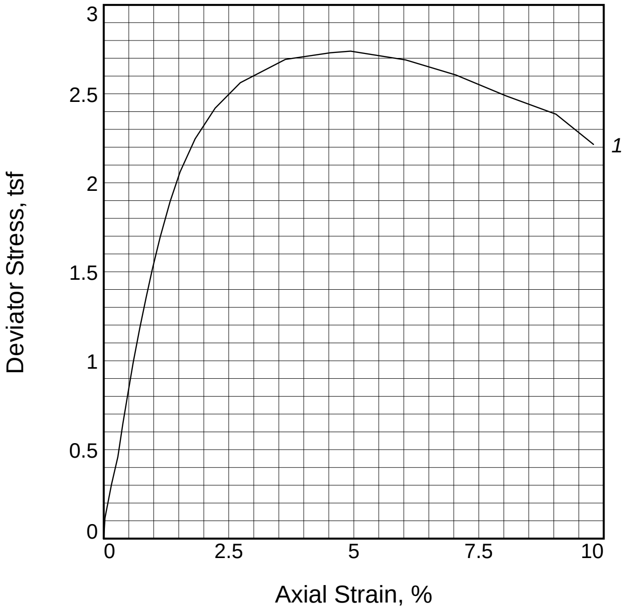
Project:

Source of Sample: B-3 **Depth:** 6'-8' **Sample Number:** 4

Project No.: KG24-027(3223) **Figure** ________

Tested By: FA **Checked By:** VC





Sample No.		1
Initial	Water Content, %	25.9
	Dry Density, pcf	98.2
	Saturation, %	
	Void Ratio	0.6844
	Diameter, in.	2.77
	Height, in.	5.59
At Test	Water Content, %	0.0
	Dry Density, pcf	0.0
	Saturation, %	0.0
	Void Ratio	N/A
	Diameter, in.	2.77
	Height, in.	5.59
Strain rate, in./min.		0.028
Back Pressure, psi		0.00
Cell Pressure, psi		7.20
Fail. Stress, tsf		2.74
Ult. Stress, tsf		
σ_1 Failure, tsf		3.26
σ_3 Failure, tsf		0.52

Type of Test:
Unconsolidated Undrained

Sample Type: Shelbyn Tube

Description:

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: ECS

Project:

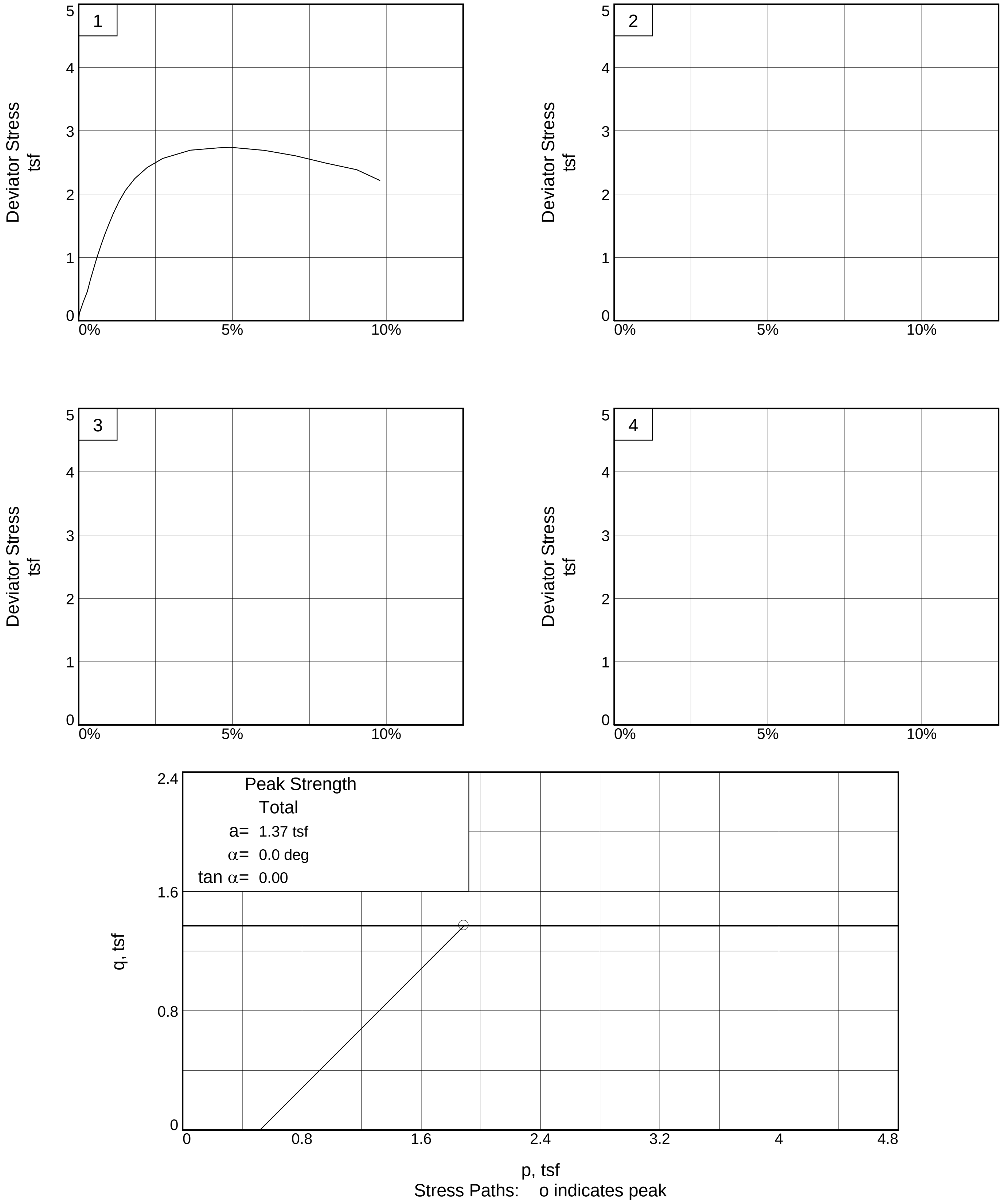
Source of Sample: B-5 **Depth:** 8'-10'

