GEOTECHNICAL ENGINEERING REPORT
RETAINING WALLS STUDY
GILCREASE MUSEUM ROAD WIDENING
TULSA, OKLAHOMA
KLEINFELDER PROJECT NO.: 20230052.006A

MARCH 31, 2023

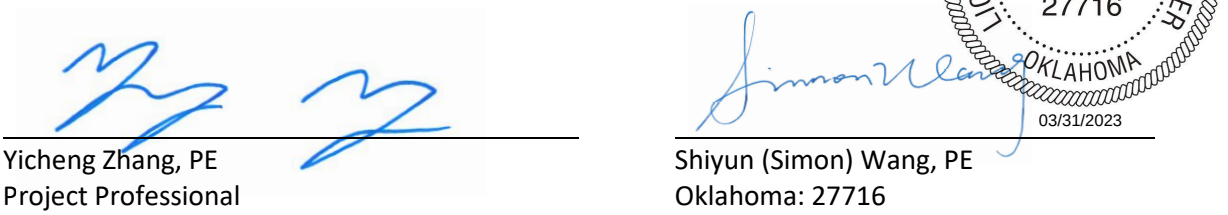
12727 East 61st Street, Suite A, Tulsa, OK 74146 **p**| 918.627.6161 **f**| 918.627.6262

A Report Prepared for:

Ms. Cynthia Y. Lynn, President
Thunderhead Testing, LLC
1540 N. 107th E. Ave.,
Tulsa, Oklahoma 74116

GEOTECHNICAL ENGINEERING REPORT
RETAINING WALLS STUDY
GILCREASE MUSEUM ROAD WIDENING
TULSA, OKLAHOMA

Prepared by:



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Ms. Cynthia Y. Lynn, President
Thunderhead Testing, LLC
1540 N. 107th E. Ave.,
Tulsa, Oklahoma 74116

Subject: **Geotechnical Engineering Report**
Retaining Walls Study
Gilcrease Museum Road Widening
Tulsa, Oklahoma

Dear Ms. Lynn:

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluations for the above-referenced project. The purpose of the geotechnical study was to explore and evaluate the subsurface conditions and provide geotechnical recommendations for the proposed retaining walls along the Gilcrease Museum Road in Tulsa, Oklahoma. The attached Kleinfelder report contains a description of the findings of our field exploration and laboratory testing program, our engineering interpretation of the results with respect to the project characteristics, and our geotechnical site development recommendations as well as construction guidelines for the planned project

Recommendations provided herein are contingent on the provisions outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. The project Owner should become familiar with these provisions in order to assess further involvement by Kleinfelder and other potential impacts to the proposed project.

We appreciate the opportunity to be of service to you on this project and are prepared to provide the recommended additional services. Please call us if you have any questions concerning this report.

Sincerely,

KLEINFELDER, INC.
Certificate of Authorization #7292, Expires 6/30/23

Yicheng Zhang, PE
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GEOTECHNICAL ENGINEERING REPORT
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GILCREASE MUSEUM ROAD WIDENING
TULSA, OKLAHOMA

1. INTRODUCTION

1.1 GENERAL

Kleinfelder has completed the authorized subsurface explorations and geotechnical engineering evaluations for the proposed retaining walls associated with the roadway widening project along the Gilcrease Museum Road in Tulsa, Oklahoma. The services provided were in general accordance with the work order dated January 24, 2023.

This report includes our recommendations related to the geotechnical aspects of the project design and construction. Recommendations presented in the report are based on the subsurface information encountered at the locations of our exploration and the provisions and requirements outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. In addition, an article prepared by The Geoprofessional Business Association (GBA), *Important Information About This Geotechnical Engineering Report*, has been included in Appendix D. We recommend that all individuals read the report limitations along with the included GBA document.

1.2 PROPOSED CONSTRUCTION

We understand that the City of Tulsa (City) is planning to widen the existing Gilcrease Museum Road from Edison Street extending north approximately one mile to W. Pine Street. As part of the project, three retaining walls are proposed, one on the west side of Gilcrease Museum Road up to the Newton Street intersection (Wall 'A'); one on the west side of Gilcrease Museum Road north of Newton Street (Wall 'B'); and one on the east side of Gilcrease Museum Road north of Newton Street (Wall 'C'). The final types, exact locations, and geometries of the retaining walls had not been determined at the time of this report. General locations of the proposed walls and boring locations were provided to Kleinfelder.

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Based on the preliminary retaining wall plans prepared by Poe & Associates Inc., retaining wall 'A' will be approximately 1,220 feet long (Station 10+25 to Station 22+45). The wall will be constructed in cut sections and will have a maximum height of approximately 18 feet.

Retaining wall 'B' will be approximately 900 feet long (Station 30+30 to Station 39+30). Wall 'B' will be constructed in both cut and fill sections and will have a maximum wall height of approximately 12 feet.

Retaining wall 'C' will be approximately 1,130 feet long (Station 50+30 to Station 61+60). Wall 'C' will be constructed in both cut and fill sections and will have a maximum wall height of approximately 11 feet.

After the conference call between City of Tulsa (project owner), Poe & Associates (project designer), and Kleinfelder (geotech engineer of record) on March 14, 2023, we understand the following:

- Wall 'A' will be either a soil nail wall or a soldier pile wall depending upon the availability of right of way. No soil nails will be installed inside private properties.
- The southern portion (approximately 300 feet) of Wall 'B' will be soldier pile walls and the remainder will be conventional CIP (cast-in-place) retaining walls.
- Wall 'C' will be a conventional CIP (cast-in-place) retaining wall.

The scope of the exploration and engineering evaluation for this study, as well as the recommendations in this report, were based on our understanding of the project as described above. If pertinent details of the project have changed or otherwise differ from our descriptions, we must be notified and engaged to review the changes and modify our recommendations, if needed.

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2. SITE CONDITIONS

2.1 SITE DESCRIPTION

The general location of the project site is shown on Figure 1, Site Location Diagram. South of Newton Street, the project site is surrounded by heavily wooded steep slopes to the east and wooded areas and residential areas to the west. North of Newton Street, the project site is surrounded by residential neighborhood to the east and the Gilcrease Museum to the west.

The existing road is a two-lane, two-direction asphaltic concrete paved roadway with grass and/or gravel shoulders. An existing rock wall, constructed on top of the existing terrain, is present along the west side of the Gilcrease Museum Road north of Newton Street. The height of this wall ranged from 2 to 5 feet. The wall starts from Newton Street and extend north approximately 920 feet to the south side of the Gilcrease Museum entrance. This existing wall appears to be a non-structural rock wall and is located approximately 23 feet west of the centerline of the existing Gilcrease Museum Road.

The site terrain is hilly and generally slopes downward from west to east. The site is lowest in elevation near the Newton Street intersection. Existing overhead and underground utilities were noted along the project alignment. An exposed underground utility was observed at the surface near boring B-15 on the east side of the road. Rock outcroppings were visible at several locations within the project sites.

2.2 GENERAL SITE GEOLOGY

According to the "Engineering Classification of Geological Materials – Division Eight" (1965) by ODOT, the project site appears to be located within the **Coffeyville Unit (Pcf)**. This unit consists predominantly of silty to sandy shale with many thick zones of tan sandstone. The sandstone generally is thin-bedded and moderately hard to soft. Locally, at the base of the unit, a black fissile shale about 15 feet thick is present. The sandstone zones are generally about 15 to 40 feet thick. The total thickness ranges from 175 feet in northern Division 8 to about 500 feet in the south. The Coffeyville Unit outcrops in Creek, Nowata, Rogers, Tulsa, and Washington Counties of Division 8. In Tulsa and Creek Counties, the thick sandstone zones cap prominent scarps.

2.3 SUBSURFACE CONDITIONS

Kleinfelder explored the subsurface conditions by performing a total of 36 borings (B-1 through B-36) between February 6 and 10, 2023. The approximate boring locations are shown onFigures 2 through 5, Boring Location Plan(s). The field exploration and laboratory testing programs are presented in APPENDIX A and APPENDIX B, respectively.

Table 2-1 indicates the ground surface elevations, overburden soils, and the approximate depth and elevation to the top of competent bedrock at the respective boring locations. Depth to competent bedrock is defined as the depth at which the penetration from a Standard Penetration test (SPT), conducted in accordance with ASTM D1586, is less than or equal to 6 inches with 50 blows.

Specific subsurface conditions encountered at the boring locations are presented on the respective boring logs in APPENDIX A. The Subsurface Cross Sections, Figures A-1 through A-3, depict the generalized subsurface profiles across the project sites based on the information obtained from the borings. The stratification lines shown on the logs and subsurface cross sections represent the approximate boundaries between material types; in-situ, the transitions may vary or be gradual.

Table 2-1. Summary of Subsurface Strata

Walls	Boring No.	Ground Surface Elevation (ft.)	Overburden Soil	Depth to Weathered Bedrock (ft.)	Depth to Competent Bedrock (ft.)	Competent Bedrock	Competent Bedrock Elevation (ft.)
A	B-13	804	Sand, Clay, Silt	11	16.0	Shale	788.0
	B-14	813	-	1.0	3.5	Sandstone	809.5
	B-15	827	-	1.0	2.0	Sandstone	825.0
	B-16	836	-	1.0	1.5	Sandstone	834.5
	B-17	843	-	1.0	1.5	Sandstone	841.5
	B-18	847	-	1.0	1.5	Sandstone	845.5
	B-19	847	-	1.0	1.5	Sandstone	845.5
	B-20	850	Silty Sand	-	5.0	Sandstone	845.0
	B-21	846	-	1.0	1.5	Sandstone	844.5
	B-22	849	Sandy Silt	-	4.0	Sandstone	845.0
	B-23	836	-	-	1.0	Sandstone	835.0
	B-24	833	Silty Sand	-	4.0	Sandstone	829.0
	B-25	813	Silty Sand	-	5.0	Sandstone	808.0
	B-26	812	Sandy Silt	-	-	-	-

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Table 2-1. Summary of Subsurface Strata							
Walls	**Boring No.**	**Ground Surface Elevation (ft.)**	**Overburden Soil**	**Depth to Weathered Bedrock (ft.)**	**Depth to Competent Bedrock (ft.)**	**Competent Bedrock**	**Competent Bedrock Elevation (ft.)**
B	B-27	812	Silty Sand	4.0	-	-	808.0
	B-28	827	Silty Sand	4.0	9.5	Sandstone	817.5
	B-29	833	-	-	0.5	Sandstone	832.5
	B-30	829	-	-	0.5	Sandstone	828.5
	B-31	821	Silt	-	4.5	Sandstone	816.5
	B-32	822	-	0.5	-	Sandstone	821.5
	B-33	825	Silty Sand	4.0	8.5	Sandstone	816.5
	B-34	827	Silt	3.5	8.5	Sandstone	818.5
	B-35	828	Silt	4.0	8.5	Sandstone	819.5
	B-36	827	Silt	4.5	9.0	Sandstone	818.0
C	B-1	812	Sandy Silt	-	3.5	Sandstone	808.5
	B-2	816	-	0.5	3.5	Sandstone	812.5
	B-3	819	-	0.5	3.0	Sandstone	816.0
	B-4	820	-	0.5	3.5	Sandstone	816.5
	B-5	820	Sandy Silt	4.0	6.0	Sandstone	814.0
	B-6	820	Sandy Silt	-	8.0	Sandstone	812.0
	B-7	820	Sandy Silt	-	6.0	Sandstone	814.0
	B-8	822	-	0.5	3.5	Sandstone	818.5
	B-9	823	-	0.5	3.5	Sandstone	819.5
	B-10	824	-	0.5	4.0	Sandstone	820.0
	B-11	824	-	0.5	4.0	Sandstone	820.0
	B-12	823	-	0.5	4.0	Sandstone	819.0

2.4 GROUNDWATER OBSERVATIONS

No groundwater was observed in the borings during and at end of drilling operations with the exception of Boring B-26. Groundwater was observed at a depth of approximately 5 feet below the existing grade in boring B-26 during drilling operations. However, laboratory moisture characteristics test of the overburden soils indicated high degree of saturation in few of the other boring locations.

The materials encountered in the borings have a wide range of permeabilities, and water level observations over an extended period of time through use of piezometers or cased borings would be required to better define groundwater conditions. Groundwater is likely perched at the bottom of the fill section and above the bedrock, especially during rainy seasons. Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

3. GEOTECHNICAL RECOMMENDATIONS

3.1 GENERAL

Based on the results of our field investigation and engineering evaluations, various types of earth retaining structures could be constructed. Conventional cast-in-place retaining wall, soldier pile walls, and soil nail wall options are presented in the following sections.

The recommendations submitted here are based, in part, upon data obtained from our subsurface exploration. The nature and extent of subsurface variations that may exist at the proposed project site will not become evident until construction. If variations appear evident, then the recommendations presented in this report should be evaluated. In the event that any changes in the nature, design, or location of the proposed project are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed, and our recommendations modified in writing.

3.2 CIP (CAST-IN-PLACE) WALLS

3.2.1 General

As mentioned in Section 1.2, it is our understanding that CIP retaining walls may be designed for the north portion of Wall 'B' and entire Wall 'C'. CIP retaining walls can be supported on spread footings for the proposed location along the Gilcrease Museum Road. The bottom of the spread footings should be placed at least 2 feet below the ground surface to avoid frost penetration depth.

3.2.2 Bearing and Sliding Resistance

If chosen, the CIP retaining walls could be supported on shallow footings founded on one foot of compacted fill material to provide a uniform bearing surface. The compacted fill material should be either ODOT Type "A" aggregate base, lean concrete or controlled low strength (CLSM) type of material. Shallow footings should be proportioned using a maximum geotechnical factored bearing resistance of 2,500 psf (pounds per square foot).

The factored bearing resistance (Strength I Limit State) for retaining walls was estimated using a resistance factor 0.45 for sandy soils (AASHTO, 2020). An effective strength friction coefficient of 0.6 (concrete on gravel-sand mixture) could be used to estimate the sliding resistance of the footings and a corresponding resistance factor of 0.80 should be used (AASHTO, 2020). These factors assume that groundwater is at least 2 feet below the footing bearing level.

The same wall section should be supported on similar bearing material, or a construction joint should be installed between the sections that are supported on different materials. Bearing resistance at utility crossings should be evaluated on a case-by-case basis as the project plans are developed.

