REPORT OF SUBSURFACE EXPLORATION
AND GEOTECHNICAL EVALUATION
CHEROKEE NATION FOOD DISTRIBUTION CENTER EXPANSION
JAY, OKLAHOMA
BUILDING & EARTH PROJECT NO.: TU220026

PREPARED FOR:
Childers Architect

MARCH 11, 2022

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

1403 South 70th East Avenue
Tulsa, OK 74112
Ph: (918) 439-9005
www.BuildingAndEarth.com

March 11, 2022

Childers Architect
45 South 4th Street
Fort Smith, Arkansas 72901

Attention: Mr. J. Breck Childers, AIA

Subject: Report of Subsurface Exploration and Geotechnical Evaluation
Cherokee Nation Food Distribution Center (FDC) Expansion
Jay, Oklahoma
Building & Earth Project No: TU220026

Dear Mr. Childers:

Building & Earth Sciences, Inc. has completed the authorized subsurface exploration and geotechnical engineering evaluation for the for the above referenced project in Jay, Oklahoma.

The purpose of this exploration and evaluation was to determine general subsurface conditions at the site and to address applicable geotechnical aspects of the proposed construction and site development. The recommendations in this report are based on a physical reconnaissance of the site and observation and classification of samples obtained from four (4) test borings conducted at the site. Confirmation of the anticipated subsurface conditions during construction is an essential part of geotechnical services.

We appreciate the opportunity to provide consultation services for the proposed project. If you have any questions regarding the information in this report or need any additional information, please call us.

Respectfully Submitted,
BUILDING & EARTH SCIENCES, INC.
Certificate of Authorization #3975, Expires 6/30/2022

M. Dharmateja

MARCO V.
VICENTE SILVESTRE
PE21903
3/11/2022

Dharmateja Maganti, E.I.T.
Project Manager

Marco V. Vicente Silvestre, P.G., P.E.
Regional Vice President – Principal
OK: 21903

cc: Mr. Chase Myska - Draftsman

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APPENDIX

1.0 PROJECT & SITE DESCRIPTION

The subject site is located at 1260 North Industrial Park Road in Jay, Oklahoma. General information relative to the proposed site and the proposed development is listed in Table 1 below. Google Earth satellite imagery of the site and photographs depicting the current site conditions are presented on the following pages.

Development Item	Detail	Description
General Site	Size (Ac.)	Approx. 1.3
	Existing Development	Cherokee Nation Food Distribution Center with associated parking area
	Vegetation	The building addition area was covered with grass and topsoil. Areas to the south and west of existing FDC building was covered with asphaltic concrete pavement
	Slopes	Planned building addition area was relatively flat, with a grade differential of less than 2 feet
	Retaining Walls	No retaining walls were noted in the area
	Drainage	Natural surface drainage
	Cuts & Fills	Fill of up to 2 feet to achieve design grades (see note 2)
Proposed Buildings	No. of Bldgs	One (1)
	Square Ft.	Cooler/Freezer – 1,584
	Stories	Single-story
	Construction	Pre-engineered metal building with light-gauge steel framing
	Wall Loads	Less than 50 kips (assumed)
	Bearing Wall Spacing	Less than 2 kips per linear foot (assumed)
	Preferred Foundation	Conventional shallow foundation (assumed)
	Preferred Slab	Slab-on-grade (assumed)
Pavements	Traffic	Not Provided
	Standard Duty	Rigid, 135,000 ESALs (assumed)

Table 1: Project and Site Description

Reference:

- Overall Floor Plan, FDC 65% construction document, prepared by James R. Childers Architect, Inc., dated 12/10/2021
- Survey Plan, provided by James R. Childers Architect, Inc., dated 9/24/21

Table 1 Notes:

- If actual loading conditions exceed assumed loads, Building & Earth should be allowed to review proposed structural design and its effects on our recommendations for foundation design.
- A site grading plan was not available at the time of this report. Based on information provided to our office, we understand that the finished floor of the planned addition will match the finished floor of the existing building, requiring fill depths of less than 2 feet to achieve design grades. When a grading plan is finalized, Building & Earth should be allowed to review the plan and its effects on our recommendations.
- Based on information provided to our office by Mr. Chase Myska, we understand that the existing pavements will be demolished and reconstructed using Portland Cement Concrete.

Figure 1: Approximate location of the project area (Google Earth, dated October 2017)

At the time of our site reconnaissance, the existing facility was an active food distribution center. The parking lots consisted of asphaltic concrete on the west and south sides of the existing building. Underground utility markings comprised of sewer and electric were noted to the east of the planned addition area. Equipment pads were also noted within the planned addition area.

Figure 2: East side of existing facility, looking North

Figure 3: East side of existing facility, looking northwest at proposed cooler/freezer area

Figure 4: West side of existing facility, looking Southeast

2.0 SCOPE OF SERVICES

The authorized subsurface exploration was performed on February 16, 2022, in conformance with our proposal TU24038, dated February 2, 2022. Notice to proceed was provided by signing and returning the proposal on February 4, 2022.

The purpose of the geotechnical exploration was to determine general subsurface conditions at specific boring locations and to gather data on which to base a geotechnical evaluation with respect to the proposed construction. The subsurface exploration for this project consisted of four (4) test borings. The site was drilled using a Diedrich D-50 track mounted drill rig equipped with hollow stem augers and an automatic hammer.

The boring locations were determined in the field by a representative of our staff using handheld GPS equipment. As such, the boring locations shown on the Boring Location Plan attached to this report should be considered approximate.

The samples recovered during our site investigation were visually classified and specific samples were selected by the project engineer for laboratory analysis. The laboratory analysis consisted of:

Test	ASTM	No. of Tests
Natural Moisture Content	D2216	14
Atterberg Limits	D4318	3
Material Finer Than No. 200 Sieve by Washing	D1140	1

Table 2: Scope of Laboratory Tests

The results of the laboratory analysis are presented on the enclosed Boring Logs and in tabular form in the Appendix of this report. Descriptions of the laboratory tests that were performed are also included in the Appendix.

The information gathered from the exploration was evaluated to determine a suitable foundation type for the proposed addition. The information was also evaluated to help determine if any special subgrade preparation procedures will be required during the earthwork phase of the project.

The results of the work are presented within this report that addresses:

- General site geology.
- Summary of existing surface conditions.
- A description of the subsurface conditions encountered at the boring locations.
- A description of the groundwater conditions observed in the boreholes during drilling. Long-term monitoring was not included in the scope of work.
- Presentation of laboratory test results.
- Site preparation considerations including material types to be expected at the site, treatment of any encountered unsuitable soils, excavation considerations, and surface drainage.
- Recommendations to be used for shallow foundation design, including appropriate bearing material types, bearing pressure, and depths.
- Presentation of expected total and differential settlements.
- Recommendations to be used for design of slabs-on-grade, including modulus of subgrade reaction.
- Seismic Site Classification per IBC 2015 based on SPT test boring information.
- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommended typical minimum rigid pavement sections based on assumed traffic loading conditions.

3.0 GEOTECHNICAL SITE CHARACTERIZATION

The following discussion is intended to create a general understanding of the site from a geotechnical engineering perspective. It is not intended to be a discussion of every potential geotechnical issue that may arise, nor to provide every possible interpretation of the conditions identified. The following conditions and subsequent recommendations assume that significant changes in subsurface conditions do not occur between boreholes. However, anomalous conditions can occur due to variations in existing fill or the geologic conditions at the site, and it will be necessary to evaluate the assumed conditions during site grading and foundation installation.

3.1 GENERAL SITE GEOLOGY

According to the Oklahoma State Geologic Map published by the United States Geological Survey (USGS), the subject site is underlain by Early Mississippian age, Keokuk Formation. The Keokuk formation is noted to consist of chert and limestone. The conditions encountered at the project site correlate with residuum associated with the Keokuk Formation.

3.2 EXISTING SURFACE CONDITIONS

At the time of our subsurface exploration, the planned building addition area was covered with grass and topsoil that had a thickness of about 2 inches.

The ground surface at boring locations P-01 and P-02 was covered with asphalt that was approximately 3 and 5.5 inches in thickness. Aggregate base was encountered below the asphalt pavement that was about 3 to 5 inches thick.

The topsoil conditions and pavement thicknesses reported apply only to the specific boring locations. It should be noted that topsoil and pavement thicknesses likely vary at unexplored locations of the project site. No testing has been performed to verify that soils meet the requirements of “topsoil”. For this report, topsoil is defined as the soil horizon which contains the root mat of the noted vegetation.

3.3 SUBSURFACE CONDITIONS

A generalized stratification summary has been prepared using data from the test borings and is presented in the table below. The stratification depicts the general soil and rock conditions and stratum types encountered during our field investigation.

Stratum No.	Typical Thickness	Description	Consistency/Relative Density	Lab Testing Data [(2)]
1	1.3′ (Encountered in boring P-01 only)	**Possible Fill:** Lean to Fat Clay (CL-CH) with tree roots and wood Yellowish brown and brown in color	Medium stiff to stiff	*Moisture content: 25%*
2	2.7 to 4.8′	**Clay Residuum:** Lean Clay (CL) and Lean to Fat Clay (CL-CH) with fine roots and chert fragments Brown, dark reddish brown and black in color	Soft to medium stiff clays within the upper 1 to 1.5 feet Medium stiff to very stiff below 1.5 feet	*Atterberg Limits: LL = 37 to 48 PI = 18 to 26* *Moisture contents: 21 to 28%* *Passing #200 Sieve: 83%*
3 (1)	Termination Layer	**Gravelly Residuum:** Clayey Chert Gravel (GC) with clay seams and layers, and chert cobbles and boulders Various shades and combinations of yellow, brown, white, and red	Dense to very dense chert gravel	*Moisture contents: 9 to 24%*

Table 3: Stratification Summary

Notes:

(1) All borings terminated within this stratum at depths ranging between 6.5 and 15 feet.
(2) For Atterberg Limits: LL = Liquid Limit, and PI = Plasticity Index

A subsurface profile has been prepared based on the data obtained at the specific boring locations and is presented in the Appendix. For specific details on the information obtained from individual borings, refer to Boring Logs in the Appendix. The ground surface elevations at the boring locations indicated in this report were estimated from contour lines shown on the provided topographic survey plan and should be considered approximate.