Sample Number: 5

Proj. No.: KG24-027(3223) **Date Sampled:**

Kenallgeo

Tested By: FA **Checked By:** VC



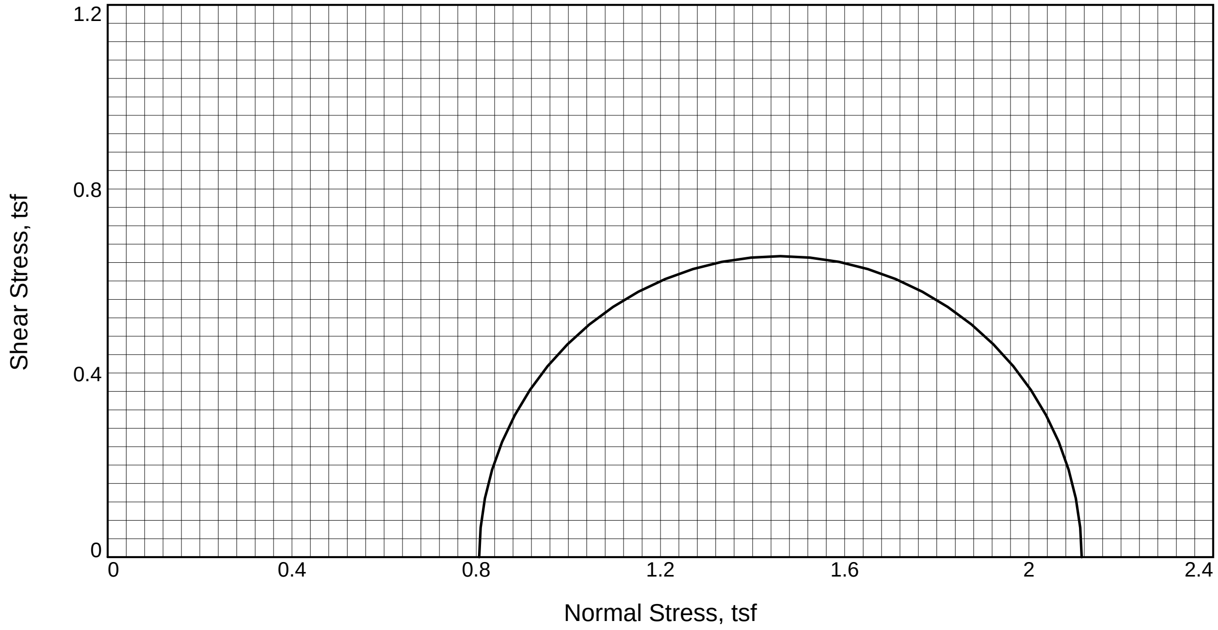
Client: ECS

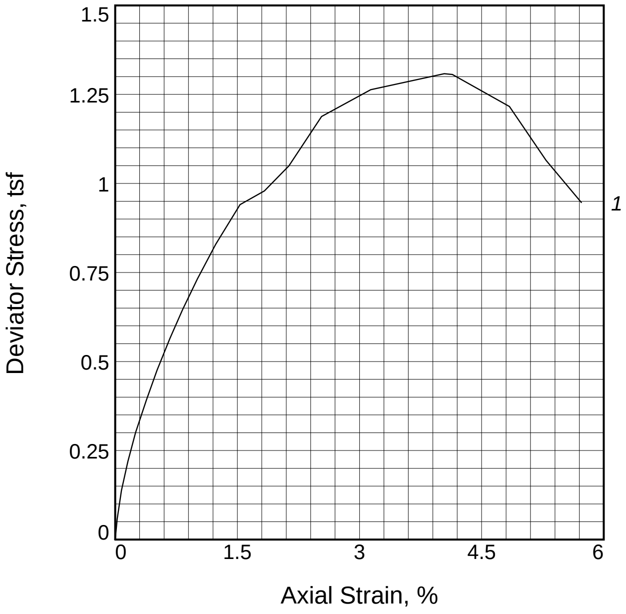
Project:

Source of Sample: B-5 **Depth:** 8'-10' **Sample Number:** 5

Project No.: KG24-027(3223) **Figure** ________

Tested By: FA **Checked By:** VC





Sample No.		1
Initial	Water Content, %	22.3
	Dry Density, pcf	105.6
	Saturation, %	
	Void Ratio	0.5669
	Diameter, in.	2.73
	Height, in.	5.58