3.2.3 Lateral Earth Pressure

Active and passive earth pressure coefficients and equivalent fluid density for level backfill conditions are summarized in Table 3-1. The values in Table 3-1 are based on the assumption that the wall will be backfilled with granular and free draining backfill both above the wall footing and within a 1 horizontal to 1 vertical wedge going up from the heel of the wall footing. Passive earth pressures are provided based on the foundation soil properties. When considering passive earth pressures, soils to depths of 2 feet below the ground surface or to the top of footing (whichever is greater) should be ignored.

The static active and passive earth pressure have triangular distribution, with largest load occurring at the bottom of the wall. The typical components of the CIP wall system are presented in Figure 3.1 below.

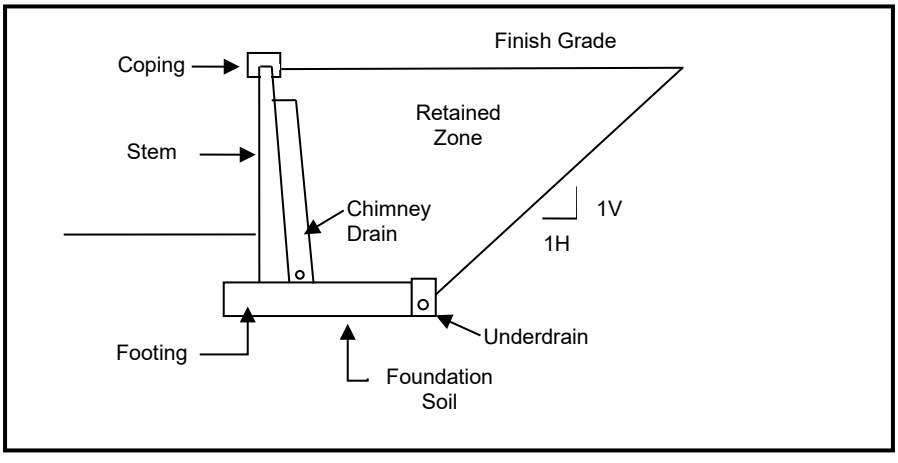

Figure 3.1: CIP Wall System Components (not to scale)

The values in Table 3-1 assume that backfill materials of the wedge are free-draining and, therefore, hydrostatic pressures are not included. Adequate drainage must be provided behind the wall for these coefficients to be valid as shown in Figure 3.1. Uniformly distributed vertical surcharge loads should be applied as a uniform (rectangular) distributed pressure with the appropriate corresponding lateral earth pressure coefficient (active).

Table 3-1. Summary of Lateral Earth Pressures – Level Backfill				
	Earth Pressure Coefficients		Equivalent Fluid Density[a,b,c] (pcf)	
Backfill Slope	Active	Passive	Active	Passive
Horizontal	0.3	3.0	38	360

Notes: H – Horizontal, V – Vertical, pcf – pounds per cubic foot
[a] The resultant static active earth pressures act at a height of 0.33 H above the wall base, where H is the height of the wall.
[b] Nominal values are provided for earth pressures.
[c] Unit weight of granular backfill = 125 pcf; unit weight of foundation soil = 120 pcf

3.2.4 Global Stability

Global stability analysis can be adequately performed once the wall type and configurations are available.

3.2.5 Settlements

Long-term structural settlement for the footings designed and constructed as outlined above should be one inch or less. Differential settlements of approximately one inch or less per 100 feet of wall length should be anticipated. Utility backfill within the wall footprint must be properly compacted to reduce the potential for localized differential settlement.

3.3 SOLDIER PILE WALL

Soldier pile walls are steel H-Piles that are vertically driven or drilled into the ground at regular intervals prior to excavation. As excavation progresses in stages, horizontal lagging (could be timber, steel, or precast concrete panels) is then installed behind the front flanges of H-Piles to retain soils as the excavation continues. The soldier pile walls can be designed as cantilever walls or anchors, or bracing could be installed to provide additional lateral support.

Due to shallow depths to bedrock encountered at the site and the expected wall heights, anchors or bracing are not anticipated for this project. However, pre-drilling may be required for the construction of H-Piles. It should also be noted that cantilever soldier pile size increase dramatically for wall height of 13 feet or greater. It is the sole responsibility of the wall contractor to design the soldier pile wall system.

3.4 SOIL NAIL WALLS

Soil nail walls are typically designed and constructed using a design-build approach by an experienced soil nail wall contractor. The geotechnical engineer typically provides the soil and rock parameters and the preliminary soil nail grout to ground bond stresses to be considered in the design and confirms the global stability meets the required factors of safety. Final wall design should be based on the results of verification load testing performed on several sacrificial test anchors prior to production soil nail installation and wall construction. The geotechnical engineer should select the locations for verification test nails.

After evaluation, a soil nail grout to ground bond stress of 50 psi could be considered in the preliminary design of the soil nail walls. This recommended soil nail grout to ground bond stress is dependent not only upon the bedrock conditions, but also the quality of materials and installation methods, which are the responsibility of the contractor. The bond stress and pullout resistance achieved from the contractor's means and methods should be verified by testing during construction. If necessary, the pullout resistance can be improved by using larger diameter drill holes and/or other grouting methods (e.g., pressure grouting or secondary grouting). Casing the drilled holes for soil nails may be necessary depending on the construction methods or sequencing to prevent caving in the existing soils. The soil nail grout should be placed using a tremie from the bottom of the drilled hole to the top in order to construct a continuously bonded soil nail.

The soil nail wall designer should design a drainage system to prevent hydrostatic pressures from occurring behind the soil nail wall facing, to limit the soaking of soil behind the soil nail wall face and prevent piping or erosion of soil from behind the soil nail wall. The drainage system usually includes a gutter constructed along the crest of the wall, geo-composite strip drains spaced intermittently behind the soil nail wall facing that are connected into weepholes, and/or manifolds/pipes to discharge water away from the bottom of the soil nail wall.

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Based on PTI (2014), permanent soil nails should be designed using Class I (encapsulated tendon) corrosion protection. Corrosion protection for grout and other elements should be considered in the design.

Design, construction, and soil nail testing (i.e., verification, proof and performance testing) should be in accordance with PTI (2014) guidance. Plans and specifications should be reviewed by the Geotechnical Engineer. The Geotechnical Engineer or their representative should observe the soil nail installation and testing, and construction.

Deflection monitoring of the soil nail wall during construction is recommended where there are existing structures or utilities that could be impacted by up to ½-inch of lateral or vertical displacement. Deflection monitoring should be performed weekly during construction for horizontal and vertical movement to an accuracy of 0.01 feet. Following completion of wall construction, the monitoring can be discontinued when two consecutive optical survey measurements taken at least one week apart show no horizontal or vertical movements greater than the precision of the survey method.

3.5 SEISMIC HAZARDS DETERMINATION

We have evaluated the seismic hazards based in the 2020 AASHTO LRFD Bridge Design Specification, 9th Edition. Based on our subsurface information and evaluation of the data, we recommend a Site Class “C” be used in design.

4. SITE DEVELOPMENT

4.1 CLEARING AND GRUBBING

Clearing and grubbing should be performed in accordance with the more stringent of the procedures outlined in this section or as specified by the Oklahoma Department of Transportation (ODOT) "Standard Specifications for Highway Construction (2019)", Section 201. We recommend that all unsuitable materials be removed from the site prior to select fill being placed. We recommend that qualified engineering personnel monitor the stripping operations to observe that all unsuitable materials have been removed. Soils removed during stripping operations could be wasted outside of the project site. Care should be exercised to separate these materials to avoid incorporation of the organic matter in structural fill sections.

Care should be taken during required tree excavations to thoroughly remove all root systems from the proposed construction area. Materials disturbed during removal of stumps should be undercut and replaced with structural fill.

4.2 UTILITIES, STORM DRAINS, AND CULVERTS

Relocation of any existing utility lines within or below the foundation and/or active zone should also be completed as part of the site preparation. The lines should be relocated to areas outside the footprint of the proposed retaining walls. We recommend the proposed relocation of the utilities, if any, be completed prior to the beginning of the wall construction. Additionally, any temporary trench excavation for placement or maintenance of utilities within one wall height in front of the wall or two wall heights behind the face should be designed by an engineer who has reviewed this report and the final retaining wall design.

Excavations created by removal of the existing lines or relocating new lines should be cut wide enough to allow for use of heavy construction equipment to compact the backfill. As an alternative, the excavations could be backfilled with Controlled Low Strength Material (CLSM). In addition, the base of the excavations should be thoroughly evaluated by a geotechnical engineer or engineering technician prior to placement

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of backfill. All backfill should be placed in accordance with the recommendations presented in Section 4.6 of this report.

Note that utilities, storm drains, and culverts constructed within or below the active zone of soldier pile walls create difficulty in the placement of reinforcement elements and reinforced fill and may require demolition of the wall structure for maintenance/repair. Utilities constructed in or below the active zone may introduce water flow in-excess of the wall drainage capabilities, resulting in wall distress or failure. Where necessary, utilities, storm drains, and culverts should cross perpendicular to the wall face, and backfill around the utility should be closely monitored for proper compaction.

The wall designer should incorporate slip joints into the wall at utility, storm drains, or culvert crossings that may create localized differential settlement (large diameter storm sewers, box culverts, etc.). The civil engineer should consider the potential impact of differential settlement when designing utilities, storm drains, and culverts that are near the proposed retaining wall and incorporate design measures to reduce the risk of leakage from these structures. These storm drains and culverts should be inspected regularly for leaks and any leaks should be promptly repaired.

4.3 MOISTURE CONDITIONING AND COMPACTION

Prior to placement of any required fill, the moisture content of the exposed subgrade should be evaluated. Depending on the in-situ moisture content of the subgrade exposed, moisture conditioning of the exposed grade may be required prior to proof rolling and/or fill placement. The moisture content of the exposed grade in these fill areas should be adjusted to within the range recommended for structural fill, to allow the exposed material to be compacted to a minimum of 95 percent of the Standard Proctor maximum dry density.

Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques. Suitable structural fill should be placed to reach the design grade as soon as practical after reworking the subgrade to avoid moisture changes in the underlying soils.

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4.4 TEST ROLLING (PROOF ROLLING)

Following moisture conditioning, it is recommended that the exposed subgrade for the CIP walls be test rolled. Test Rolling should be performed in accordance with the Oklahoma Department of Transportation (ODOT) "Standard Specifications for Highway Construction (2019)" Section 203.

4.5 EXCAVATIONS

4.5.1 General

It is anticipated that excavations will be in mostly native granular soils, and in weathered and competent sandstone and siltstone bedrock. Excavation of the native soils should be possible with conventional heavy equipment such as backhoes, loaders, etc. Excavations for the retaining walls, recommended permanent underdrain system, and for wall foundation ground improvement should anticipate shallow to surface bedrock. Excavation of the bedrock in confined excavations such as trenches will be difficult and will likely require the use of hydraulic breakers or other rock excavation techniques.

4.5.2 Foundation and Utility Excavations and Slopes

Excavations should be cut to a stable slope or be temporarily braced, depending on the excavation depths and the subsurface conditions encountered. ***Temporary construction slopes should be designed in strict compliance with the most recent governing regulations.*** The contractor should also be aware that slope height, slope inclination, or excavation depths (including utility trench excavations) should in no case exceed those specified in local, State and/or federal safety regulations, such as OSHA Health and Safety Standard for Excavations, 29 CFR Part 1926, or successor regulations.

Construction slopes should be closely observed for signs of mass movement: tension cracks at the crest, bulging at the toe, etc. If potential stability problems are observed, a geotechnical engineer should be contacted immediately. ***The responsibility for excavation safety and stability of temporary construction slopes lies solely with the contractor.*** Shoring, bracing, or underpinning may be required to provide structural stability and to protect personnel working within the excavation.

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4.5.3 Construction Considerations

Stockpiles and equipment should be placed well away from the edge of excavations and their height should be controlled so they do not surcharge the sides of excavations. Surface drainage should be carefully controlled to prevent the flow of water into excavations.

4.6 STRUCTURAL FILL

4.6.1 Materials

Granular backfill is recommended for the backfill of the CIP walls (within the wedge of approximately 1 horizontal to 1 vertical extending up from the footing at the base of the wall). All granular backfill material should be prepared or meet the properties of the materials specified in Section 703.07 of ODOT 2019 Standard Specification.

The shallow footings of CIP retaining walls should be supported on one foot of compacted fill material to provide a uniform bearing surface. The compacted fill material should be either ODOT Type “A” aggregate base, lean concrete or controlled low strength (CLSM) type of material.

Structural fill required to achieve design grades at other locations should consist of approved materials, free of organic matter and debris. Other than specified above, structural fill placed should consist of a non-plastic to lower plasticity soil with a maximum Plasticity Index (PI) of 22, as determined by the Atterberg limits test ASTM D4318, wet preparation procedure.

4.6.2 Compaction Criteria

Fill should be placed in lifts having a maximum loose lift thickness of 9 inches. The lift thickness may need to be reduced, depending upon the type/size of compaction equipment utilized at the site. All fill placed at the site should be compacted to a minimum of 95 percent of the material's Maximum Dry Density (MDD) as determined by ASTM D698 (Standard Proctor compaction). Moisture contents of the fill at the time of compaction should be maintained within the range as specified in Table 4-1 until completion of the subgrade preparation.

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Table 4-1. Compaction Criteria		
Material	**Required Moisture Content (%)**	**Percent Compaction (%)**
PI > 22	0% to 4% point above optimum	95% of MDD
PI < = 22	Within 2% point from optimum	95% of MDD

4.6.3 Existing Onsite Soils

Based on the conditions encountered in the borings, it appears that the onsite soils are suitable for use as general embankment fill, but not as the select backfill behind the proposed retaining walls. Additional field testing is required to verify if the existing onsite soils are used as structural fill.

4.6.4 Organic Soils

Topsoil and more highly organic soils removed during site preparation could be utilized in the upper portion of the fill sections in landscaped areas of the site. Depth of organic fill and degree of compaction should be established to provide a stable surface that will be conducive to the growth of grass cover.