3.3.1 GROUNDWATER

Groundwater was not encountered in the borings during drilling, and they were dry at completion of drilling operations and prior to backfilling.

Water levels reported are accurate only for the time and date that the borings were drilled. Long term monitoring of the boreholes was not included as part of our subsurface exploration. The borings were backfilled the same day that they were drilled.

3.4 SEISMIC SITE CLASSIFICATION

Basis of Evaluation	Recommended Site Classification
2015 International Building Code (IBC) and ASCE 7, Chapter 20	C
This recommended seismic site classification is based on the 2015 Edition of the International Building Code, the subsurface conditions encountered in the borings, and our knowledge of the geologic conditions of the site. Our subsurface exploration extended to a maximum depth of about 15 feet; hence the seismic site classification should be re-evaluated in the event subsurface information is made available to a depth of 100 feet.	

Table 4: Seismic Site Classification

4.0 SITE DEVELOPMENT CONSIDERATIONS

Based on information provided to our office, we understand that the finished floor of the planned addition will match the finished floor of the existing building, requiring fill depths of less than 2 feet to achieve design grades. If the final grading plan for the site indicates a different finished floor elevation, Building & Earth should be allowed to review the plan and its effects on our recommendations.

Based on our evaluation of the subsurface conditions, and the assumed foundation loads, it appears that construction with shallow footings is feasible. The site development recommendations outlined below are intended for development of the site to support construction with a conventional shallow foundation system. ***For this report, we assumed the existing building is supported on shallow footings and that basements are not present. We further assume that shallow footings and slab-on-grade are preferred for the proposed building addition.***

The primary geotechnical considerations for this project are:

- The presence of existing air conditioning and generator pads, and utility lines within the planned addition area.
- Possible fill materials were encountered in boring P-01 below the asphalt pavement, extending to a depth of about 2 feet below top of pavement.

- The near-surface, clay soils are moisture sensitive, prone to losing strength and stability with slight increases in moisture content.
- Lower consistency soils with relatively high soil moisture contents up to about 28 percent were encountered within the upper 1 to 1.5 feet across most of the proposed building addition and existing pavement areas that likely will not provide for stable subgrade conditions for start of structural fill placement and/or long-term support of floor slabs and pavements.
- Onsite clay residuum generally exhibited medium to high plasticity characteristics that has a moderate shrink-swell potential.
- The gravelly residuum encountered at depths of about 2 to 5 feet below grade included chert cobbles and boulders, which resulted in SPT refusal in P-01 at a depth of 2.5 feet.

Recommendations addressing the site conditions are presented in the following sections.

4.1 INITIAL SITE PREPARATION

Initial site preparation should commence with demolition of the existing pavements, structures, and associated foundations. All structures should be removed from the proposed construction areas prior to any fill placement or new construction.

All vegetation, roots, topsoil, and any other deleterious materials should be removed from the proposed construction areas. Approximately 2 inches of topsoil was observed in borings; however, topsoil could extend to greater depths in unexplored areas of the site.

The geotechnical engineer or their designated representative should observe demolition, stripping and undercutting operations to evaluate that all unsuitable materials are removed from locations for proposed construction.

As mentioned previously in this report, underground utilities were noted within the area proposed for construction. When located in proposed building addition areas, the utilities should be rerouted outside of the proposed addition footprints and the trenches backfilled in accordance with requirements outlined in the *Structural Fill* section of this report.

Materials disturbed during clearing operations should be stabilized in place or, if necessary, undercut to undisturbed materials and backfilled with properly compacted, approved structural fill.

During site preparation activities, the contractor should identify borrow source materials that will be used as structural fill and provide samples to the testing laboratory so that conformance to the *Structural Fill* requirements outlined below and appropriate moisture-density relationship curves can be determined.

4.2 MOISTURE SENSITIVE SOILS

Moisture sensitive, lean clay soils were encountered across the site. These soils will degrade if allowed to become saturated. Therefore, not allowing water to pond by maintaining positive drainage and temporary dewatering methods (if required) is important to help avoid degradation and softening of the soils.

The contractor should anticipate some difficulty during the earthwork phase of this project if moisture levels are moderate to high during construction. Increased moisture levels will soften the subgrade and the soils may become unstable under the influence of construction traffic. Accordingly, construction during wet weather conditions should be avoided, as this could result in soft and unstable soil conditions that would require ground modification, such as in place stabilization or undercutting.

4.3 LOW CONSISTENCY SOILS

Following initial site preparation, soft to medium stiff clays with relatively high soil moisture contents up to 28 percent likely will be encountered across most of the proposed building addition and pavement areas. These near-surface, low consistency soils likely will not provide a stable platform for structural fill placement and long-term support of proposed floor slabs and pavements.

Prior to start of fill placement or construction of the building pad and pavement subgrade, we recommend scarifying the subgrade to a depth of 12 inches, moisture conditioning it to within range of ±2 percent of the optimum moisture content, and recompacting it to at least 95 percent of the standard Proctor maximum dry density.

If scarification, moisture conditioning, and recompaction is not effective to establish a stable platform for start of structural fill placement, soft/unstable soils should be undercut to expose underlying stable material. The area should then be replaced with structural fill in accordance with the recommendation noted within the *Structural Fill* section of this report.

The placement procedure, compaction and composition of the structural fill must meet the requirements of the *Structural Fill* section of this report. The undercutting should be conducted under the observation of the geotechnical engineer or his representative.

4.4 THOROUGH EVALUATION OF POSSIBLE FILL MATERIALS

Following demolition of existing pavements, possible fill materials are anticipated to be exposed within portions of the planned parking areas. There is a risk the fill contains soft zones, over-sized rock, large amounts of debris, organics, or otherwise unsuitable soils that could not be reasonably deduced from the widely spaced borings across the site.

As a minimum, we recommend the exposed fill be thoroughly evaluated by the geotechnical engineer or designated representative. We recommend the exposed fill be evaluated by means of proofrolling with a heavy (20- to 25-ton), loaded tandem axle dump truck. Areas with unstable or soft/loose soils should be marked in the field. Additionally, test pits should be excavated within the delineated areas of concern to evaluate the condition of the existing fill below the exposed subgrade level.

If any soft/loose soils, organic materials, debris, over-sized rock, or any other unsuitable materials are encountered, these unsuitable materials must be removed full depth from construction areas and replaced with low plasticity *Structural Fill*.

4.5 BUILDING PAD PREPARATION

Following initial site preparation and depending on final design grades, residual lean clays are anticipated to be exposed throughout the planned building addition area. The residual clays generally exhibited medium to high plasticity characteristics with a moderate shrink-swell potential.

The potential vertical rise of the onsite clays encountered in the borings was evaluated using the Texas Department of Transportation's test method TEX-124-E, Potential Vertical Rise (PVR). This method estimates the PVR of the clay soils based on the plasticity characteristics, thickness of the soil strata, and surcharge loads. For this project site, an active zone of 6 feet was used in the calculations. The TxDOT method estimates a PVR of ¾ to 1 inch for the soils in their current condition with an "average" soil moisture content as defined by the PVR method.

When onsite soils are allowed to dry within the active zone while exposed to the elements during construction, the PVR will increase to 1 to 1¼ inches, requiring undercut to a level that allows for placement of at least 12 inches of low plasticity structural fill below all floor slabs.

For this project, we assumed a maximum PVR of 1-inch is acceptable for grade supported slabs. If stricter PVR criteria are to be considered for this project, Building & Earth should be contacted to re-evaluate building pad preparation recommendations based on revised maximum PVR criteria.

Prior to placement of structural fill or base stone, we recommend the exposed subgrade within the proposed building addition areas be prepared in accordance with *Subgrade Evaluation and Preparation* section of this report.

4.6 PAVEMENT SUBGRADE PREPARATION

Following initial site preparation, medium to high plasticity clay soils are anticipated to be exposed within proposed pavement areas. These soils typically pose a risk for tension cracks when soil moisture contents increase post-construction. Considering the higher plasticity characteristics of the clay soils, we recommend the subgrade be prepared using one of the following two options:

4.6.1 OPTION I:

Provided the owner is willing to accept the above-described risks, as a minimum, we recommend that the exposed subgrade be prepared in accordance with *Subgrade Preparation and Evaluation* section of this report.

4.6.2 OPTION II:

In lieu of conventional moisture conditioning and recompation of exposed subgrade, consideration can be given to placement of at least 8 inches of imported low plasticity structural fill in all paving areas.

Following undercutting and prior to fill placement, the exposed subgrade should be prepared in accordance with the *Subgrade Evaluation and Preparation* section of this report.

4.7 SUBGRADE EVALUATION AND PREPARATION

At the time of the subsurface exploration, most of the near-surface clays exhibited lower consistencies with relatively high soil moisture contents up to 28 percent. Following undercutting and prior to start of fill placement, the exposed clay subgrade will need to be scarified to a depth of 12 inches, moisture conditioned within range of 1 percent below to 3 percent above the optimum moisture content, and recompacted to at least 95 percent of the standard Proctor maximum dry density.

We recommend that the project geotechnical engineer or a qualified representative evaluate the subgrade after the site is prepared. Some unsuitable or unstable areas may be present in unexplored areas of the site. All areas that will require fill or that will support structures should be carefully proofrolled with a heavy (20- to 25-ton), loaded tandem axle dump truck at the following times.

- After an area has been stripped, pavement demolished and removed, and undercut as needed, prior to the placement of any fill.
- After grading an area to the finished subgrade elevation in building and pavement areas.
- After areas have been exposed to any precipitation, and/or have been exposed for more than 48 hours.