At Test	Water Content, %	0.0
	Dry Density, pcf	0.0
	Saturation, %	0.0
	Void Ratio	N/A
	Diameter, in.	2.73
	Height, in.	5.58
Strain rate, in./min.		0.028
Back Pressure, psi		0.00
Cell Pressure, psi		11.20
Fail. Stress, tsf		1.31
Ult. Stress, tsf		
σ_1 Failure, tsf		2.11
σ_3 Failure, tsf		0.81

Type of Test:
Unconsolidated Undrained

Sample Type: Shelby Tube

Description:

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: ECS

Project:

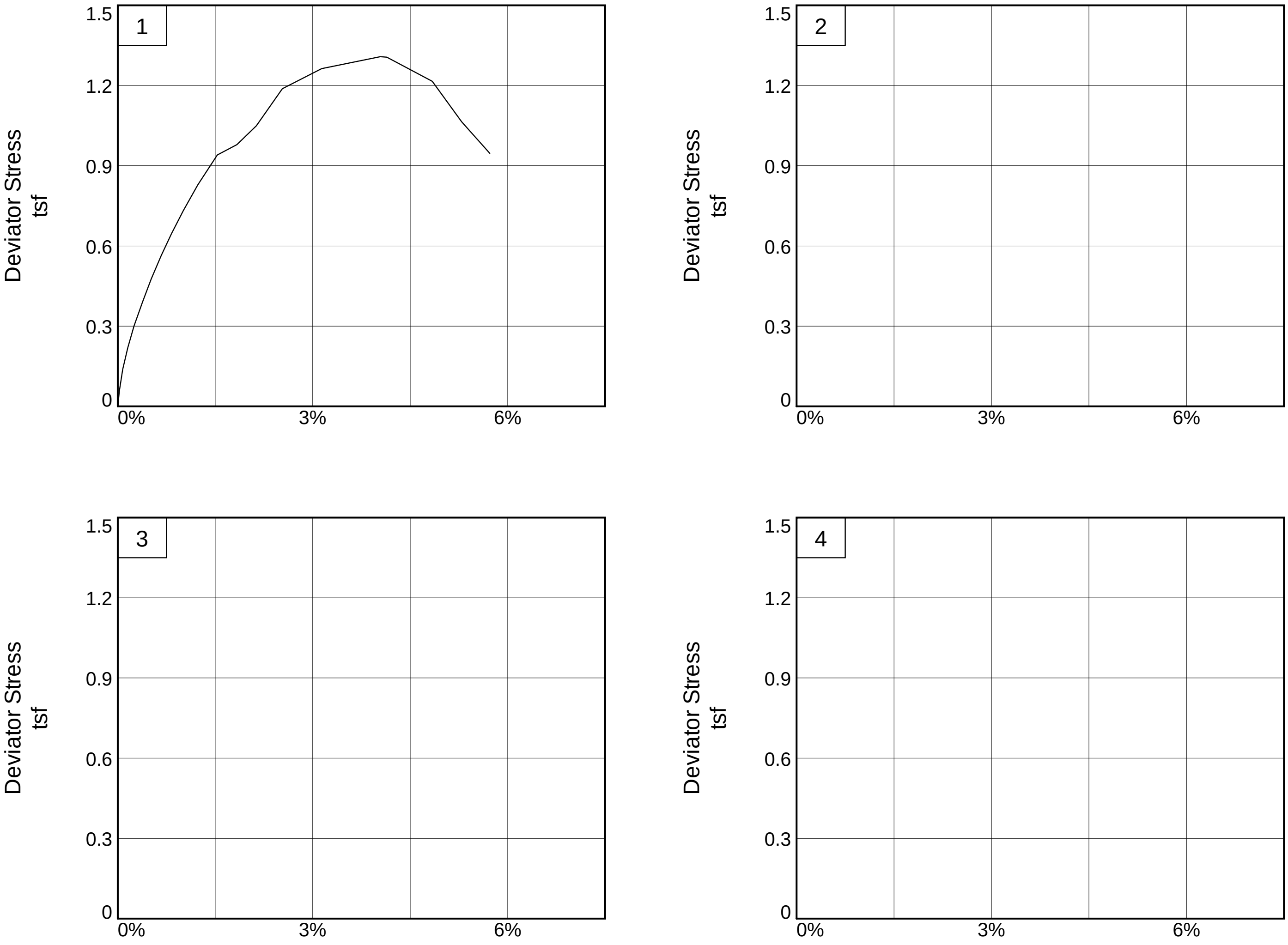
Source of Sample: B-7 **Depth:** 13'-15'