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5. ADDITIONAL SERVICES

5.1 PLANS AND SPECIFICATIONS REVIEW

We recommend that Kleinfelder conduct a general review of the final plans and specifications to evaluate that our recommendations have been properly interpreted and implemented during design. In the event Kleinfelder is not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

5.2 CONSTRUCTION OBSERVATION AND TESTING

We recommend that all earthwork and retaining wall installation be monitored by a representative from Kleinfelder, including site preparation, excavation, and placement of all engineered fill. The purpose of these services would be to provide Kleinfelder the opportunity to observe the subsurface conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the subsurface conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

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6. LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided. The scope of our services did not include any environmental assessment or exploration for the presence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on, below, or around this site.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report. Land use, site conditions (both on-site and off-site), regulations, or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the Client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and the client agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized or non-compliance.

The work performed was based on project information provided by the Client. If the Client does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, the Client must obtain written approval from Kleinfelder's engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder's recommendations.

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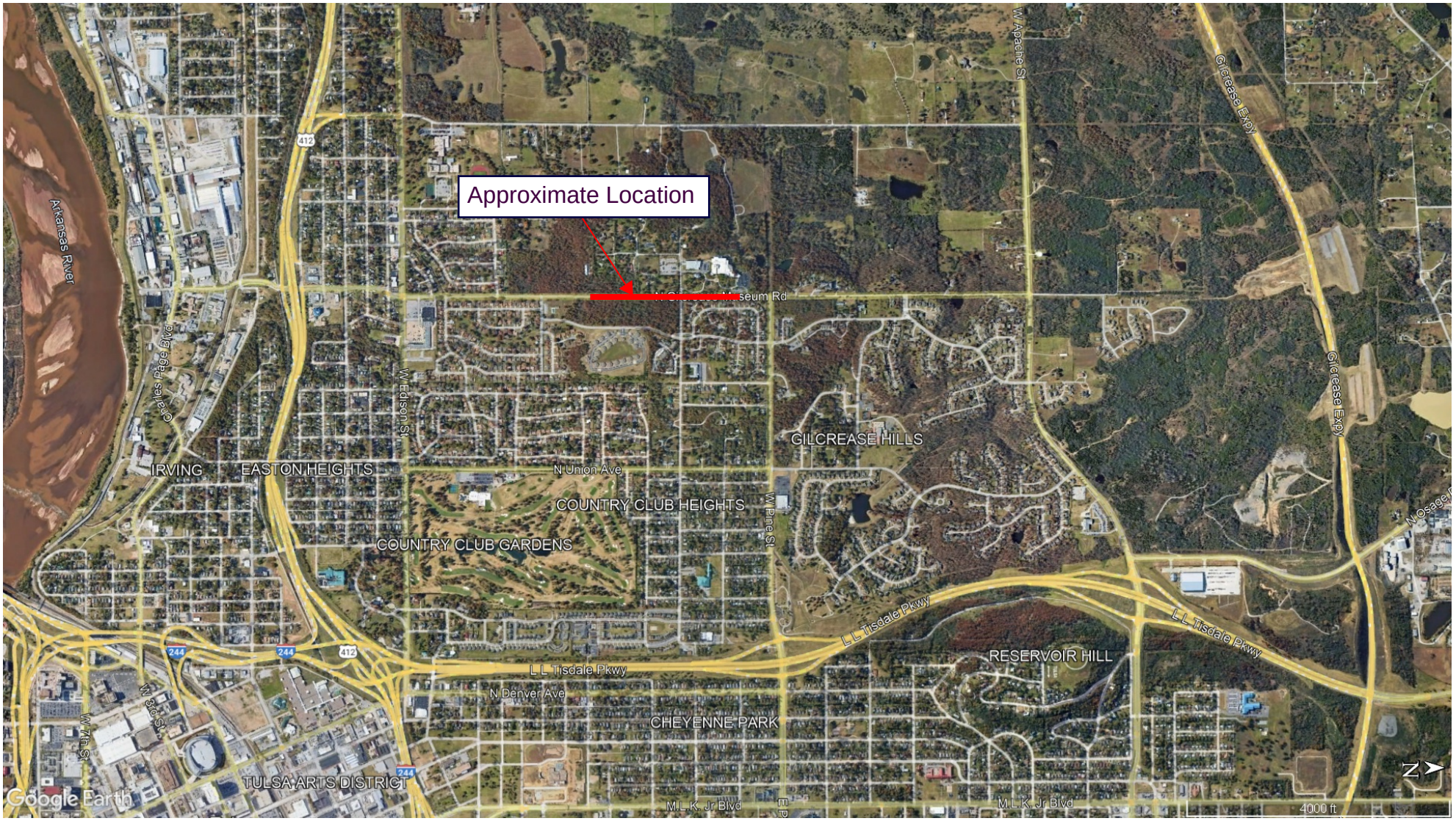
Figures



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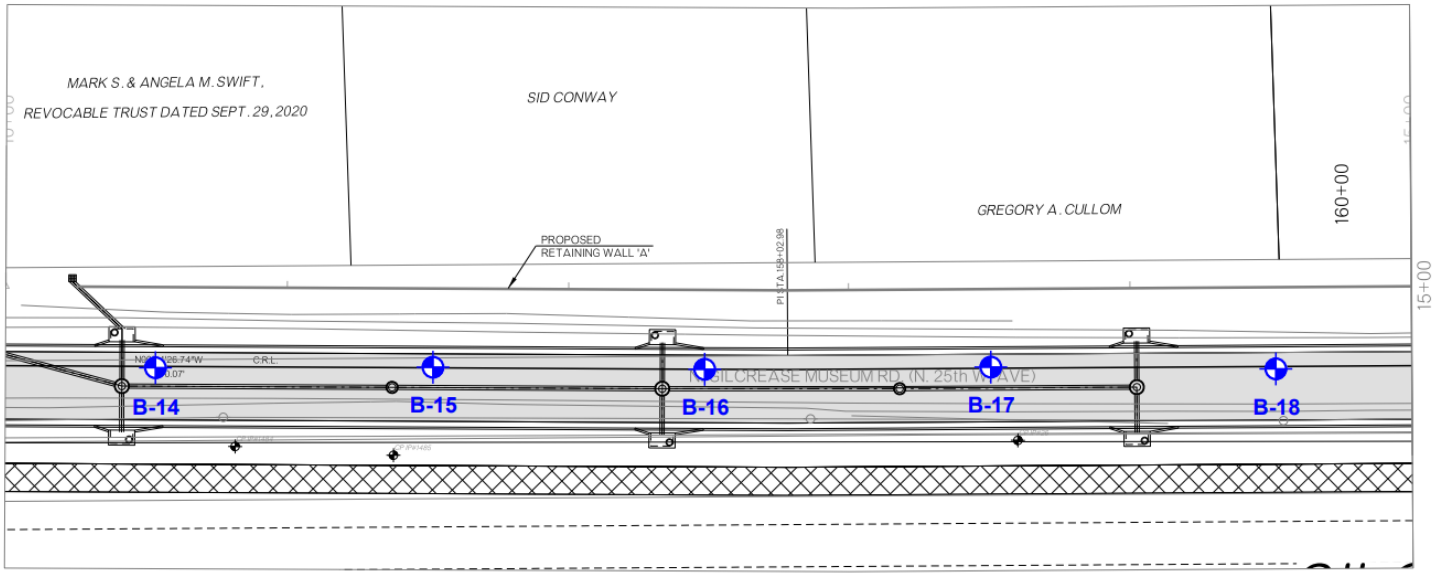
FILE NAME: FIGURE	

SITE LOCATION DIAGRAM

RETAINING WALL STUDY
GILCREASE MUSEUM RD/S. 25TH W. AVE WIDENING
TULSA, OKLAHOMA

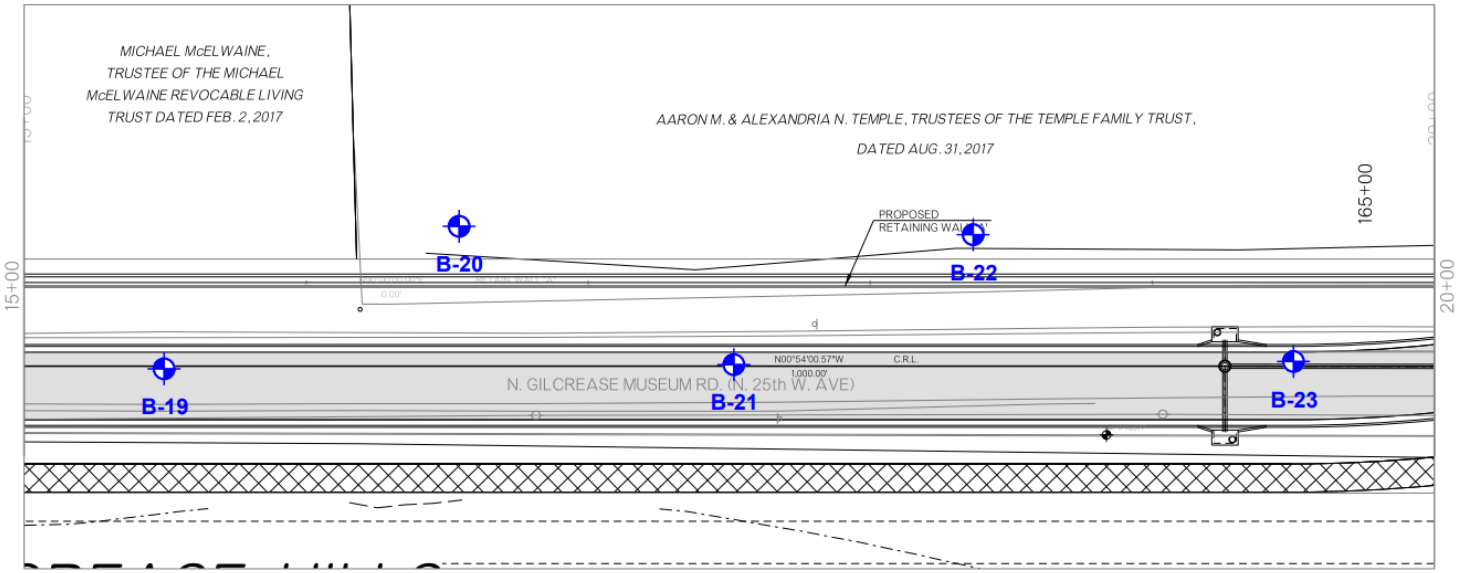
FIGURE:

1



HORIZONTAL SCALE IN FEET
20 0 20 40
VERTICAL SCALE IN FEET
5 0 5 10

NOTE: WALL DESIGN & MATERIAL TO BE DETERMINED AT A LATER DATE



HORIZONTAL SCALE IN FEET
20 0 20 40
VERTICAL SCALE IN FEET
5 0 5 10

NOTE: WALL DESIGN & MATERIAL TO BE DETERMINED AT A LATER DATE

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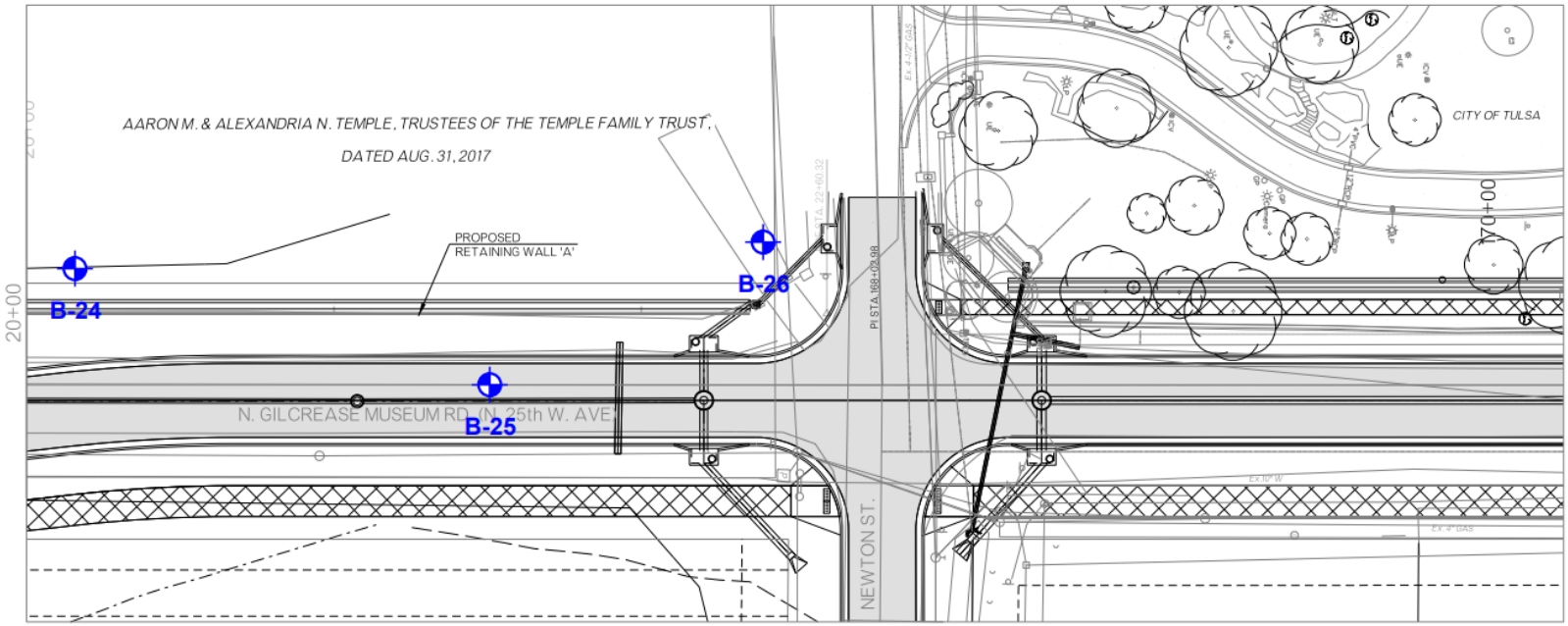
BORING LOCATION DIAGRAM
(WALL A)