Care should be exercised during proofrolling adjacent to existing building foundations to avoid possible influence on the existing structure. The project geotechnical engineer or their designated representative should observe the proofrolling operations.

Some instability may exist during construction, depending on climatic and other factors immediately preceding and during construction. If any soft or otherwise unsuitable soils are identified during the proofrolling process, they must be undercut or stabilized prior to fill placement, floor slab, or pavement construction. All unsuitable material identified during the construction shall be removed and replaced in accordance with the *Structural Fill* section of this report.

4.8 STRUCTURAL FILL

Requirements for structural fill on this project are as follows:

Soil Type	USCS Classification	Property Requirements	Placement Location
Imported Clayey Gravel, Silty Clayey Gravel, Silty Gravel, Sandy Clay, and Clayey Sand	GC, GC-GM, GM, CL, SC	LL<40, PI<20, γ_d>100 pcf, P200>15%, max 3" particle size in any dimension.	**Low Plasticity Structural Fill** to be used for construction of building pad and pavement subgrade (see note 4)
Onsite Clayey Chert Gravel and Lean Clays	GC, CL (LL<40, PI < 20)	As listed above for imported structural fill	***Likely Suitable*** for placement as low plasticity structural fill in building pad areas (see notes 5 and 6)
Onsite Lean Clays and Lean to Fat Clays	CL (PI >20), CL-CH	Not applicable	***Not Suitable*** for placement as low plasticity structural fill due to higher plasticity characteristics

Table 5: Structural Fill Recommendations

Notes:

1. All structural fill should be free of vegetation, topsoil, and any other deleterious materials. The organic content of materials to be used for fill should be less than 3 percent.
2. LL indicates the soil Liquid Limit; PI indicates the soil Plasticity Index; γ_d indicates the maximum dry density as defined by the density standard outlined in the table below.
3. Representative bulk samples for any imported offsite materials are to be collected for soil classification and moisture-density relationship determination purposes as part of evaluating suitability for their intended use.
4. Material native to the region that may not meet the above structural fill criteria may be used if it contains more than 70% cherty sand and gravel retained on a No. 200 sieve (with maximum particle size of 3 inches) and is approved by the geotechnical engineer. Bulk samples of such material should be provided for, but not necessarily limited to, particle size analysis, Atterberg limits, and moisture-density relationship testing.
5. Portions of the near-surface lean clays (CL) with LL<40 and PI<20 likely will be suitable for use as low plasticity structural fill; however, the near-surface soils had high soil moisture contents up to 28 percent at the time of drilling. The contractor should anticipate the need for moisture conditioning and double handling of the onsite soils when used as structural fill. The near-surface clays transition to higher plasticity clays with increasing depth, requiring careful evaluation by the geotechnical engineer to ensure that only materials with lower plasticity characteristics be used in proposed building and pavement areas.
6. Cobble- and boulder-sized broken chert was observed in the onsite gravelly residuum. Materials placed within depth of 24 inches below finished subgrade should have maximum particle size of 3 inches in any dimension. Below depth of 24 inches, a maximum particle-size up to 6 inches in any dimension is allowed.

Placement requirements for structural fill are as follows:

Specification	Requirement
Lift Thickness	Maximum loose lift thickness of 8 to 12 inches, depending on type of compaction equipment used.
Density	Minimum 95% of the standard Proctor maximum dry density (ASTM D698)
Moisture	±2% of the optimum moisture content as determined by ASTM D698
Density Testing Frequency	**Building and foundation areas**: One test per 2,500 square feet (SF) per lift with a minimum of three tests performed per lift **Pavement areas**: One test per 5,000 SF per lift with a minimum of three tests performed per lift **Utility trenches**: One test per 150 linear feet per lift with a minimum of 2 tests per lift.

Table 6: Structural Fill Placement Requirements

4.9 EXCAVATION CONSIDERATIONS

All excavations performed at the site should follow OSHA guidelines for temporary excavations. Excavated soils should be stockpiled according to OSHA regulations to limit the potential cave-in of soils.

We anticipate the residuum can be excavated using a large track hoe in good working condition equipped with rock teeth. It should be noted that cobble- and boulder-sized chert was observed in the gravelly residuum stratum that resulted in SPT refusal. In areas where very dense cobble to boulder sized broken chert are encountered, the use of a hydraulic hoe ram attachment may be required in confined excavations.

The ability to excavate rock is a function of the material, the equipment used, the skill of the operator, the desired rate of removal and other factors. The contractor should review the borings logs and use their own method to evaluate excavation difficulty.

4.9.1 PROTECTION OF EXISTING FOUNDATIONS AND BEARING MATERIALS

Care should be exercised during footing excavation or undercutting of the onsite soils within the proposed building addition areas, along the existing building to avoid possible influence on the existing structure. The bearing materials of the foundations supporting the existing building should be protected during excavation. Depending on excavation depths, the contractor may need to develop a shoring or underpinning plan.

4.9.2 PERCHED WATER

Although not encountered at the time of drilling, perched water may be encountered in footing excavations and utility trenches. It should be noted that fluctuations in the water level could occur due to seasonal variations in rainfall. The contractor must be prepared to remove groundwater seepage from excavations if encountered during construction. Excavations extending below groundwater levels will require dewatering systems (such as sump pumps or trench drains). The contractor should evaluate the most economical and practical dewatering method.

4.10 UTILITY TRENCH BACKFILL

All utility trenches must be backfilled and compacted in the manner specified above for structural fill. It may be necessary to reduce the lift thickness to 4 to 6 inches to achieve compaction using hand-operated equipment.

At the perimeter wall crossings, we recommend that clay soils or a flowable fill be used to backfill the utility trench. The clay or flowable fill will act as a relatively impermeable plug reducing the risk of water migration from the outside into the interior of the building. The plug should be at least 36 inches wide and should extend below the perimeter walls to provide for a proper seal.

4.11 LANDSCAPING AND DRAINAGE CONSIDERATION

The potential for soil moisture fluctuations within building areas and pavement subgrades should be reduced to lessen the potential of subgrade movement. Site grading should include positive drainage away from buildings and pavements. Excessive irrigation of landscaping poses a risk of saturating and softening soils below shallow footings, which could result in settlement of footings. In addition, moisture absorption by higher plasticity clay soils at the perimeter of buildings will result in swelling and potentially subsequent heave of slabs-on-grade and lightly loaded footings, and premature failure of pavements.

4.12 WET WEATHER CONSTRUCTION

Excessive movement of construction equipment across the site during wet weather may result in ruts, which will collect rainwater, prolonging the time required to dry the subgrade soils.

During rainy periods, additional effort will be required to properly prepare the site and establish/maintain an acceptable subgrade. The difficulty will increase in areas where clay or silty soils are exposed at the subgrade elevation, as is seen throughout this project site. Grading contractors typically postpone grading operations during wet weather to wait for conditions that are more favorable. Contractors can typically disk or aerate the upper soils to promote drying during intermittent periods of favorable weather. When deadlines restrict postponement of grading operations, additional measures such as undercutting and replacing saturated soils or stabilization can be utilized to facilitate placement of additional fill material.

5.0 FOUNDATION RECOMMENDATIONS

Specific structural loading conditions were not known at the time of this report. For this report we have assumed that the individual column loads will be less than 50 kips and wall loads will be less than 2 kips per linear foot. ***If these assumptions concerning structural loading are incorrect, our office should be contacted, such that our recommendations can be reviewed***.

Based on the subsurface conditions encountered in the test borings and after the site preparation and grading recommendations are implemented, the proposed building addition can be supported on conventional shallow foundations bearing in medium stiff to stiff clays, and/or new structural fill.

Footings founded in the recommended materials can be designed using a maximum net allowable bearing capacity of 2,000 psf.

Column footings should be at least 24 inches wide and strip footings should be at least 18 inches wide. These dimensions facilitate hand cleaning of footing subgrades disturbed by the excavation process and the placement of reinforcing steel. They also reduce the potential for localized punching shear failure.

The onsite clays exhibited higher plasticity characteristics. The contractor should use caution during foundation construction as to not allow the bearing soils to dry while exposed to the elements. Drying of the clay soils would increase their swell potential and the subsequent risk of heave of footings. Desiccated soils will need to be undercut prior to placement of reinforcing steel and replaced with properly compacted, approved lower plasticity structural fill.

All exterior footings should bear at least 24 inches below the adjacent exterior grade. Care should be taken that footings of the proposed building addition constructed next to the existing building are founded at the same elevation as the existing footings, so that no additional loads are applied on either of the footings.

Total settlement of footings designed and constructed as recommended above is estimated to be less than ¾-inch. Differential settlement between any two points spaced 40 feet across the slab, or along continuous footings is estimated to be less than ½-inch. Structural design should account for differential settlement of ½-inch between the existing structure and the proposed addition.

The following items should be considered during the preparation of construction documents and foundation installation:

- The geotechnical engineer of record should observe the exposed foundation bearing surfaces prior to concrete placement to verify that the conditions anticipated during the subsurface exploration are encountered.
- All bearing surfaces must be free of soft or loose soil and debris prior to placing concrete.
- The bottom surface of all footings should be level.
- Concrete should be placed the same day the excavations are completed and bearing materials verified by the engineer. If the excavations are left open for an extended period, or if the bearing surfaces are disturbed after the initial observation, then the bearing surfaces should be re-evaluated prior to concrete placement.
- Water should not be allowed to pond in foundation excavations prior to concrete placement or above the concrete after the foundation is completed.
- Wherever possible, the foundation concrete should be placed “neat”, using the sides of the excavations as forms. Where this is not possible, the excavations created by forming the foundations must be backfilled with suitable structural fill and properly compacted.
- Grades around the building pad should be sloped to drain away from the building foundations.
- Roof drains should be routed away from the foundation soils. All drains should be collected in pipes or discharged outside buildings to prevent drainage into the subsurface soils.