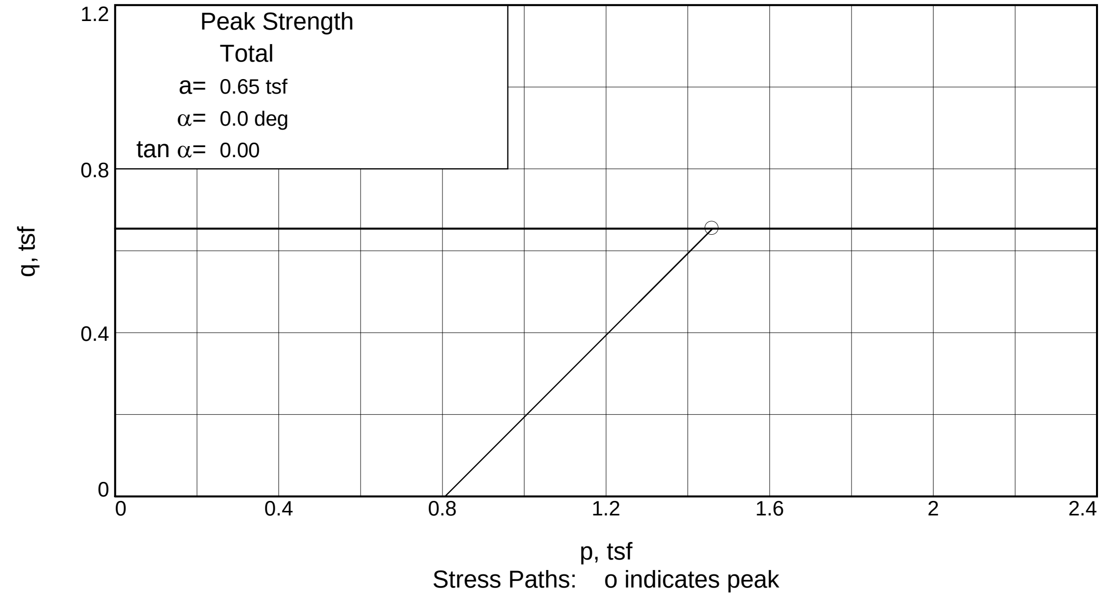
Sample Number: 6

Proj. No.: KG24-027(3223) **Date Sampled:**

Kenallgeo

Tested By: FA **Checked By:** VC





Client: ECS

Project:

Source of Sample: B-7 **Depth:** 13'-15' **Sample Number:** 6

Project No.: KG24-027(3223) **Figure** ________

Tested By: FA **Checked By:** VC