RETAINING WALL STUDY
GILCREASE MUSEUM RD/S. 25TH W. AVE WIDENING
TULSA, OKLAHOMA

FIGURE:
2



HORIZONTAL SCALE IN FEET
20 0 20 40
5 0 5 10
VERTICAL SCALE IN FEET

NOTE: WALL DESIGN & MATERIAL TO BE DETERMINED AT A LATER DATE

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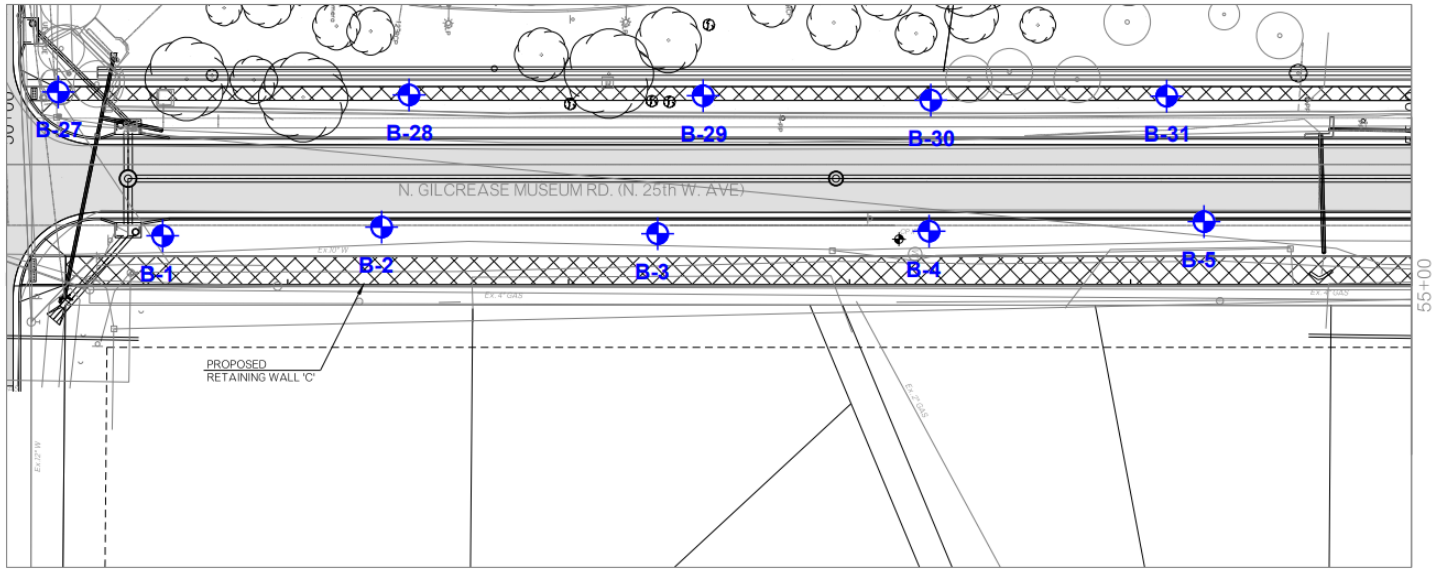
BORING LOCATION DIAGRAM
(WALL A)

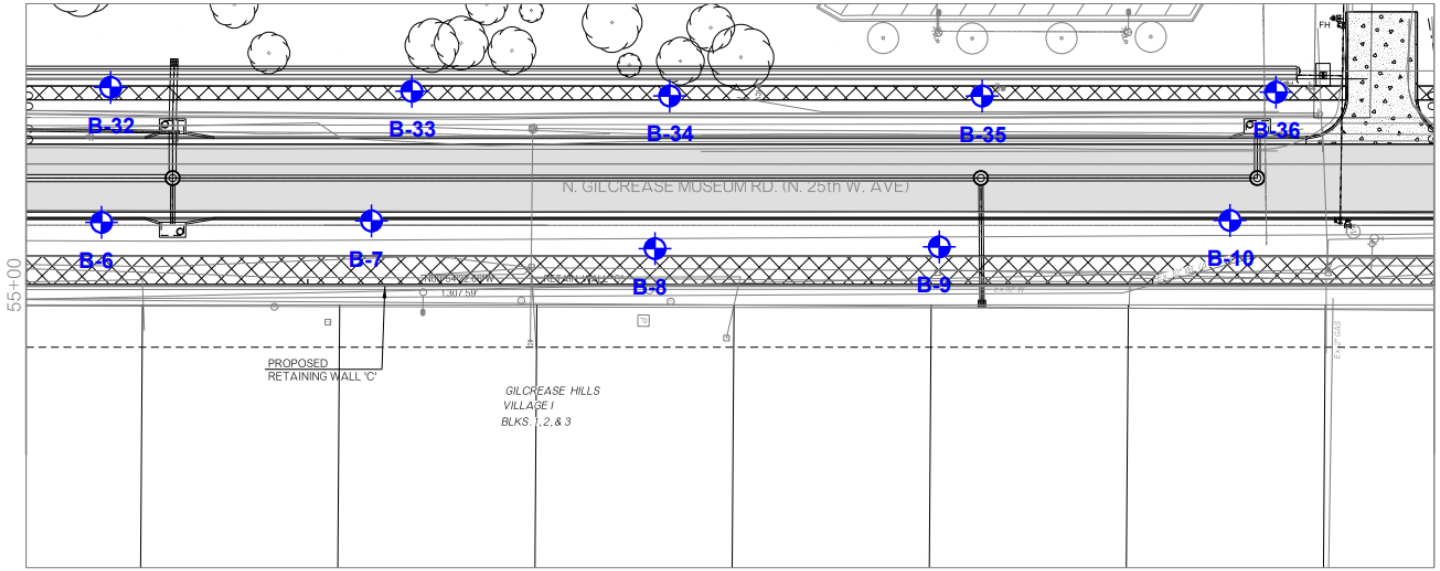
RETAINING WALL STUDY
GILCREASE MUSEUM RD/S. 25TH W. AVE WIDENING
TULSA, OKLAHOMA

FIGURE:
3



HORIZONTAL SCALE IN FEET
20 0 20 40
5 0 5 10
VERTICAL SCALE IN FEET

NOTE: WALL DESIGN & MATERIAL TO BE DETERMINED AT A LATER DATE



HORIZONTAL SCALE IN FEET
20 0 20 40
5 0 5 10
VERTICAL SCALE IN FEET

NOTE: WALL DESIGN & MATERIAL TO BE DETERMINED AT A LATER DATE

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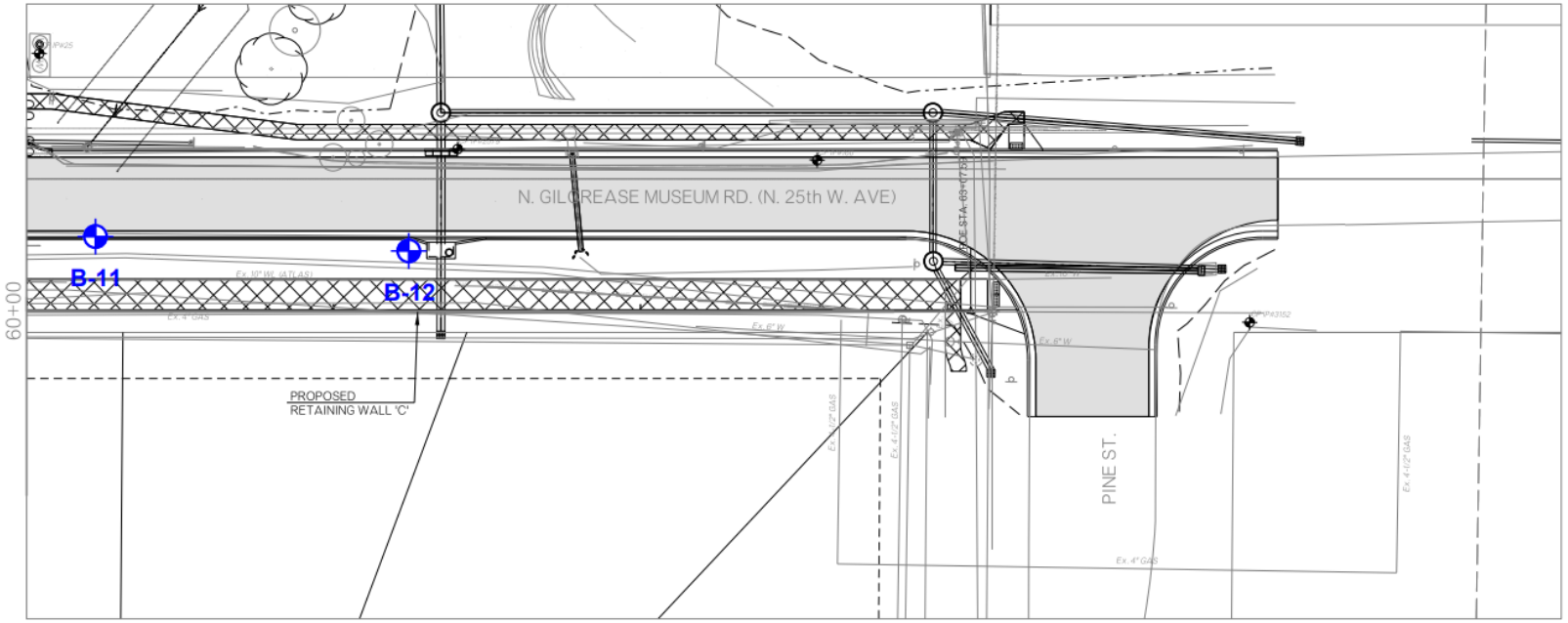
FIGURE

BORING LOCATION DIAGRAM
(WALL B & WALL C)

RETAINING WALL STUDY
GILCREASE MUSEUM RD/S. 25TH W. AVE WIDENING
TULSA, OKLAHOMA

FIGURE:
4



HORIZONTAL SCALE IN FEET
20 0 20 40
5 0 5 10
VERTICAL SCALE IN FEET

NOTE: WALL DESIGN & MATERIAL TO BE DETERMINED AT A LATER DATE

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FILE NAME: FIGURE

BORING LOCATION DIAGRAM
(WALL C)

RETAINING WALL STUDY
GILCREASE MUSEUM RD/S. 25TH W. AVE WIDENING
TULSA, OKLAHOMA

FIGURE:
5

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Appendix A

FIELD EXPLORATION PROGRAM

Kleinfelder conducted the field work for this study between February 6 and 10, 2023. The exploration consisted of 36 borings drilled to a maximum depth of 35 feet below existing grade. Boring locations were established in the field by a representative of Kleinfelder. A GPS unit was used to locate the exploration with an accuracy of less than 15 feet. Approximate elevations at the boring locations were estimated by Kleinfelder with Plan and Profile drawings prepared by Poe & Associates Inc. Locations and elevations of the borings should be considered accurate only to the degree implied by the methods used. The GPS coordinates and approximate elevations are shown on the top left corner of the boring logs.

The borings were performed with a rubber tire ATV-mounted drill rig (CME-550X) and a track ATV (Diedrich D-50) using solid stem augers. Soil samples were obtained utilizing Standard Penetration test (SPT) method using a 2-inch split-barrel sampler. Split-barrel sampling was conducted in general accordance with ASTM D1586. The split-barrel sampler is driven into the bottom of the boring over an 18-inch sampling interval by a 140-pound hammer that is dropped from a distance of 30 inches. The SPT N-value, recorded on the boring logs, is the number of blows required to drive the split-barrel sampler the final 12 inches of the 18-inch sampling interval. The samples were sealed and returned to our laboratory for further examination, classification, and testing. The borings were backfilled in accordance with the appropriate Oklahoma Water Resources Board Regulations. The weathered bedrock encountered in the borings were also evaluated through use of SPT.

Boring logs included in this Appendix present such data as soil and bedrock descriptions, relative density, consistency, and hardness evaluations, depths, sampling intervals, and observed groundwater conditions. Conditions encountered in each of the borings were monitored and recorded by the drill crew and field professional. Field logs included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final boring logs represent the engineer's interpretation of the field logs combined with laboratory observation and testing of the samples. Visual classifications were made in accordance with the Unified Soil Classification System presented on the Graphics Key, Soil Description Key and Rock Description Key that are also presented as figures (Figures A-4, A-5, and A-6) in this appendix. The Subsurface Cross Sections, Figures A-1 through A-3, depict the generalized subsurface profiles along the approximate alignments of the proposed retaining walls based on the information obtained from the

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borings for each wall. Stratification boundaries indicated on the boring logs and cross sections were based on observations during our field work, an extrapolation of information obtained by examining samples from the borings, and comparisons of soils with similar engineering characteristics. Locations of these boundaries are approximate, and the transitions between material types may be gradual rather than clearly defined.

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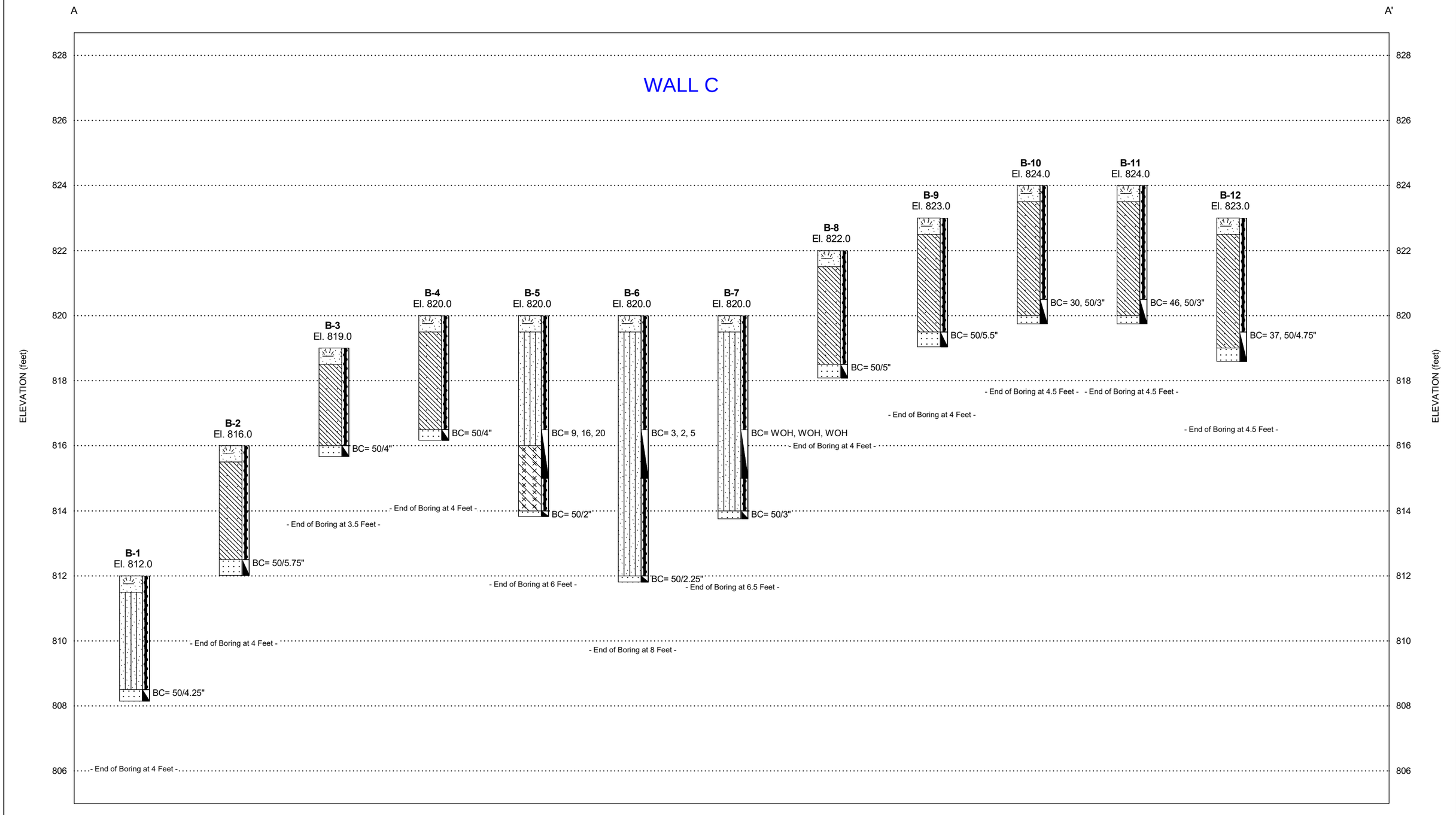

NOTE:
REFER TO INDIVIDUAL LOGS FOR DETAILED INFORMATION AND THE GRAPHIC LEGEND KEYS FOR GRAPHICAL SYMBOL INFORMATION.