5.1 SHEAR RESISTANCE

Passive earth pressures of materials adjacent to the footings as well as bearing material friction at the base may be used to resist shear.

The following table presents recommended friction coefficient and passive earth pressure values for new structural fill comprised of onsite available residuum. The structural engineer should use a factor of safety of at least 1.5 when sizing the foundations to resist shear loads using the below ultimate soil parameter values.

Material	Friction Coefficient	Equivalent Fluid Unit Weight for Passive Condition Lateral Earth Pressures (pcf)
Residuum or New Structural Fill	0.30	250

Table 7: Soil Parameter Values Resisting Shear

6.0 FLOOR SLABS

The building pad preparation recommendations presented earlier in this report are based on a maximum PVR criterium of 1-inch. If stricter PVR criteria apply for this project, our office needs to be contacted to provide alternate building pad preparation recommendations.

We understand that the planned addition will include a freezer and cooler area to the east of the existing building. As such, freezer and cooler slab design is to accommodate an adequate subfloor insultation system and use of subgrade materials that are not frost susceptible, e.g., No. 57 stone. Geotechnical recommendations for freezer and cooler subgrade preparation should be provided by the designer or manufacturer of the freezers and coolers.

7.0 RIGID PAVEMENT CONSIDERATIONS

We understand that new pavements will be constructed using Portland cement concrete. Specific traffic information was not provided. For this report we assumed that the pavements will be subjected to maintenance vehicles and occasional heavy trucks with 18-kip Equivalent Single Axle Loads (ESALs) of 135,000. In addition, we have assumed the following design parameters:

Design Criteria	Value
Design life (Years)	20
Terminal Serviceability	2.0
Reliability	85%
Initial Serviceability	4.5 (Rigid)
Standard Deviation	0.35 (Rigid)

Table 8: Assumed Rigid Pavement Design Parameters

All subgrade, base and pavement construction operations should meet minimum requirements of the Oklahoma Department of Transportation (ODOT), Standard Specifications for Highway Construction, dated 2019. The applicable sections of the specifications are identified as follows:

Material	Specification Section
Portland Cement Concrete Pavement	414 & 701
Mineral Aggregate Base Materials	303 & 703

Table 9: ODOT Specification Sections

The following rigid pavement sections are based on the design parameters presented above. We assume a modulus of subgrade reaction (k) of 100 pci. We have assumed concrete elastic modulus (E_c) of 3.1 X 10^6 psi, and a concrete modulus of rupture (S'_c) of 600 psi.

Minimum Recommended Thickness (in)		Material
Option I (per Section 4.6.1)	Option II (per Section 4.6.2)	
5.0	5.5	Portland Cement Concrete, f'_c=3,500 psi
4.0	---	Crushed Aggregate Base (ODOT Type "A")
---	8.0	Lower Plasticity Structural Fill
12.0	12.0	Moisture Conditioned and Recompacted Subgrade

Table 10: Rigid Pavement Recommendations

For access drive approaches, trash compactor pads, loading areas, and other pavement areas that are frequently subject to high traffic loads with frequent braking and turning of wheels, consideration should be given to using a reinforced rigid pavement section comprised of seven (7) inches of Portland cement concrete over six (6) inches of crushed aggregate base course.

The concrete should be protected against moisture loss, rapid temperature fluctuations, and construction traffic for several days after placement. All pavements should be sloped for positive drainage. We suggest that a curing compound be applied after the concrete has been finished.

Although not referenced in the ODOT specifications, based on our experience with project sites in this region and anticipated traffic loads, we recommend Portland cement concrete should have a minimum 28-day compressive strength of 3,500 psi, maximum slump of 4 inches, and air content of 5 to 7 percent.

For rigid pavements, we recommend a jointing plan be developed to control cracking and help preclude surficial migration of water into the base course and subgrade. If a jointing plan includes a widely spaced pattern (spacing typically greater than 30 times the slab thickness), consideration should be given to include steel reinforcement in rigid pavements, per Section 3.4 of the American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures 1993, and Section 3.8 of the American Concrete Institute (ACI) Guide for the Design and Construction of Concrete Parking Lots. Additionally, we recommend the joints be sealed to further preclude surficial moisture migration into the underlying supporting soils.

All pavements should be sloped, approximately ¼ inch per foot, to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature deterioration of the pavements because of loss of strength and stability. Periodic maintenance of the pavement should be anticipated. This should include sealing of cracks and joints and maintaining proper surface drainage to avoid ponding of water on or near the pavement areas.

8.0 SUBGRADE REHABILITATION

The subgrade soils often become disturbed during the period between initial site grading and construction of surface improvements. The amount and depth of disturbance will vary with soil type, weather conditions, construction traffic, and drainage.

The engineer should evaluate the subgrade soil during final grading to verify that the subgrade is suitable to receive pavement and/or concrete slab base materials. The final evaluation may include proofrolling or density tests.

Subgrade rehabilitation can become a point of controversy when different contractors are responsible for site grading and building construction. The construction documents should specifically state which contractor will be responsible for maintaining and rehabilitating the subgrade. Rehabilitation may include moisture conditioning and re-compacting soils. When deadlines or weather restrict grading operations, additional measures such as undercutting and replacing saturated soils or chemical stabilization can often be utilized.

9.0 CONSTRUCTION MONITORING

Field verification of site conditions is an essential part of the services provided by the geotechnical consultant. To confirm our recommendations, it will be necessary for Building & Earth personnel to make periodic visits to the site during site grading. Typical construction monitoring services are listed below.

- Periodic observations and consultations by a member of our engineering staff during site grading
- Field density tests during structural fill placement on a continuous basis
- Observation and verification of the bearing surfaces exposed after foundation excavation
- Reinforcing steel inspections
- Molding and testing of concrete cylinders
- Structural steel inspections
- Continuous monitoring and testing during pavement installation

10.0 CLOSING AND LIMITATIONS

This report was prepared for the Cherokee Nation and Childers Architect for specific application to the subject project in Jay, Oklahoma. The information in this report is not transferable. This report should not be used for a different development on the same property without first being evaluated by the engineer.

The recommendations in this report were based on the information obtained from our field exploration and laboratory analysis. The data collected is representative of the locations tested. Variations are likely to occur at other locations throughout the site. Engineering judgment was applied regarding conditions between borings. It will be necessary to confirm the anticipated subsurface conditions during construction.

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GEOTECHNICAL INVESTIGATION METHODOLOGIES

The subsurface exploration, which is the basis of the recommendations of this report, has been performed in accordance with industry standards. Detailed methodologies employed in the investigation are presented in the following sections.

DRILLING PROCEDURES – STANDARD PENETRATION TEST (ASTM D1586)

At each boring location, soil samples were obtained at standard sampling intervals with a split-spoon sampler. The borehole was first advanced to the sample depth by augering and the sampling tools were placed in the open hole. The sampler was then driven 18 inches into the ground with a 140-pound automatic hammer free-falling 30 inches. The number of blows required to drive the sampler each 6-inch increment was recorded. The initial increment is considered the "seating" blows, where the sampler penetrates loose or disturbed soil in the bottom of the borehole.

The blows required to penetrate the final two (2) increments are added together and are referred to as the Standard Penetration Test (SPT) N-value. The N-value, when properly evaluated, gives an indication of the soil's strength and ability to support structural loads. Many factors can affect the SPT N-value, so this result cannot be used exclusively to evaluate soil conditions.

The SPT testing was performed using a drill rig equipped with an automatic hammer. Automatic hammers mechanically control the height of the hammer drop, and doing so, deliver higher energy efficiency (90 to 99 % efficiency) than manual hammers (60 % efficiency) which are dropped using a manually operated rope and cathead system. Because historic data correlations were developed based on use of a manual hammer, it is necessary to adjust the N-values obtained using an automatic hammer to make these correlations valid. Therefore, an energy correction factor of 1.3 was applied to the recorded field N-values from the automatic hammer for the purpose of our evaluation. The N-values discussed or mentioned in this report and shown on the boring logs are recorded field values.

Samples retrieved from the boring locations were labeled and stored in plastic bags at the jobsite before being transported to our laboratory for analysis. The project engineer prepared Boring Logs summarizing the subsurface conditions at the boring locations.

BORING LOG DESCRIPTION

Building & Earth Sciences, Inc. used the gINT software program to prepare the attached boring logs. The gINT program provides the flexibility to custom design the boring logs to include the pertinent information from the subsurface exploration and results of our laboratory analysis. The soil and laboratory information included on our logs is summarized below:

DEPTH AND ELEVATION

The depth below the ground surface and the corresponding elevation are shown in the first two columns.

SAMPLE TYPE

The method used to collect the sample is shown. The typical sampling methods include Split Spoon Sampling, Shelby Tube Sampling, Grab Samples, and Rock Core. A key is provided at the bottom of the log showing the graphic symbol for each sample type.

SAMPLE NUMBER

Each sample collected is numbered sequentially.

BLOWS PER INCREMENT, REC%, RQD%

When Standard Split Spoon sampling is used, the blows required to drive the sampler each 6-inch increment are recorded and shown in column 5. When rock core is obtained the recovery ration (REC%) and Rock Quality Designation (RQD%) is recorded.

SOIL DATA

Column 6 is a graphic representation of four different soil parameters. Each of the parameters use the same graph, however, the values of the graph subdivisions vary with each parameter. Each parameter presented on column 6 is summarized below:

- N-value- The Standard Penetration Test N-value, obtained by adding the number of blows required to drive the sampler the final 12 inches, is recorded . The graph labels range from 0 to 50.
- Qu – Unconfined Compressive Strength estimate from the Pocket Penetrometer test in tons per square foot (tsf). The graph labels range from 0 to 5 tsf.
- Atterberg Limits – The Atterberg Limits are plotted with the plastic limit to the left, and liquid limit to the right, connected by a horizontal line. The difference in the plastic and liquid limits is referred to as the Plasticity Index. The Atterberg Limits test results are also included in the Remarks column on the far right of the boring log. The Atterberg Limits graph labels range from 0 to 100%.
- Moisture – The Natural Moisture Content of the soil sample as determined in our laboratory.