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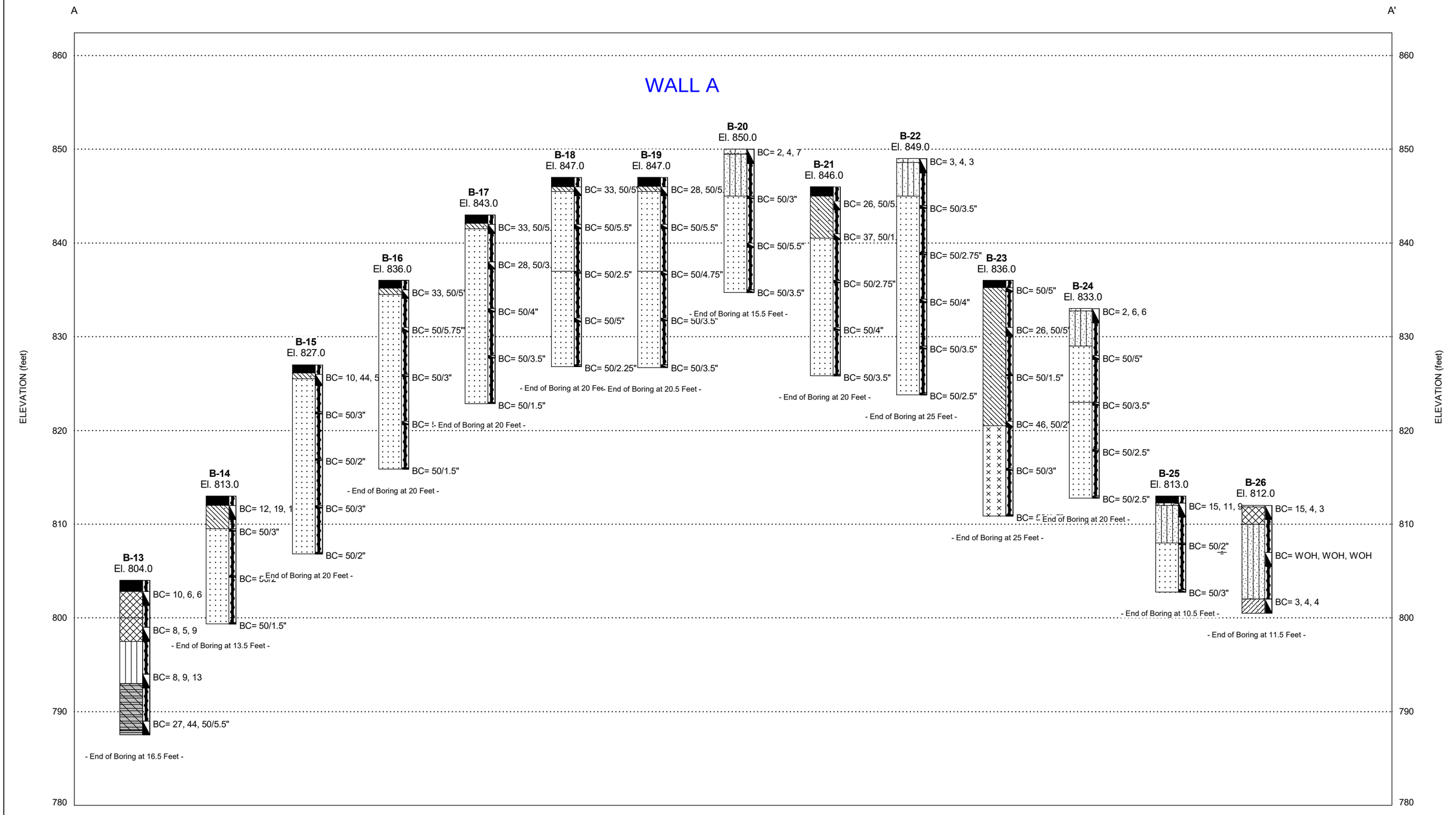
SUBSURFACE CROSS-SECTION

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

FIGURE
A-1



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SUBSURFACE CROSS-SECTION

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

FIGURE

A-2

A A'

WALL B

ELEVATION (feet)

840 835 830 825 820 815 810 805 800

B-28
El. 827.0
BC= 10, 12, 16
BC= 26, 34, 50/4"
BC= 50/5.25"
- End of Boring at 14 Feet -

B-29
El. 833.0
BC= 50/5.5"
BC= 32, 50/4.25"
BC= 49, 50/2"
BC= 50/4"
- End of Boring at 19 Feet -

B-30
El. 829.0
BC= 50/5.75"
BC= 47, 50/1"
BC= 50/2.75"
- End of Boring at 13.5 Feet -

B-31
El. 821.0
BC= 8, 17, 50/3"
- End of Boring at 5 Feet -

B-32
El. 822.0
BC= 26, 28, 24
- End of Boring at 5 Feet -

B-33
El. 825.0
BC= 8, 20, 38
BC= 50/4.25"
- End of Boring at 9 Feet -

B-34
El. 827.0
BC= 7, 9, 20
BC= 50/4"
- End of Boring at 9 Feet -

B-35
El. 828.0
BC= 4, 12, 28
BC= 50/3.25"
- End of Boring at 9 Feet -

B-36
El. 827.0
BC= 10, 10, 19
BC= 45, 50/5"
- End of Boring at 9.5 Feet -

B-27
El. 812.0
BC= 10, 20, 23
- End of Boring at 5 Feet -

NOTE:
REFER TO INDIVIDUAL LOGS FOR DETAILED INFORMATION AND THE GRAPHIC LEGEND KEYS FOR GRAPHICAL SYMBOL INFORMATION.

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SUBSURFACE CROSS-SECTION

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

FIGURE
A-3

DRILLING METHOD/SAMPLER TYPE GRAPHICS

SOLID STEM AUGER

STANDARD PENETRATION SPLIT SPOON SAMPLER (2 in. (50.8 mm.) outer diameter and 1-3/8 in. (34.9 mm.) inner diameter)

GROUND WATER GRAPHICS

- WATER LEVEL (level where first observed)
- WATER LEVEL (level after stabilizing period)
- WATER LEVEL (additional levels after exploration)
- OBSERVED SEEPAGE

NOTES

- The report and graphics key are an integral part of these logs. All data and interpretations in this log are subject to the explanations and limitations stated in the report.
- Solid lines separating strata on the logs represent approximate boundaries only, dashed lines are inferred or extrapolated boundaries. Actual transitions may be gradual or differ from those represented.
- No warranty is provided as to the continuity of soil or rock conditions between individual sample locations.
- Logs represent general soil or rock conditions observed at the point of exploration on the date indicated.
- In general, Unified Soil Classification System (ASTM D2488/D2487) designations presented on the logs were based on visual classification in the field and were modified where appropriate based on gradation and index property testing.
- Fine grained soils that plot within the hatched area on the Plasticity Chart, and coarse grained soils with between 5% and 12% passing the No. 200 sieve require dual USCS symbols, ie., CL-ML, GW-GM, GP-GM, GW-GC, GP-GC, GC-GM, SW-SM, SP-SM, SW-SC, SP-SC, SC-SM.
- If sampler is not able to be driven at least 6 inches then 50/X indicates number of blows required to drive the identified sampler X inches with a 140 pound hammer falling 30 inches.

ABBREVIATIONS
WOH - Weight of Hammer
WOR - Weight of Rod

REFERENCES
1. American Society for Materials and Testing (ASTM), 2011, ASTM D2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System).

UNIFIED SOIL CLASSIFICATION SYSTEM[1]

COARSE GRAINED SOILS (More than 50% retained on No. 200 Sieve)	**GRAVELS** (More than 50% of coarse fraction retained on No. 4 Sieve)	CLEAN GRAVEL WITH <5% FINES	**GW**	WELL-GRADED GRAVEL, WELL-GRADED GRAVEL WITH SAND
			GP	POORLY GRADED GRAVEL, POORLY GRADED GRAVEL WITH SAND
		GRAVELS WITH 5% TO 12% FINES	**GW-GM**	WELL-GRADED GRAVEL WITH SILT, WELL-GRADED GRAVEL WITH SILT AND SAND
			GW-GC	WELL-GRADED GRAVEL WITH CLAY (OR SILTY CLAY), WELL-GRADED GRAVEL WITH CLAY AND SAND (OR SILT CLAY AND SAND)
			GP-GM	POORLY GRADED GRAVEL WITH SILT, POORLY GRADED GRAVEL WITH SILT AND SAND
			GP-GC	POORLY GRADED GRAVEL WITH CLAY (OR SILTY CLAY), POORLY GRADED GRAVEL WITH CLAY AND (OR SILTY CLAY AND SAND)
		GRAVELS WITH > 12% FINES	**GM**	SILTY GRAVEL, SILTY GRAVEL WITH SAND
			GC	CLAYEY GRAVEL, CLAYEY GRAVEL WITH SAND
			GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL WITH SAND
	SANDS (50% or more of coarse fraction passes the No. 4 Sieve)	CLEAN SANDS WITH <5% FINES	**SW**	WELL-GRADED SAND, WELL-GRADED SAND WITH GRAVEL
			SP	POORLY GRADED SAND, POORLY GRADED SAND WITH GRAVEL
		SANDS WITH 5% TO 12% FINES	**SW-SM**	WELL-GRADED SAND WITH SILT, WELL-GRADED SAND WITH SILT AND GRAVEL
			SW-SC	WELL-GRADED SAND WITH CLAY (OR SILTY CLAY), WELL-GRADED SAND WITH CLAY AND GRAVEL (OR SILTY CLAY AND GRAVEL)
			SP-SM	POORLY GRADED SAND WITH SILT, POORLY GRADED SAND WITH SILT AND GRAVEL
			SP-SC	POORLY GRADED SAND WITH CLAY, POORLY GRADED SAND WITH CLAY AND GRAVEL (OR SILTY CLAY AND GRAVEL)
		SANDS WITH > 12% FINES	**SM**	SILTY SAND, SILTY SAND WITH GRAVEL
			SC	CLAYEY SAND, CLAYEY SAND WITH GRAVEL
			SC-SM	SILTY, CLAYEY SAND, SILTY, CLAYEY SAND WITH GRAVEL
FINE GRAINED SOILS (50% or more passes the No. #200 sieve)	SILTS AND CLAYS (Liquid Limit less than 50)		**ML**	SILT, SILT WITH SAND, SILT WITH GRAVEL
			CL	LEAN CLAY, LEAN CLAY WITH SAND, LEAN CLAY WITH GRAVEL
			CL-ML	SILTY CLAY, SILTY CLAY WITH SAND, SILTY CLAY WITH GRAVEL
			OL	ORGANIC CLAY, ORGANIC CLAY WITH SAND, ORGANIC CLAY WITH GRAVEL, ORGANIC SILT, ORGANIC SILT WITH SAND, ORGANIC SILT WITH GRAVEL
	SILTS AND CLAYS (Liquid Limit 50 or greater)		**MH**	ELASTIC SILT. ELASTIC SILT WITH SAND, ELASTIC SILT WITH GRAVEL
			CH	FAT CLAY, FAT CLAY WITH SAND, FAT CLAY WITH GRAVEL
			OH	ORGANIC CLAY, ORGANIC CLAY WITH SAND, ORGANIC CLAY WITH GRAVEL, ORGANIC SILT, ORGANIC SILT WITH SAND, ORGANIC SILT WITH GRAVEL

NOTE: USE MATERIAL DESCRIPTION ON THE LOG TO DEFINE A GRAPHIC THAT MAY NOT BE PROVIDED ON THIS LEGEND.

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GRAPHICS KEY

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

FIGURE
A-4

GRAIN SIZE[1]

DESCRIPTION		SIEVE SIZE	GRAIN SIZE
Boulders		>12 in.	>12 in. (304.8 mm.)
Cobbles		3 - 12 in.	3 - 12 in. (76.2 - 304.8 mm.)
Gravel	coarse	3/4 -3 in.	3/4 -3 in. (19 - 76.2 mm.)
	fine	#4 - 3/4 in.	0.19 - 0.75 in. (4.8 - 19 mm.)
Sand	coarse	#10 - #4	0.079 - 0.19 in. (2 - 4.9 mm.)
	medium	#40 - #10	0.017 - 0.079 in. (0.43 - 2 mm.)
	fine	#200 - #40	0.0029 - 0.017 in. (0.07 - 0.43 mm.)
Fines		Passing #200	<0.0029 in. (<0.07 mm.)

SECONDARY CONSTITUENT[1]

Term of Use	AMOUNT	
	Secondary Constituent is Fine Grained	Secondary Constituent is Coarse Grained
Trace	<5%	<15%
With	≥5 to <15%	≥15 to <30%
Modifier	≥15%	≥30%

PLASTICITY[1]

DESCRIPTION	CRITERIA
Non-Plastic	A 1/8 in. (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

MOISTURE CONTENT[1]

DESCRIPTION	FIELD TEST
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

CONSISTENCY - FINE-GRAINED SOIL[2, 3]

CONSISTENCY	SPT - N (# blows / ft)	Pocket Pen (tsf)	UNCONFINED COMPRESSIVE STRENGTH (Q_u)(psf)	VISUAL / MANUAL CRITERIA
Very Soft	<2	PP < 0.25	<500	Easily penetrated several inches by fist
Soft	2 - 4	0.25 ≤ PP <0.5	500 - 1,000	Easily penetrated several inches by thumb
Medium Stiff	4 - 8	0.5 ≤ PP <1	1,000 - 2,000	Can be penetrated several inches by thumb with moderate effort
Stiff	8 - 15	1 ≤ PP <2	2,000 - 4,000	Readily indented by thumb but penetrated only with great effort
Very Stiff	15 - 30	2 ≤ PP <4	4,000 - 8,000	Readily indented by thumbnail
Hard	>30	4 ≤ PP	>8,000	Indented by thumbnail with difficulty

APPARENT DENSITY - COARSE-GRAINED SOIL[2]

APPARENT DENSITY	SPT-N (# blows / ft)
Very Loose	<4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	>50

STRUCTURE[1]

DESCRIPTION	CRITERIA
Stratified	Alternating layers of varying material or color with layers at least 1/4-in. (6mm) thick, note thickness.
Laminated	Alternating layers of varying material or color with the layers less than 1/4-in. (6 mm) thick, note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout

ANGULARITY[1]

DESCRIPTION	CRITERIA
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

REACTION WITH HYDROCHLORIC ACID[1]

DESCRIPTION	FIELD TEST
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

CEMENTATION[1]

DESCRIPTION	FIELD TEST
Weakly	Crumbles or breaks with handling or little finger pressure
Moderately	Crumbles or breaks with considerable finger pressure
Strongly	Will not crumble or break with finger pressure

REFERENCES

1. American Society for Materials and Testing (ASTM), 2017, ASTM D2488: Standard Practice for Description and Identification of Soils (Visual Manual Procedures).
2. Terzaghi, K and Peck, R., 1948, Soil Mechanics in Engineering Practice, John Wiley & Sons, New York.
3. United States Department of the Interior Bureau of Reclamation (USBR), 1998, Earth Manual, Part I.

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SOIL DESCRIPTION KEY
(For additional tables, see ASTM D2488)

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

FIGURE
A-5

INFILLING TYPE[3]

NAME	ABBR	NAME	ABBR
Albite	Al	Muscovite	Mus
Apatite	Ap	None	No
Biotite	Bi	Pyrite	Py
Clay	Cl	Quartz	Qz
Calcite	Ca	Sand	Sd
Chlorite	Ch	Sericite	Ser
Epidote	Ep	Silt	Si
Gypsum	Gy	Talc	Ta
Iron Oxide	Fe	Unknown	Uk
Manganese	Mn		

DENSITY/SPACING OF DISCONTINUITIES[5]

DESCRIPTION	SPACING CRITERIA
Unfractured	>6 ft. (>1.83 meters)
Slightly Fractured	2 - 6 ft. (0.061 - 1.83 meters)
Moderately Fractured	8 in - 2 ft. (203.20 - 609.60 mm)
Highly Fractured	2 - 8 in (50.80 - 203.30 mm)
Intensely Fractured	<2 in (<50.80 mm)

ADDITIONAL TEXTURAL ADJECTIVES[5]

DESCRIPTION	RECOGNITION
Pit (Pitted)	Pinhole to 0.03 ft. (3/8 in.) (>1 to 10 mm.) openings
Vug (Vuggy)	Small openings (usually lined with crystals) ranging in diameter from 0.03 ft. (3/8 in.) to 0.33 ft. (4 in.) (10 to 100 mm.)
Cavity	An opening larger than 0.33 ft. (4 in.) (100 mm.), size descriptions are required, and adjectives such as small, large, etc., may be used
Honeycombed	If numerous enough that only thin walls separate individual pits or vugs, this term further describes the preceding nomenclature to indicate cell-like form.
Vesicle (Vesicular)	Small openings in volcanic rocks of variable shape and size formed by entrapped gas bubbles during solidification.

WEATHERING[5]

DESCRIPTION	CRITERIA
Unweathered	No evidence of chemical / mechanical alternation; rings with hammer blow.
Slightly Weathered	Slight discoloration on surface; slight alteration along discontinuities; <10% rock volume altered.
Moderately Weathered	Discoloring evident; surface pitted and alteration penetration well below surface; Weathering "halos" evident; 10-50% rock altered.
Highly Weathered	Entire mass discolored; Alteration pervading most rock, some slight weathering pockets; some minerals may be leached out.
Decomposed	Rock reduced to soil with relic rock texture/structure; Generally molded and crumbled by hand.

RELATIVE HARDNESS / STRENGTH DESCRIPTIONS[4]

GRADE		UCS	FIELD TEST
R0	Extremely Weak	0.25 - 1.0	Indented by thumbnail
R1	Very Weak	1.0 - 5.0	Crumbles under firm blows of geological hammer, can be peeled by a pocket knife.
R2	Weak	5.0 - 25	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.
R3	Medium Strong	25 - 50	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single firm blow of a geological hammer.
R4	Strong	50 - 100	Specimen requires more than one blow of geological hammer to fracture it.
R5	Very Strong	100 - 250	Specimen requires many blows of geological hammer to fracture it.
R6	Extremely Strong	> 250	Specimen can only be chipped with a geological hammer.

ROCK QUALITY DESIGNATION (RQD)[2]

DESCRIPTION	RQD (%)
Very Poor	0 - 25
Poor	25 - 50
Fair	50 - 75
Good	75 - 90
Excellent	90 - 100

APERTURE[1]

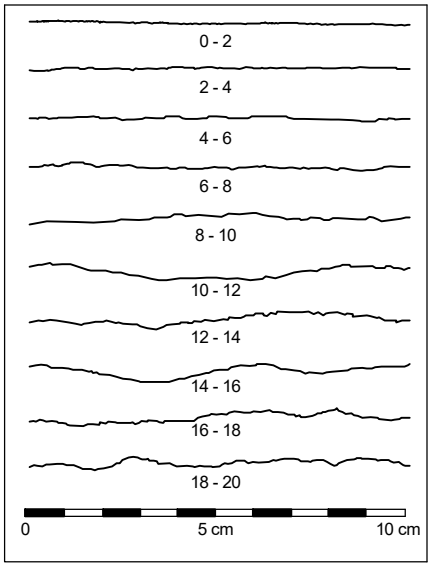
DESCRIPTION	CRITERIA [in (mm)]
Tight	<0.04 (<1)
Open	0.04 - 0.20 (1 - 5)
Wide	>0.20 (>5)

BEDDING CHARACTERISTICS[6]

DESCRIPTION	Thickness [in (mm)]
Very Thick Bedded	>36 (>915)
Thick Bedded	12 - 36 (305 - 915)
Moderately Bedded	4 - 12 (102 - 305)
Thin Bedded	1 - 4 (25 - 102)
Very Thin Bedded	0.4 - 1 (10 - 25)
Laminated	0.1 - 0.4 (2.5 - 10)
Thinly Laminated	<0.1 (<2.5)

Bedding Planes	Planes dividing the individual layers, beds, or stratigraphy of rocks.
Joint	Fracture in rock, generally more or less vertical or traverse to bedding.
Seam	Applies to bedding plane with unspecified degree of weather.

JOINT ROUGHNESS COEFFICIENT (JRC)[4]



RQD Rock-quality designation (RQD) Rough measure of the degree of jointing or fracture in a rock mass, measured as a percentage of the drill core in lengths of 4 in. (10 cm.) or more.

REFERENCES

1. Bieniawski, Z.T., 1989, Engineering Rock Mass Classifications. John Wiley & Sons, New York. (Mod. by Kleinfelder).
2. Deere, D.U., and Deere, D.W., 1989, Rock Quality Designation (RQD) After Twenty Years, USACE Contract Report GL-89-1.
3. Federal Highway Administration (FHWA), 2002, Subsurface Investigations, FHWA-NHI-01-031. (Mod. by Kleinfelder).
4. International Society for Rock Mechanics (ISRM), 1978, "Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses," International Joint Rock Mechanics and Mining Sciences & Geomechanics Abstracts, Vol. 15.
5. United States Army Corps of Engineers (USACE), 1994, Rock Foundations, EM 1110-1-2908, November 30, 1994.
6. United States Department of the Interior Bureau of Reclamation (USBR), 1998, Engineering Geology Field Manual, Volume 1.

CORE SAMPLER TYPE GRAPHICS

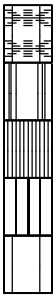
CORE SAMPLER

AQ CORE BARREL
(1.067 in. (27.1 mm.) core diameter)

AX CORE BARREL
(1.185 in. (30.1 mm.) core diameter)

BQ CORE BARREL
(1.433 in. (36.4 mm.) core diameter)

CONTINUOUS CORE SAMPLE
(2.000 in. (50.8 mm.) core diameter)



EX CORE BARREL
(0.846 in. (21.5 mm.) core diameter)

HQ CORE SAMPLE
(2.500 in. (63.5 mm.) core diameter)

NQ CORE SAMPLE
(1.874 in. (47.6 mm.) core diameter)

NO RECOVERY CORE SAMPLE

NX CORE SAMPLE
(2.154 in. (54.7 mm.) core diameter)

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PROJECT NO.: 20230052.006A

DRAWN BY: YZ

CHECKED BY: SYW

DATE: 3/30/2023

ROCK DESCRIPTION KEY

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

FIGURE

A-6

BORING LOG B-1

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17305° N
Longitude: -96.01973° E
Approximate Ground Surface Elevation (ft.): 812.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Sandy SILT (ML): brown, moist, loose to medium dense												
810															
			SANDSTONE: brown and reddish brown, extremely weak, weathered	SS-1		BC=50/4.25"	4"		11.1		100	27			
	5														
805															
	10														
800															

The boring was terminated at approximately 4 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.: 20230052.006A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 3/29/2023

BORING LOG B-1

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-1

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-2**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17327° N
Longitude: -96.01974° E
Approximate Ground Surface Elevation (ft.): 816.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
815			**Highly Weathered SANDSTONE**: brown, extremely weak												
			SANDSTONE: brown, extremely weak	SS-1		BC=50/5.75"	5"		11.1		100	43			
	5														
810															
	10														
805															

The boring was terminated at approximately 4 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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BORING LOG B-2

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-2

PAGE: 1 of 1

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-3**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			FIELD EXPLORATION: Latitude: 36.17353° N, Longitude: -96.01973° E, Approximate Ground Surface Elevation (ft.): 819.0, Surface Condition: Grass					LABORATORY RESULTS							
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: brown, extremely weak												
			SANDSTONE: brown, extremely weak	SS-1		BC=50/4"	4"		11.1		100	39			
815			The boring was terminated at approximately 3.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.												
	5														
810															
	10														
805															

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-3

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-3

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-4**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			FIELD EXPLORATION					LABORATORY RESULTS							
			Latitude: 36.17380° N Longitude: -96.01974° E Approximate Ground Surface Elevation (ft.): 820.0 Surface Condition: Grass												
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: brown, extremely weak												
			SANDSTONE: light brownish gray, extremely weak	SS-1		BC=50/4"	4"		10.5		100	45			
815	5														
810	10														

The boring was terminated at approximately 4 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
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DATE:	3/29/2023

BORING LOG B-4

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING

B-4

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-5**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17406° N
Longitude: -96.01974° E
Approximate Ground Surface Elevation (ft.): 820.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Sandy SILT (ML): brown and reddish brown, moist, medium dense												
				SS-1		BC=9 16 20	18"		14.1		100	54			
815	5		**Highly Weathered SILTSTONE**: brown, extremely weak												
			SANDSTONE: brown, extremely weak	SS-2		BC=50/2"	2"								
810	10														

The boring was terminated at approximately 6 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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DATE: 3/29/2023

BORING LOG B-5

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-5

BORING LOG B-6

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17434° N
Longitude: -96.01974° E
Approximate Ground Surface Elevation (ft.): 820.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Sandy SILT (ML): brown and reddish brown, moist, loose												
				SS-1		BC=3 2 5	18"		14.4		100	50			
815	5														
			SANDSTONE: brown, extremely weak	SS-2		BC=50/2.25"	2"								
810	10														

The boring was terminated at approximately 8 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
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DATE:	3/29/2023

BORING LOG B-6

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-6

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-7**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17460° N
Longitude: -96.01970° E
Approximate Ground Surface Elevation (ft.): 820.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Sandy SILT (ML): brown, moist to wet, very loose												
				SS-1		BC=WOH WOH WOH	12"		20.9		100	55			
815	5														
			SANDSTONE: brown, extremely weak	SS-2		BC=50/3"	3"								
810	10														

The boring was terminated at approximately 6.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
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CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-7

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-7

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-8**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Approximate Elevation (feet)	Depth (feet)	Graphical Log	FIELD EXPLORATION Latitude: 36.17488° N Longitude: -96.01970° E Approximate Ground Surface Elevation (ft.): 822.0 Surface Condition: Grass Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	LABORATORY RESULTS USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: brown, extremely weak												
820															
			SANDSTONE: brown, extremely weak	SS-1		BC=50/5"	5"		9.4		100	21			
	5														
815															
	10														
810															

The boring was terminated at approximately 4 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
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CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-8

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-8

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-9**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			Latitude: 36.17516° N Longitude: -96.01970° E Approximate Ground Surface Elevation (ft.): 823.0 Surface Condition: Grass												
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: brown and reddish brown, extremely weak												
820			**SANDSTONE**: brown and reddish brown, extremely weak	SS-1		BC=50/5.5"	5"		14.0		100	26			
	5														
815															
	10														
810															

The boring was terminated at approximately 4 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-9

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-9
PAGE: 1 of 1

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-10**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Latitude: 36.17544° N
Longitude: -96.01973° E
Approximate Ground Surface Elevation (ft.): 824.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: brown and reddish brown, extremely weak												
				SS-1		BC=30 50/3"	9"		22.4		100	35			
820			**SANDSTONE**: brown and reddish brown, extremely weak												
	5														
815															
	10														
810															