SOIL DESCRIPTION

The soil description prepared in accordance with ASTM D2488, Visual Description of Soil Samples. The Munsel Color chart is used to determine the soil color. Strata changes are indicated by a solid line, with the depth of the change indicated on the left side of the line and the elevation of the change indicated on the right side of the line. If subtle changes within a soil type occur, a broken line is used. The Boring Termination or Auger Refusal depth is shown as a solid line at the bottom of the boring.

GRAPHIC

The graphic representation of the soil type is shown. The graphic used for each soil type is related to the Unified Soil Classification chart. A chart showing the graphic associated with each soil classification is included.

REMARKS

Remarks regarding borehole observations, and additional information regarding the laboratory results and groundwater observations.

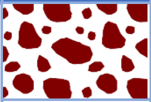
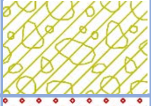
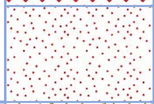
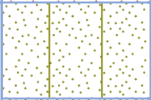
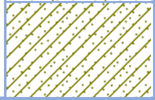
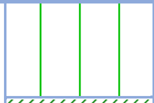
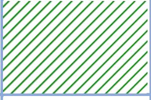
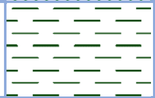
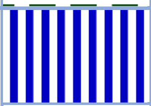
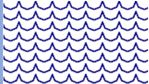
Major Divisions			***Symbols***		***Group Name & Typical Description***
			Lithology	***Group***	
Coarse Grained Soils *More than 50% of material is larger than No. 200 sieve size*	***Gravel and Gravelly Soils*** *More than 50% of coarse fraction is larger than No. 4 sieve*	***Clean Gravels*** *(Less than 5% fines)*		**GW**	*Well-graded gravels, gravel – sand mixtures, little or no fines*
				**GP**	*Poorly-graded gravels, gravel – sand mixtures, little or no fines*
		Gravels with Fines *(More than 12% fines)*		**GM**	*Silty gravels, gravel – sand – silt mixtures*
				**GC**	*Clayey gravels, gravel – sand – clay mixtures*
	Sand and Sandy Soils *More than 50% of coarse fraction is smaller than No. 4 sieve*	***Clean Sands*** *(Less than 5% fines)*		**SW**	*Well-graded sands, gravelly sands, little or no fines*
				**SP**	*Poorly-graded sands, gravelly sands, little or no fines*
		Sands with Fines *(More than 12% fines)*		**SM**	*Silty sands, sand – silt mixtures*
				**SC**	*Clayey sands, sand – clay mixtures*
Fine Grained Soils *More than 50% of material is smaller than No. 200 sieve size*	***Silts and Clays*** *Liquid Limit less than 50*	***Inorganic***		**ML**	*Inorganic silts and very find sands, rock flour, silty or clayey fine sands or clayey silt with slight plasticity*
				**CL**	*Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays*
		Organic		**OL**	*Organic silts and organic silty clays of low plasticity*
	Silts and Clays *Liquid Limit greater than 50*	***Inorganic***		**MH**	*Inorganic silts, micaceous or diatomaceous fine sand, or silty soils*
				**CH**	*Inorganic clays of high plasticity*
		Organic		**OH**	*Organic clays of medium to high plasticity, organic silts*
Highly Organic Soils				**PT**	*Peat, humus, swamp soils with high organic contents*

Table 1: Soil Classification Chart (based on ASTM D2487)

SOIL CLASSIFICATION METHODOLOGY

Building & Earth Sciences classifies soil in general accordance with the Unified Soil Classification System (USCS) presented in ASTM D2487. Table 1 and Figure 1 exemplify the general guidance of the USCS. Soil consistencies and relative densities are presented in general accordance with Terzaghi, Peck, & Mesri's (1996) method, as shown on Table 2, when quantitative field and/or laboratory data is available. Table 2 includes Consistency and Relative Density correlations with N-values obtained using either a manual hammer (60 percent efficiency) or automatic hammer (90 percent efficiency). The *Blows Per Increment* and *SPT N-values* displayed on the boring logs are the unaltered values measured in the field. When field and/or laboratory data is not available, we may classify soil in general accordance with the Visual Manual Procedure presented in ASTM D2488.

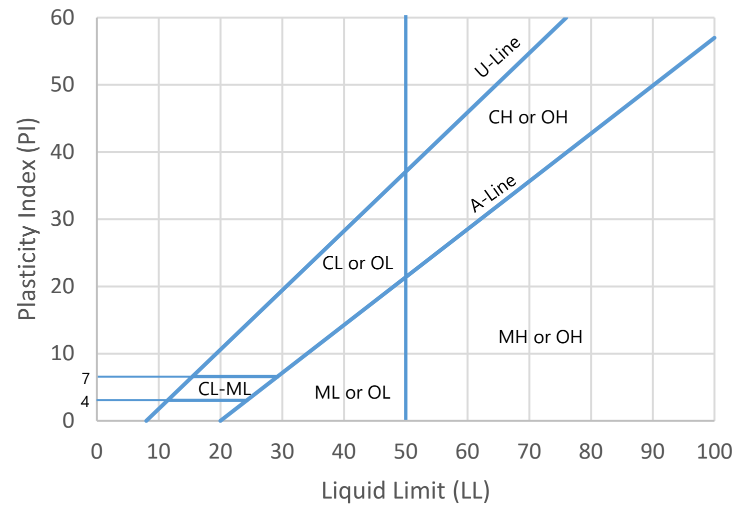


Figure 1: Plasticity Chart (based on ASTM D2487)

Non-cohesive: Coarse-Grained Soil			Cohesive: Fine-Grained Soil			
SPT Penetration (blows/foot)		Relative Density	SPT Penetration (blows/foot)		Consistency	Estimated Range of Unconfined Compressive Strength (tsf)
			Automatic Hammer*	Manual Hammer		
Automatic Hammer*	Manual Hammer		< 2	< 2	Very Soft	< 0.25
0 - 3	0 - 4	Very Loose	2 - 3	2 - 4	Soft	0.25 – 0.50
3 - 8	4 - 10	Loose	3 - 6	4 - 8	Medium Stiff	0.50 – 1.00
8 - 23	10 - 30	Medium Dense	6 - 12	8 - 15	Stiff	1.00 – 2.00
23 - 38	30 - 50	Dense	12 - 23	15 - 30	Very Stiff	2.00 – 4.00
> 38	> 50	Very Dense	> 23	> 30	Hard	> 4.00

Table 2: Soil Consistency and Relative Density (based on Terzaghi, Peck & Mesri, 1996)

* - Modified based on 80% hammer efficiency

KEY TO LOGS

☒	Standard Penetration Test ASTM D1586 or AASHTO T-206	⬇	Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399
■	Shelby Tube Sampler ASTM D1587	○	No Sample Recovery
▥	Rock Core Sample ASTM D2113	▽	Groundwater at Time of Drilling
▮	Auger Cuttings	▼	Groundwater as Indicated

Table 1: Symbol Legend

Soil	Particle Size	U.S. Standard
Boulders	Larger than 300 mm	N.A.
Cobbles	300 mm to 75 mm	N.A.
Gravel	75 mm to 4.75 mm	3-inch to #4 sieve
Coarse	75 mm to 19 mm	3-inch to ¾-inch sieve
Fine	19 mm to 4.75 mm	¾-inch to #4 sieve
Sand	4.75 mm to 0.075 mm	#4 to #200 Sieve
Coarse	4.75 mm to 2 mm	#4 to #10 Sieve
Medium	2 mm to 0.425 mm	#10 to #40 Sieve
Fine	0.425 mm to 0.075 mm	#40 to #200 Sieve
Fines	Less than 0.075 mm	Passing #200 Sieve
Silt	Less than 5 µm	N.A.
Clay	Less than 2 µm	N.A.

Table 2: Standard Sieve Sizes

N-Value ☐	Standard Penetration Test Resistance calculated using ASTM D1586 or AASHTO T-206. Calculated as sum of original, field recorded values.	Atterberg Limits |—| PL LL	A measure of a soil's plasticity characteristics in general accordance with ASTM D4318. The soil Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL).
Qu ▲	Unconfined compressive strength, typically estimated from a pocket penetrometer. Results are presented in tons per square foot (tsf).	% Moisture ●	Percent natural moisture content in general accordance with ASTM D2216.

Table 3: Soil Data

Hollow Stem Auger	Flights on the outside of the shaft advance soil cuttings to the surface. The hollow stem allows sampling through the middle of the auger flights.
Mud Rotary / Wash Bore	A cutting head advances the boring and discharges a drilling fluid to support the borehole and circulate cuttings to the surface.
Solid Flight Auger	Flights on the outside bring soil cuttings to the surface. Solid stem requires removal from borehole during sampling.
Hand Auger	Cylindrical bucket (typically 3-inch diameter and 8 inches long) attached to a metal rod and turned by human force.

Table 4: Soil Drilling Methods

Descriptor	Meaning
Trace	Likely less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

Table 5: Descriptors

Manual Hammer	The operator tightens and loosens the rope around a rotating drum assembly to lift and drop a sliding, 140-pound hammer falling 30 inches.
Automatic Trip Hammer	An automatic mechanism is used to lift and drop a sliding, 140-pound hammer falling 30 inches.
Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399	Uses a 15-pound steel mass falling 20 inches to strike an anvil and cause penetration of a 1.5-inch diameter cone seated in the bottom of a hand augered borehole. The blows required to drive the embedded cone a depth of 1-3/4 inches have been correlated by others to N-values derived from the Standard Penetration Test (SPT).

Table 6: Sampling Methods

Non-plastic	A 1/8-inch 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 re-rolled 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 re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Table 7: Plasticity

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.

Table 8: Moisture Condition

Stratified	Alternating layers of varying material or color with layers at least ½ inch thick.
Laminated	Alternating layers of varying material or color with layers less than ¼ inch thick.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensides	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.
Homogeneous	Same color and appearance throughout.

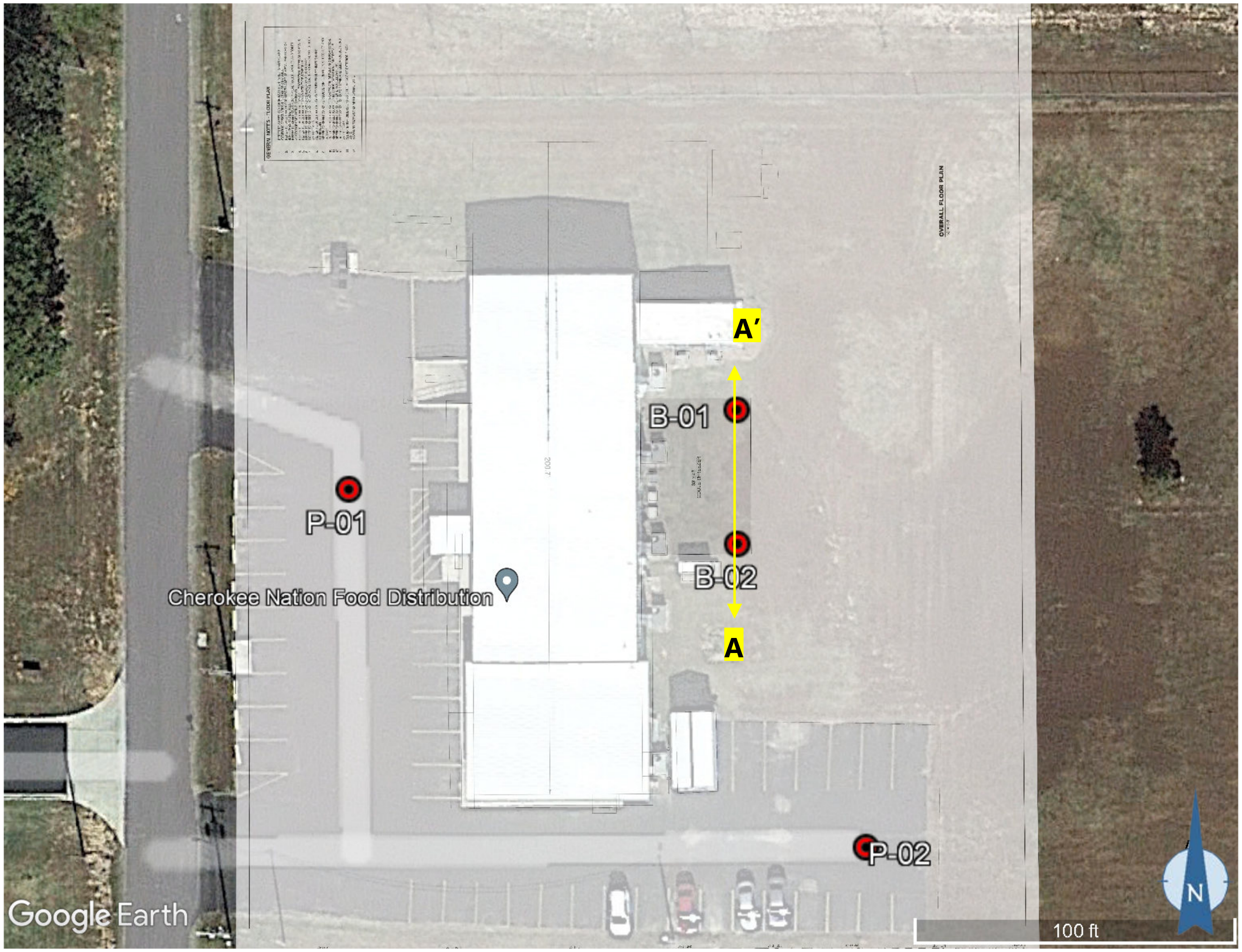
Table 9: Structure

KEY TO HATCHES

Hatch	Description	Hatch	Description	Hatch	Description
▨	**GW** - Well-graded gravels, gravel – sand mixtures, little or no fines	■	Asphalt	▨	Clay with Gravel
▨	**GP** - Poorly-graded gravels, gravel – sand mixtures, little or no fines	▨	Aggregate Base	▨	Sand with Gravel
▨	**GM** - Silty gravels, gravel – sand – silt mixtures	▨	Topsoil	▨	Silt with Gravel
▨	**GC** - Clayey gravels, gravel – sand – clay mixtures	▨	Concrete	▨	Gravel with Sand
▨	**SW** - Well-graded sands, gravelly sands, little or no fines	▨	Coal	▨	Gravel with Clay
▨	**SP** - Poorly-graded sands, gravelly sands, little or no fines	▨	**CL-ML** - Silty Clay	▨	Gravel with Silt
▨	**SM** - Silty sands, sand – silt mixtures	▨	Sandy Clay	▨	Limestone
▨	**SC** - Clayey sands, sand – clay mixtures	▨	Clayey Chert	▨	Chalk
▨	**ML** - Inorganic silts and very find sands, rock flour, silty or clayey fine sands or clayey silt with slight plasticity	▨	Low and High Plasticity Clay	▨	Siltstone
▨	**CL** - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	▨	Low Plasticity Silt and Clay	▨	Till
▨	**OL** - Organic silts and organic silty clays of low plasticity	▨	High Plasticity Silt and Clay	▨	Sandy Clay with Cobbles and Boulders
▨	**MH** - Inorganic silts, micaceous or diatomaceous fine sand, or silty soils	▨	Fill	▨	Sandstone with Shale
▨	**CH** - Inorganic clays of high plasticity	▨	Weathered Rock	▨	Coral
▨	**OH** - Organic clays of medium to high plasticity, organic silts	▨	Sandstone	▨	Boulders and Cobbles
▨	**PT** - Peat, humus, swamp soils with high organic contents	▨	Shale	▨	Soil and Weathered Rock

Table 1: Key to Hatches Used for Boring Logs and Soil Profiles

BORING LOCATION PLAN



REFERENCE USED TO PRODUCE THIS DRAWING:

Google Earth Satellite Imagery dated October 2017 with overlay of Overall Floor Plan, prepared by James R. Childers Architect, Inc., dated 12/10/2021

BORING LOCATION PLAN

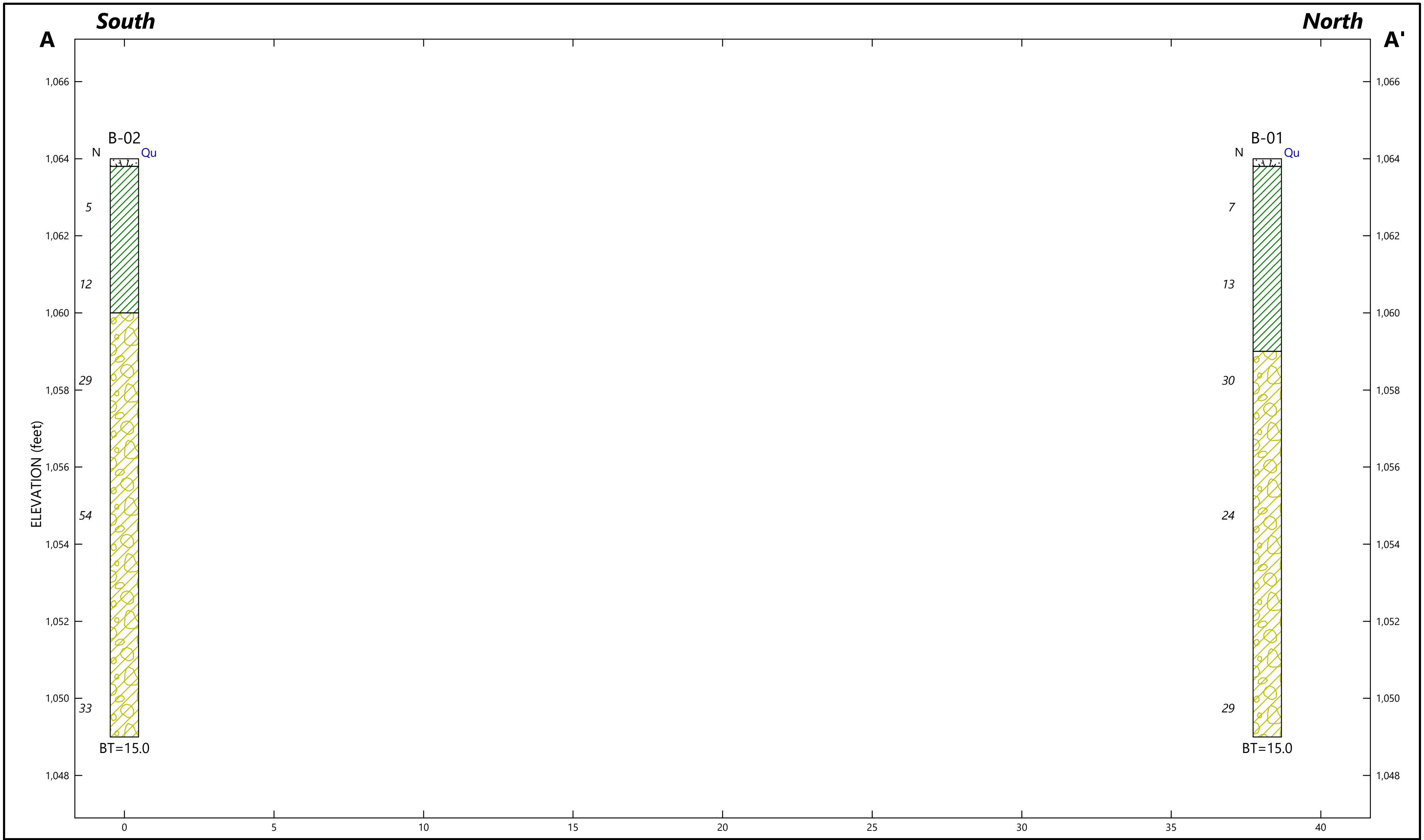
DATE: 2/16/2022

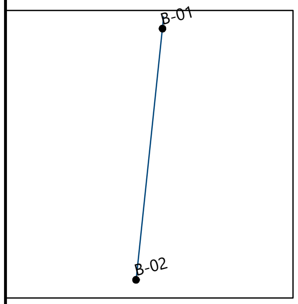
PROJECT NO.	**PROJECT NAME / LOCATION:**	**SCALE:**
TU220026	Cherokee Nation Food Distribution Center Expansion Jay, Oklahoma	As Shown

BUILDING & EARTH

Geotechnical, Environmental, and Materials Engineers

SUBSURFACE PROFILE





Site Map Scale 1 inch equals 30 feet

Key to Hatches

▨	Topsoil
🟩	USCS Low Plasticity Clay
🟨	USCS Clayey Gravel

Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)
▽ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.