The boring was terminated at approximately 4.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.:	20230052.006A
DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-10

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-10

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-11**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Latitude: 36.17570° N
Longitude: -96.01973° E
Approximate Ground Surface Elevation (ft.): 824.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: light brown and brown, extremely weak												
				SS-1		BC=46 50/3"	9"		12.1		100	43			
820			**SANDSTONE**: light brown and brown, extremely weak												
	5														
815															
	10														
810															

The boring was terminated at approximately 4.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-11

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-11

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-12**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17598° N
Longitude: -96.01971° E
Approximate Ground Surface Elevation (ft.): 823.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: light brown and brown, extremely weak												
820				SS-1		BC=37 50/4.75"	10"		11.4		100	38			
			SANDSTONE: light brown and brown, extremely weak												
	5														
815															
	10														
810															

The boring was terminated at approximately 4.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-12

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-12

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-13**
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.16922° N
Longitude: -96.01988° E
Approximate Ground Surface Elevation (ft.): 804.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			ASPHALT: 14 inches												
			FILL - Silty Clayey SAND (SC-SM): brown with reddish brown and gray, moist, medium dense	SS-1		BC=10 6 6	18"	SC-SM	9.2		100	48	25	7	
800	5		**FILL - Sandy Lean CLAY (CL)**: brown with reddish brown and gray, moist, stiff	SS-2		BC=8 5 9	17"	CL	11.7		100	54	34	15	
795	10		**SILT (ML)**: light brown with light gray, moist, stiff to very stiff, reddish brown inclusions, micaceous inclusions, laminated, silty texture	SS-3		BC=8 9 13	18"	ML	15.1		100	92	47	18	
790	15		**Highly Weathered SHALE**: light brown with light gray, extremely weak, reddish brown inclusions, micaceous inclusions, laminated	SS-4		BC=27 44 50/5.5"	18"		10.0		100	89	41	14	
785	20		**SHALE**: gray with brown, extremely weak, with dark gray lenses, laminated, trace micaceous inclusions												
780															

The boring was terminated at approximately 16.5 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-13

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-13

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-14**
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.16949° N
Longitude: -96.01988° E
Approximate Ground Surface Elevation (ft.): 813.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			ASPHALT: 12 inches				
			Highly Weathered SANDSTONE: light grayish brown, extremely weak	SS-1		BC=12 19 16	12"
810							
			SANDSTONE: yellowish brown, very weak, with gray clay lenses, weakly cemented, trace micaceous inclusions	SS-2		BC=50/3"	3"
	5						
805				SS-3		BC=50/2"	2"
	10		- dark reddish brown below 11.5'				
800				SS-4		BC=50/1.5"	2"
	15						
795							
	20						
790							

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	12.7		100	33			

The boring was terminated at approximately 13.5 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-14

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-14
PAGE: 1 of 1

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-15**	
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION | LABORATORY RESULTS

Latitude: 36.16976° N
Longitude: -96.01988° E
Approximate Ground Surface Elevation (ft.): 827.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			ASPHALT: 10.5 inches												
			Highly Weathered SANDSTONE: brown with reddish brown and dark gray, extremely weak, trace micaceous inclusions	SS-1		BC=10 44 50/2.5"	12"		11.8		100	44			
825			**SANDSTONE**: light grayish brown, extremely weak, weathered, with reddish brown lenses, trace micaceous inclusions, weakly cemented												
	5			SS-2		BC=50/3"	3"		8.2		100	33			
820															
	10			SS-3		BC=50/2"	2"		9.8						
815															
	15		- becomes gray with light brown and reddish brown at 15.5'	SS-4		BC=50/3"	3"								
810															
	20			SS-5		BC=50/2"	2"				100	35			
805															

The boring was terminated at approximately 20 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-15

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-15

PAGE: 1 of 1

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-16**	
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17004° N
Longitude: -96.01987° E
Approximate Ground Surface Elevation (ft.): 836.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			ASPHALT: 10 inches				
835			**Highly Weathered SANDSTONE**: light brown with gray, extremely weak, trace micaceous inclusions	SS-1		BC=33 50/5"	11"
			SANDSTONE: light brown with gray, extremely weak, weathered, dark gray inclusions, sandy silty shale layer from 5' to 6', laminated				
	5			SS-2		BC=50/5.75""	6"
830							
	10			SS-3		BC=50/3"	3"
825							
	15			SS-4		BC=50/4.5"	5"
820							
	20			SS-5		BC=50/1.5"	2"
815							

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	12.2		100	37			

The boring was terminated at approximately 20 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-16

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-16

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-17**
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION | LABORATORY RESULTS

Latitude: 36.17031° N
Longitude: -96.01986° E
Approximate Ground Surface Elevation (ft.): 843.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			ASPHALT: 11 inches												
			Highly Weathered SANDSTONE: light gray with light brown and reddish brown, extremely weak, trace micaceous inclusions	SS-1		BC=33 50/5.75"	12"		10.7		100	30			
840			**SANDSTONE**: light gray with light brown, extremely weak												
	5		- ferrous staining and shale lenses at 5', weakly cemented	SS-2		BC=28 50/3.5"	10"				100	43			
835															
	10			SS-3		BC=50/4"	4"		10.1						
830															
	15			SS-4		BC=50/3.5"	4"								
825															
	20			SS-5		BC=50/1.5"	2"								
820															

The boring was terminated at approximately 20 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-17

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-17
PAGE: 1 of 1

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-18**	
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17059° N
Longitude: -96.01987° E
Approximate Ground Surface Elevation (ft.): 847.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			ASPHALT: 12 inches				
845			**Highly Weathered SANDSTONE**: light gray with light brown and reddish brown, extremely weak, trace micaceous inclusions	SS-1		BC=33 50/5"	11"
			SANDSTONE: light grayish brown, extremely weak, with rust mottling and trace micaceous inclusions, highly weathered				
	5		- dark gray inclusions starting at 5'	SS-2		BC=50/5.5"	6"
840							
	10		**SANDSTONE**: light grayish brown to light brown, extremely weak, weathered	SS-3		BC=50/2.5"	3"
835							
	15			SS-4		BC=50/5"	5"
830							
	20			SS-5		BC=50/2.25"	2"
825							

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	10.9		100	31			

The boring was terminated at approximately 20 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-18

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-18
PAGE: 1 of 1

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-19**
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17086° N
Longitude: -96.01985° E
Approximate Ground Surface Elevation (ft.): 847.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			ASPHALT: 11.5 inches				
			Highly Weathered SANDSTONE: light gray with light brown and reddish brown, extremely weak, trace micaceous inclusions	SS-1		BC=28 50/5.25"	11"
845			**SANDSTONE**: light brown with light gray, extremely weak, reddish brown mottling, trace micaceous inclusions				
	5			SS-2		BC=50/5.5"	6"
840							
	10		**SANDSTONE**: light brown with light gray, extremely weak, with reddish brown lenses interbedded throughout	SS-3		BC=50/4.75"	5"
835							
	15			SS-4		BC=50/3.5"	4"
830							
	20		- dark reddish brown and dark gray lenses at 20'	SS-5		BC=50/3.5"	4"
825			The boring was terminated at approximately 20.5 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.				

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	8.6		100	34			

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.: 20230052.006A
DRAWN BY: YZ
CHECKED BY: SYW
DATE: 3/29/2023

BORING LOG B-19

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-19
PAGE: 1 of 1

Date Begin - End:	2/10/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-20**	
Logged By:	Y. Zhang	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17114° N
Longitude: -96.01994° E
Approximate Ground Surface Elevation (ft.): 850.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			TOPSOIL: 6 inches	SS-1		BC=2 4 7	16"
			Silty SAND (SM): light brown, moist, medium dense, trace clay, fine roots				
			- becomes harder at 2.5'				
845	5		**SANDSTONE**: light grayish brown, extremely weak, weathered	SS-2		BC=50/3"	3"
840	10			SS-3		BC=50/5.5"	6"
835	15		- becomes more coarse at 15'	SS-4		BC=50/3.5"	4"
830	20						

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	15.7		100	30			

The boring was terminated at approximately 15.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 10, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-20

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-20

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-21**
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17141° N
Longitude: -96.01985° E
Approximate Ground Surface Elevation (ft.): 846.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
845	0		**ASPHALT**: 12 inches				
			Highly Weathered SANDSTONE: light grayish brown with reddish brown, extremely weak, trace micaceous inclusions	SS-1		BC=26 50/5.75"	12"
	5			SS-2		BC=37 50/1.5"	8"
840			**SANDSTONE**: light grayish brown, very weak, weathered, weakly cemented				
	10			SS-3		BC=50/2.75"	3"
835							
	15		- trace water at 15'	SS-4		BC=50/4"	4"
830			- becomes lighter in color at 18'				
	20			SS-5		BC=50/3.5"	2"
825			The boring was terminated at approximately 20 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.				

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	8.4		100	23			

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-21

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-21
PAGE: 1 of 1

Date Begin - End:	2/10/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-22**
Logged By:	Y. Zhang	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17167° N
Longitude: -96.01993° E
Approximate Ground Surface Elevation (ft.): 849.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: dark brown, moist, 5 inches	SS-1		BC=3 4 3	16"		14.8		100	28			
			Sandy SILT (ML): light grayish brown with brown, moist, loose												
845			**SANDSTONE**: light grayish brown, very weak												
	5			SS-2		BC=50/3.5"	4"								
			- silty texture starting at 8'												
840															
	10			SS-3		BC=50/2.75"	3"								
835															
	15		- ferrous inclusions and rust staining at 15', becomes dark gray and dark reddish brown inclusions below 16'	SS-4		BC=50/4"	4"		9.8		100	36			
830															
	20			SS-5		BC=50/3.5"	4"								
825															
	25		- light gray at 25'	SS-6		BC=50/2.5"	3"								
820															

The boring was terminated at approximately 25 ft. below ground surface. The boring was backfilled with auger cuttings on February 10, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.: 20230052.006A
DRAWN BY: YZ
CHECKED BY: SYW
DATE: 3/29/2023

BORING LOG B-22

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-22
PAGE: 1 of 1

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-23**	
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION | LABORATORY RESULTS

Latitude: 36.17196° N
Longitude: -96.01985° E
Approximate Ground Surface Elevation (ft.): 836.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			ASPHALT: 9 inches												
835			**Highly Weathered SANDSTONE**: brown with light gray to reddish brown, extremely weak	SS-1		BC=50/5"	5"		7.7		100	22			
			- becomes light grayish brown with rust mottling and ferrous inclusions at 2'												
	5			SS-2		BC=26 50/5"	11"								
830															
	10			SS-3		BC=50/1.5"	2"								
825			- becomes gray with light brown at 13'												
	15			SS-4		BC=46 50/2"	6"		9.9		100	59			
820			**SILTSTONE**: light brown with gray to orange with reddish brown, extremely weak												
			- becomes brown with reddish brown with trace micaceous inclusion at 18'												
	20			SS-5		BC=50/3"	3"								
815															
	25			SS-6		BC=50/1.5"	2"								
810			The boring was terminated at approximately 25 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.												

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-23

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-23

PAGE: 1 of 1

Date Begin - End:	2/10/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-24**
Logged By:	Y. Zhang	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17213° N
Longitude: -96.01996° E
Approximate Ground Surface Elevation (ft.): 833.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
833	0		**TOPSOIL**: 3 inches	SS-1		BC=2 6 6	16"		12.3		100	22			
			Silty SAND (SM): brown to light grayish brown with orange, moist, medium dense												
830															
	5		**SANDSTONE**: light gray with light brown, extremely weak, weathered, weakly cemented	SS-2		BC=50/5"	5"								
825															
	10		**SILTSTONE**: light grayish brown, extremely weak, weathered, weakly cemented, ferrous inclusions, rust mottling	SS-3		BC=50/3.5"	4"								
820															
	15			SS-4		BC=50/2.5"	3"								
815															
	20			SS-5		BC=50/2.5"	3"		8.1		100	16			
810															

The boring was terminated at approximately 20 ft. below ground surface. The boring was backfilled with auger cuttings on February 10, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-24

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-24

Date Begin - End:	2/09/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-25**
Logged By:	Y. Zhang	**Drill Crew:**	H. Wilson		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	CME-550X	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	77%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION | LABORATORY RESULTS

Latitude: 36.17252° N
Longitude: -96.01985° E
Approximate Ground Surface Elevation (ft.): 813.0
Surface Condition: Asphalt

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			ASPHALT: 9 inches												
			AGGREGATE BASE: 3 inches	SS-1		BC=15	14"		13.2		100	40			
			Silty SAND (SM): reddish brown with brown and gray, moist, medium dense, trace clay, possible fill			11 9									
810															
	5		**SANDSTONE**: light brown with gray, extremely weak, weathered, weakly cemented	SS-2		BC=50/2"	2"								
805															
	10			SS-3		BC=50/3"	3"								
800															
	15														
795															

The boring was terminated at approximately 10.5 ft. below ground surface. The boring was backfilled with auger cuttings and patched at surface on February 09, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.
GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.: 20230052.006A	BORING LOG B-25		BORING
DRAWN BY: YZ	25th W. Avenue Widening Retaining Walls Gilcrease Museum Tulsa, Oklahoma		B-25
CHECKED BY: SYW			
DATE: 3/29/2023			PAGE: 1 of 1

Date Begin - End:	2/10/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-26**
Logged By:	Y. Zhang	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17278° N
Longitude: -96.01991° E
Approximate Ground Surface Elevation (ft.): 812.0
Surface Condition: Bare Earth and Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 2 inches, underlain by 2.5-inch paver stone	SS-1		BC=15 4 3	16"		13.0		100	43			
			FILL - Silty SAND (SM): light brown, moist, loose, with gray clay and trace sandstone gravel												
810			**Sandy SILT (ML)**: light brown, moist to wet, very loose to loose												
	5		- becomes wet at 5', trace clay, rust mottling	SS-2		BC=WOH WOH WOH	18"		21.7		100	53			
805															
	10		**Sandy SILT (ML)**: light brown with light gray and reddish brown, wet, medium stiff	SS-3		BC=3 4 4	18"		21.3		100	55			
800															
	15														
795															

The boring was terminated at approximately 11.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 10, 2023.