0 5
Horizontal Scale (feet)
Vertical Exaggeration: 1.5x

Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, OK 74112

Cherokee Nation FDC Expansion - Jay
Jay, OK

A-A': Subsurface Profile

PROJECT NO: TU220026	PLATE NO: A-1	DATE: 3/7/22

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

BORING LOGS

LOG OF BORING

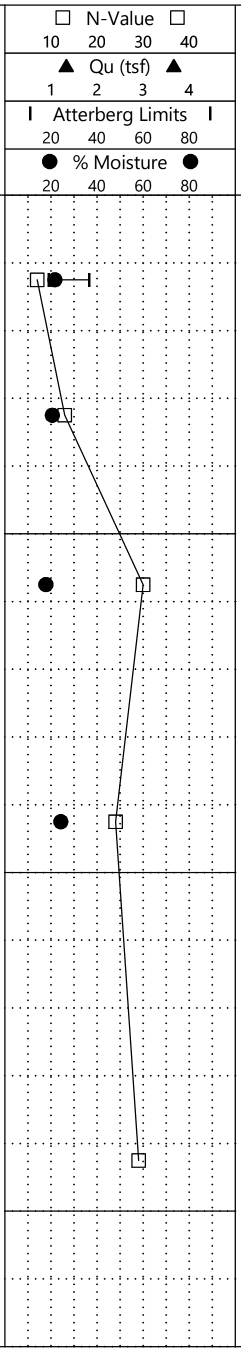
Designation: B-01

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation FDC Expansion - Jay
PROJECT NUMBER: TU220026
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Porposed Addition - NE Corner

LOCATION: Jay, OK
DATE DRILLED: 2/16/22
WEATHER: Windy, Clear
ELEVATION: 1064
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.2	1063.8					TOPSOIL: 2"	
		☒	1	2 3 4	Sample 1 LL: 37 PL: 19 PI: 18 M: 21.7%	LEAN CLAY (CL): medium stiff, gray, reddish gray, brownish yellow, medium plasticity, moist, with trace fine roots, (RESIDUAL) -stiff below 1.5 feet	
		☒	2	4 5 8	Sample 2 M: 20.6%	very stiff	
	1060						
5 / 5.0	1059.0					CLAYEY CHERT GRAVEL (GC): dense, brown, red, brownish yellow, moist, (RESIDUAL)	
		☒	3	11 15 15	Sample 3 M: 17.8%		
	1055	☒	4	5 11 13	Sample 4 M: 24.3%	yellowish red, white, with clay layers	
10							
	1050	☒	5	8 13 16			
15 / 15.0	1049.0					Boring Terminated at 15 feet.	Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

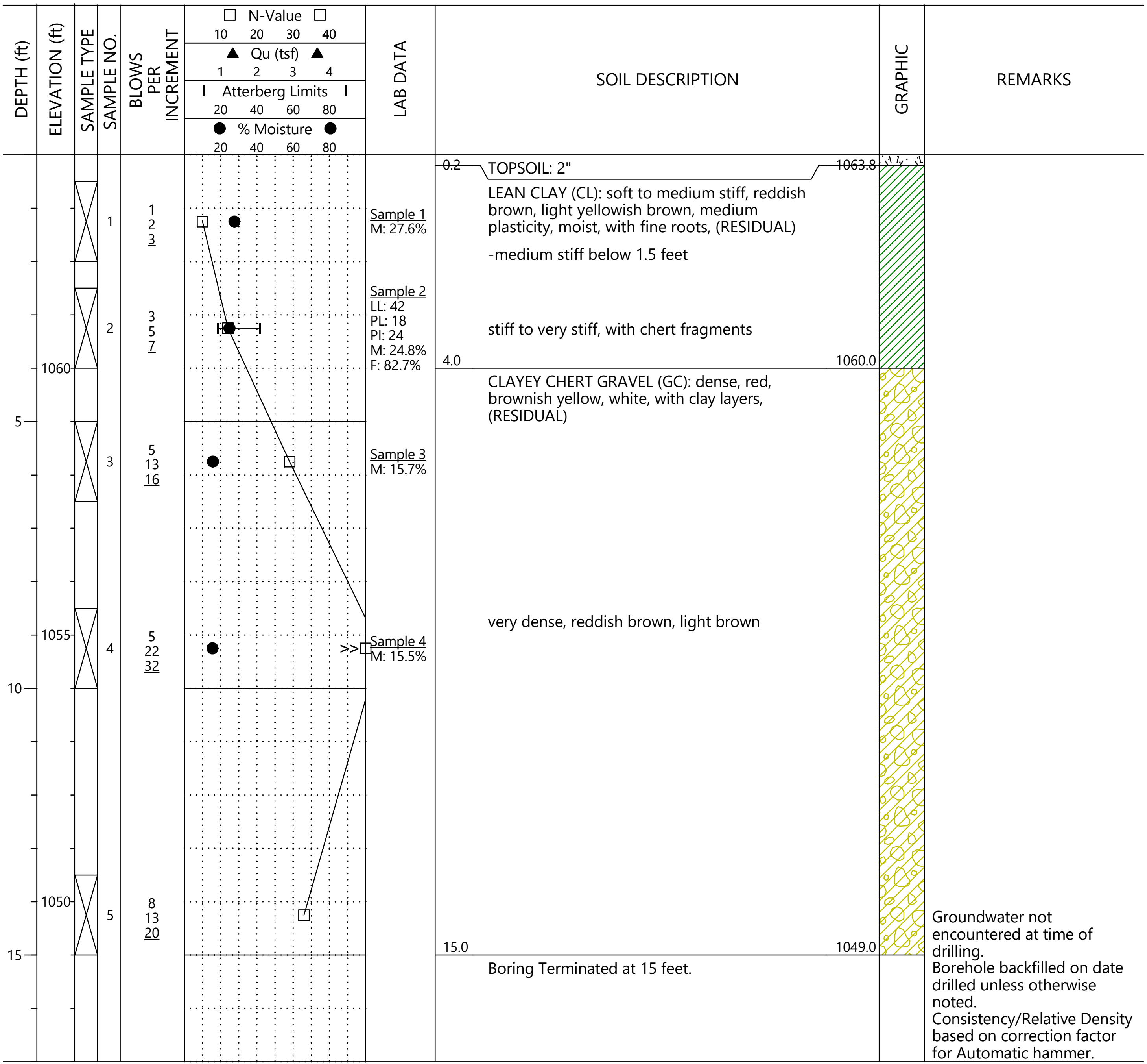
Designation: B-02

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation FDC Expansion - Jay
PROJECT NUMBER: TU220026
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Porposed Addition - SE Corner

LOCATION: Jay, OK
DATE DRILLED: 2/16/22
WEATHER: Windy, Clear
ELEVATION: 1064
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	1 2 3	Sample 1 M: 27.6%
2	3 5 7	Sample 2 LL: 42 PL: 18 PI: 24 M: 24.8% F: 82.7%
3	5 13 16	Sample 3 M: 15.7%
4	5 22 32	Sample 4 M: 15.5%
5	8 13 20	

	SOIL DESCRIPTION	
0.2	TOPSOIL: 2"	1063.8
	LEAN CLAY (CL): soft to medium stiff, reddish brown, light yellowish brown, medium plasticity, moist, with fine roots, (RESIDUAL) -medium stiff below 1.5 feet stiff to very stiff, with chert fragments	
4.0	CLAYEY CHERT GRAVEL (GC): dense, red, brownish yellow, white, with clay layers, (RESIDUAL) very dense, reddish brown, light brown	1060.0
15.0	Boring Terminated at 15 feet.	1049.0

REMARKS: Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:**	LIQUID LIMIT **M:** NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:**	PLASTIC LIMIT **F:** PERCENT PASSING NO. 200 SIEVE
∇	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:**	PLASTICITY INDEX
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

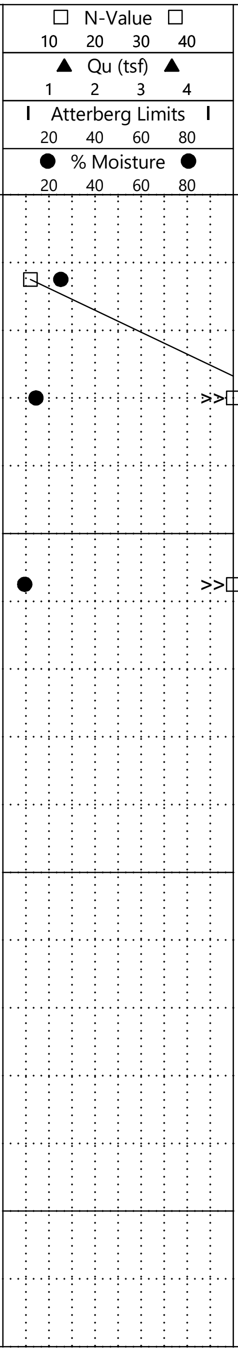
LOG OF BORING
Designation: P-01
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation FDC Expansion - Jay
PROJECT NUMBER: TU220026
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: West Parking Lot Area

LOCATION: Jay, OK
DATE DRILLED: 2/16/22
WEATHER: Windy, Clear
ELEVATION: 1063
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.3	1062.7					ASPHALT: 3"	
0.7	1062.3					AGGREGATE BASE: 5"	
2.0	1061.0	☒	1	3 3 3	Sample 1 M: 25.1%	LEAN TO FAT CLAY (CL-CH): medium stiff to stiff, brown, yellowish brown, medium to high plasticity, moist, with tree roots and wood, (POSSIBLE FILL)	
	1060	☒	2	16 50/6”	Sample 2 M: 14.4%	CLAYEY CHERT GRAVEL (GC): very dense, reddish brown, yellowish brown, white, moist, wiith chert cobbles and boulders, (RESIDUAL)	
5		☒	3	15 28 33	Sample 3 M: 9.5%	with clay layers	
6.5	1056.5					Boring Terminated at 6.5 feet.	
	1055						
10							
	1050						
15							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.



SAMPLE TYPE ☒ Split Spoon

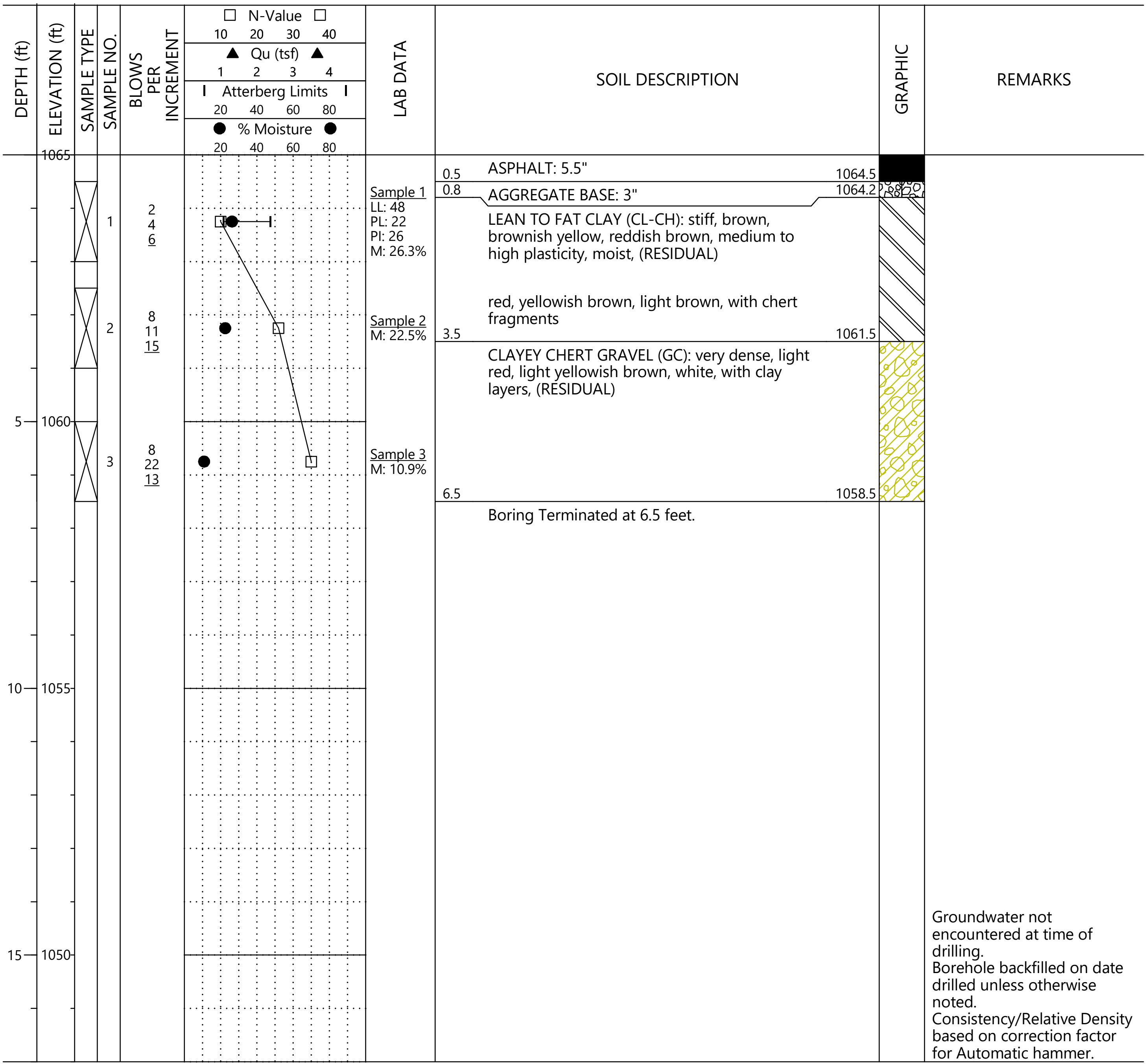
N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING
Designation: P-02
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation FDC Expansion - Jay	LOCATION:	Jay, OK
PROJECT NUMBER:	TU220026	DATE DRILLED:	2/16/22
DRILLING METHOD:	Hollow Stem Auger	WEATHER:	Windy, Clear
EQUIPMENT USED:	Diedrich D-50	ELEVATION:	1065
HAMMER TYPE:	Automatic	DRILL CREW:	Building & Earth
BORING LOCATION:	South Parking Lot Area	LOGGED BY:	Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	
0.5						ASPHALT: 5.5"	1064.5
0.8						AGGREGATE BASE: 3"	1064.2
		☒	1	2 4 6	Sample 1 LL: 48 PL: 22 PI: 26 M: 26.3%	LEAN TO FAT CLAY (CL-CH): stiff, brown, brownish yellow, reddish brown, medium to high plasticity, moist, (RESIDUAL)	
3.5		☒	2	8 11 15	Sample 2 M: 22.5%	red, yellowish brown, light brown, with chert fragments	1061.5
5	1060	☒	3	8 22 13	Sample 3 M: 10.9%	CLAYEY CHERT GRAVEL (GC): very dense, light red, light yellowish brown, white, with clay layers, (RESIDUAL)	
6.5						Boring Terminated at 6.5 feet.	1058.5

REMARKS:
Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:** LIQUID LIMIT	**M:** NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:** PLASTIC LIMIT	**F:** PERCENT PASSING NO. 200 SIEVE
▽	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:** PLASTICITY INDEX	
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

LABORATORY TEST PROCEDURES

A brief description of the laboratory tests performed is provided in the following sections.

DESCRIPTION OF SOILS (VISUAL-MANUAL PROCEDURE) (ASTM D2488)

The soil samples were visually examined by our engineer and soil descriptions were provided. Representative samples were then selected and tested in accordance with the aforementioned laboratory-testing program to determine soil classifications and engineering properties. This data was used to correlate our visual descriptions with the Unified Soil Classification System (USCS).

NATURAL MOISTURE CONTENT (ASTM D2216)

Natural moisture contents (M%) were determined on selected samples. The natural moisture content is the ratio, expressed as a percentage, of the weight of water in a given amount of soil to the weight of solid particles.

ATTERBERG LIMITS (ASTM D4318)

The Atterberg Limits test was performed to evaluate the soil's plasticity characteristics. The soil Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The Liquid Limit is the moisture content at which the soil will flow as a heavy viscous fluid. The Plastic Limit is the moisture content at which the soil is between "plastic" and the semi-solid stage. The Plasticity Index (PI = LL - PL) is a frequently used indicator for a soil's potential for volume change. Typically, a soil's potential for volume change increases with higher plasticity indices.

MATERIAL FINER THAN NO. 200 SIEVE BY WASHING (ASTM D1140)

Grain-size tests were performed to determine the partial soil particle size distribution. The amount of material finer than the openings on the No. 200 sieve (0.075 mm) was determined by washing soil over the No. 200 sieve. The results of wash #200 tests are presented on the boring logs included in this report and in the table of laboratory test results.

LABORATORY TEST RESULTS

The results of the laboratory testing are presented in the following tables.

BORING NO.	DEPTH	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	% PASSING #200 SIEVE	CLASSIFICATION
B-01	0.5 - 2.0	21.7	37	19	18		
B-01	2.5 - 4.0	20.6					
B-01	5.0 - 6.5	17.8					
B-01	8.5 - 10.0	24.3					
B-02	0.5 - 2.0	27.6					
B-02	2.5 - 4.0	24.8	42	18	24	83	CL
B-02	5.0 - 6.5	15.7					
B-02	8.5 - 10.0	15.5					
P-01	0.5 - 2.0	25.1					
P-01	2.5 - 3.5	14.4					
P-01	5.0 - 6.5	9.5					
P-02	0.5 - 2.0	26.3	48	22	26		
P-02	2.5 - 4.0	22.5					
P-02	5.0 - 6.5	10.9					

TABLE L-1: General Soil Classification Test Results

Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic

(1) Indicates visual classification. WR indicates weathered rock.

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.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of 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.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

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This report has been prepared in accordance with generally accepted standards of geotechnical engineering practice. No other warranty is expressed or implied. If changes are made, or anticipated to be made, to the nature, design, or location of the project as outlined in this report, Building & Earth must be informed of the changes and given the opportunity to either verify or modify the conclusions of this report in writing, or the recommendations of this report will no longer be valid.

The scope of services for this project did not include any environmental assessment of the site or identification of pollutants or hazardous materials or conditions. If the owner is concerned about environmental issues Building & Earth would be happy to provide an additional scope of services to address those concerns.

This report is intended for use during design and preparation of specifications and may not address all conditions at the site during construction. Contractors reviewing this information should acknowledge that this document is for design information only.

An article published by the Geoprofessional Business Association (GBA), titled *Important Information About Your Geotechnical Report*, has been included in the Appendix. We encourage all individuals to become familiar with the article to help manage risk.