GROUNDWATER LEVEL INFORMATION:
▽ Groundwater was observed at approximately 5 ft. below ground surface during drilling.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	YZ
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-26

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-26

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-27**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17295° N
Longitude: -96.01991° E
Approximate Ground Surface Elevation (ft.): 812.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
810			**Silty SAND (SM)**: brown and light brownish gray, moist, medium dense												
				SS-1		BC=10 20 23	18"		13.9		100	72			
	5		**Highly Weathered SILTSTONE**: brown and light brownish gray, extremely weak												
805															
	10														
800															
	15														
795															

The boring was terminated at approximately 5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.:	20230052.006A
DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-27

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-27

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-28**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17329° N
Longitude: -96.01990° E
Approximate Ground Surface Elevation (ft.): 827.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			TOPSOIL: 6 inches				
			Silty SAND (SM): light brownish gray and reddish brown, moist, medium dense				
825				SS-1		BC=10 12 16	18"
	5		**Highly Weathered SILTSTONE**: light brownish gray, extremely weak				
820				SS-2		BC=26 34 50/4"	16"
	10		**SANDSTONE**: light brownish gray, extremely weak				
815				SS-3		BC=50/5.25"	5"
	15						
810							

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	12.5		100	56			

The boring was terminated at approximately 14 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.: 20230052.006A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 3/29/2023

BORING LOG B-28

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-28
PAGE: 1 of 1

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-29**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17357° N
Longitude: -96.01990° E
Approximate Ground Surface Elevation (ft.): 833.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
833	0		**TOPSOIL**: 6 inches				
			Highly Weathered SILTSTONE: reddish brown and light brownish gray, extremely weak				
830				SS-1		BC=50/5.5"	5"
	5						
825				SS-2		BC=32 50/4.25"	10"
			- becomes interbedded with sandstone layers below 9'				
	10						
820				SS-3		BC=49 50/2"	8"
	15						
815			**SANDSTONE**: reddish brown and gray, extremely weak	SS-4		BC=50/4"	4"
	20						
810							

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	10.9		100	68			
	12.0		100	78			

The boring was terminated at approximately 19 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.:	20230052.006A
DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-29

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-29

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-30**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17380° N
Longitude: -96.01989° E
Approximate Ground Surface Elevation (ft.): 829.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Highly Weathered SANDSTONE: light brown and reddish brown, extremely weak												
825	5			SS-1		BC=50/5.75"	5"		8.5		100	27			
				SS-2		BC=47 50/1"	7"								
820	10		**SANDSTONE**: light brownish gray, extremely weak												
				SS-3		BC=50/2.75"	2"								
815	15		The boring was terminated at approximately 13.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.												
810															

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.: 20230052.006A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 3/29/2023

BORING LOG B-30

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-30

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-31**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Latitude: 36.17403° N
Longitude: -96.01991° E
Approximate Ground Surface Elevation (ft.): 821.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
820			**SILT with Sand (ML)**: brown and reddish brown, moist, medium dense												
				SS-1		BC=8 17 50/3"	15"		14.5		100	74			
			Highly Weathered SILTSTONE: brown and reddish brown, extremely weak												
	5														
815															
	10														
810															

The boring was terminated at approximately 5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

KLEINFELDER
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PROJECT NO.: 20230052.006A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 3/29/2023

BORING LOG B-31

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-31
PAGE: 1 of 1

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-32**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17435° N
Longitude: -96.01990° E
Approximate Ground Surface Elevation (ft.): 822.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
820			**Highly Weathered SANDSTONE**: reddish brown and light grayish brown, extremely weak	SS-1		BC=26 28 24	18"		12.1		100	44			
	5														
815															
	10														
810															

The boring was terminated at approximately 5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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DRAWN BY:	BAG
CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-32

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-32

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-33**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Latitude: 36.17464° N
Longitude: -96.01989° E
Approximate Ground Surface Elevation (ft.): 825.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			Silty SAND (SM): reddish brown, moist, loose to medium dense	SS-1		BC=8 20 38	18"		8.2		100	75			
820	5		**Highly Weathered SILTSTONE**: reddish brown and light brownish gray, extremely weak												
			SANDSTONE: brown, extremely weak	SS-2		BC=50/4.25"	4"								
815	10														

The boring was terminated at approximately 9 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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CHECKED BY:	SYW
DATE:	3/29/2023

BORING LOG B-33

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
B-33

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		**BORING LOG B-34**
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

Latitude: 36.17490° N
Longitude: -96.01988° E
Approximate Ground Surface Elevation (ft.): 827.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
825			**SILT with Sand (ML)**: light brownish gray and reddish brown, moist, medium dense	SS-1		BC=7 9 20	18"	ML	13.5		100	76	30	7	
	5		**Highly Weathered SILTSTONE**: light brownish gray, extremely weak												
820															
			SANDSTONE: reddish brown, extremely weak	SS-2		BC=50/4"	4"								
	10		The boring was terminated at approximately 9 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.												
815															

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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DATE:	3/29/2023

BORING LOG B-34

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING
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PAGE: 1 of 1

BORING LOG B-35

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing		
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17520° N
Longitude: -96.01988° E
Approximate Ground Surface Elevation (ft.): 828.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)
			TOPSOIL: 6 inches				
			Sandy SILT (ML): light brownish gray and reddish brown, moist, loose to medium dense				
825				SS-1		BC=4 12 28	18"
	5		**Highly Weathered SILTSTONE**: brown, extremely weak				
820							
			SANDSTONE: brown, extremely weak	SS-2		BC=50/3.25"	3"
815	10						

LABORATORY RESULTS

USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
	16.8		100	61			

The boring was terminated at approximately 9 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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BORING LOG B-35

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

BORING

B-35

Date Begin - End:	2/06/2023	**Drilling Company:**	Aimright Testing	**BORING LOG B-36**	
Logged By:	B. Goben	**Drill Crew:**	P. Scarborough		
Hor.-Vert. Datum:	Not Available	**Drilling Equipment:**	Diedrich D-50	**Hammer Type - Drop:**	140 lb. Auto - 30 in.
Plunge:	-90 degrees	**Drilling Method:**	Solid Flight Auger	**Hammer Efficiency:**	78.7%
Weather:	Not Available	**Exploration Diameter:**	6 in. O.D.	**Hammer Cal. Date:**	2/02/2023

FIELD EXPLORATION

Latitude: 36.17549° N
Longitude: -96.01989° E
Approximate Ground Surface Elevation (ft.): 827.0
Surface Condition: Grass

Approximate Elevation (feet)	Depth (feet)	Graphical Log	Lithologic Description	Sample Number	Sample Type	Blow Counts(BC)= Uncorr. Blows/6 in.	Recovery (NR=No Recovery)	USCS Symbol	Water Content (%)	Dry Unit Wt. (pcf)	Passing #4 (%)	Passing #200 (%)	Liquid Limit	Plasticity Index (NP=NonPlastic)	Additional Tests/ Remarks
			TOPSOIL: 6 inches												
			SILT with Sand (ML): brown and reddish brown, moist, medium dense												
825				SS-1		BC=10 10 19	18"		14.7		100	75			
	5		**Highly Weathered SANDSTONE**: brown and reddish brown, extremely weak												
820				SS-2		BC=45 50/5"	11"								
			SANDSTONE: brown and reddish brown, extremely weak												
	10		The boring was terminated at approximately 9.5 ft. below ground surface. The boring was backfilled with auger cuttings on February 06, 2023.												
815															

GROUNDWATER LEVEL INFORMATION:
Groundwater was not observed during drilling or after completion.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
A Handheld GPS unit was used to locate the exploration with an accuracy of 15 feet.

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PROJECT NO.: 20230052.006A
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BORING LOG B-36

25th W. Avenue Widening Retaining Walls
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Appendix B

LABORATORY TESTING PROGRAM

Laboratory tests were performed on select, representative samples to evaluate pertinent engineering properties of these materials. We directed our laboratory testing program primarily toward classifying the subsurface materials and measuring index values of the on-site materials. Laboratory tests were performed in general accordance with applicable standards. The results of the laboratory tests are presented on the respective boring logs. The laboratory testing program consisted of the following:

- **Moisture Content**, AASHTO T 265, Standard Method of Test for Laboratory Determination of Moisture Content of Soils.
- **Soil Classification:**
  - AASHTO T 87, Standard Method of Test for Dry preparation of Disturbed Soil and Soil Aggregate Samples for Test.
  - AASHTO T 88, Standard Method of Test for Particle Size Analysis of Soils.
  - AASHTO T 89, Standard Method of Test for Determining the Liquid Limit of Soils.
  - AASHTO T 90, Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils.
- **Visual Classification,** ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

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Exploration ID	Depth (ft.)	Sample No.	Sample Description	USCS	AASHTO	OKLAHOMA SOIL INDEX (OSI)	Water Content (%)	Atterberg Limits			Sieve Analysis (%)				
								Liquid Limits	Plastic Limits	Plasticity Index	Passing #4	Passing #10	Passing #40	Passing #100	Passing #200
B-1	3.5 - 5.0	SS-1			A-2-4		11.1				100	100	100	100	27
B-2	3.5 - 5.0	SS-1			A-4		11.1				100	100	91		43
B-3	3.0 - 4.5	SS-1			A-4		11.1				100	100	42		39
B-4	3.5 - 5.0	SS-1			A-4		10.5				100	100	89		45
B-5	3.5 - 5.0	SS-1			A-4		14.1				100	100	96		54
B-6	3.5 - 5.0	SS-1			A-4		14.4				100	100	93		50
B-7	3.5 - 5.0	SS-1			A-4		20.9				100	100	95		55
B-8	3.5 - 5.0	SS-1			A-2-4		9.4				100	100	77		21
B-9	3.5 - 5.0	SS-1			A-2-4		14.0				100	100	96		26
B-10	3.5 - 5.0	SS-1			A-2-4		22.4				100	100	95		35
B-11	3.5 - 5.0	SS-1			A-4		12.1				100	100	90		43
B-12	3.5 - 5.0	SS-1			A-4		11.4				100	100	94		38
B-13	1.16 - 2.6	SS-1	SILTY, CLAYEY SAND	SC-SM	A-4		9.2	25	18	7	100	100	79		48
B-13	5.0 - 6.5	SS-2	SANDY LEAN CLAY	CL	A-6		11.7	34	19	15	100	100	79		54
B-13	10.0 - 11.5	SS-3	SILT	ML	A-7-6		15.1	47	29	18	100	100	97		92
B-13	15.0 - 15.5	SS-4	SILT	ML	A-7-6		10.0	41	27	14	100	100	96		89
B-14	1.0 - 2.5	SS-1			A-2-4		12.7				100	100	98		33
B-15	1.0 - 2.5	SS-1			A-4		11.8				100	100	96		44
B-15	5.0 - 5.5	SS-2			A-2-4		8.2				100	100	95		33
B-15	10.0 - 10.5	SS-3					9.8								
B-15	20.0 - 20.5	SS-5			A-2-4						100	100	98		35
B-16	1.0 - 2.0	SS-1			A-4		12.2				100	100	98		37
B-17	1.0 - 2.0	SS-1			A-2-4		10.7				100	100	99		30
B-17	5.0 - 6.0	SS-2			A-4						100	100	99		43
B-17	10.0 - 10.5	SS-3					10.1								
B-18	1.0 - 2.0	SS-1			A-2-4		10.9				100	100	100	100	31
B-19	1.0 - 2.0	SS-1			A-2-4		8.6				100	100	100	100	34
B-20	0.0 - 1.5	SS-1			A-2-4		15.7				100	100	98		30

Refer to the Geotechnical Evaluation Report or the supplemental plates for the method used for the testing performed above.
NP = Nonplastic
NA = Not Available

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LABORATORY TEST RESULT SUMMARY

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

TABLE
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Exploration ID	Depth (ft.)	Sample No.	Sample Description	USCS	AASHTO	OKLAHOMA SOIL INDEX (OSI)	Water Content (%)	Atterberg Limits			Sieve Analysis (%)				
								Liquid Limits	Plastic Limits	Plasticity Index	Passing #4	Passing #10	Passing #40	Passing #100	Passing #200
B-21	1.5 - 2.5	SS-1			A-2-4		8.4				100	100	94		23
B-22	0.0 - 1.5	SS-1			A-2-4		14.8				100	100	97		28
B-22	15.0 - 15.5	SS-4			A-4		9.8				100	100	96		36
B-23	0.75 - 1.6	SS-1			A-2-4		7.7				100	100	98		22
B-23	15.0 - 16.0	SS-4			A-4		9.9				100	100	85		59
B-24	0.0 - 1.16	SS-1			A-2-4		12.3				100	100	95		22
B-24	20.0 - 20.5	SS-5			A-2-4		8.1				100	100	84		16
B-25	0.75 - 1.16	SS-1			A-4		13.2				100	100	95		40
B-26	0.0 - 1.5	SS-1			A-4		13.0				100	100	93		43
B-26	5.0 - 6.5	SS-2			A-4		21.7				100	100	99		53
B-26	10.0 - 11.5	SS-3			A-4		21.3				100	100	97		55
B-27	3.5 - 5.0	SS-1			A-4		13.9				100	100	98		72
B-28	3.5 - 5.0	SS-1			A-4		12.5				100	100	92		56
B-29	3.5 - 4.0	SS-1			A-4		10.9				100	100	98		68
B-29	8.5 - 9.5	SS-2			A-4		12.0				100	100	97		78
B-30	3.5 - 4.0	SS-1			A-2-4		8.5				100	100	96		27
B-31	3.5 - 5.0	SS-1			A-4		14.5				100	100	96		74
B-32	3.5 - 5.0	SS-1			A-4		12.1				100	100	95		44
B-33	3.5 - 5.0	SS-1			A-4		8.2				100	100	95		75
B-34	3.5 - 5.0	SS-1	SILT WITH SAND	ML	A-4		13.5	30	23	7	100	100	95		76
B-35	3.5 - 5.0	SS-1			A-4		16.8				100	100	96		61
B-36	3.5 - 5.0	SS-1			A-4		14.7				100	100	94		75

Refer to the Geotechnical Evaluation Report or the supplemental plates for the method used for the testing performed above.
NP = Nonplastic
NA = Not Available

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LABORATORY TEST RESULT SUMMARY

25th W. Avenue Widening Retaining Walls
Gilcrease Museum
Tulsa, Oklahoma

TABLE
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Appendix C

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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