Project Manual

Bid Package 01

Cherokee Nation Entertainment
TAHLEQUAH CASINO

Tahlequah, Oklahoma

March 6th, 2018

JAMES R. CHILDERS ARCHITECT, INC.

Tel: 479.783.2480 Fax: 479.783.4844 E-mail: casey@childersarchitect.com Web: www.childersarchitect.com

TABLE OF CONTENTS

SECTION 00 0102

PROJECT INFORMATION

PART 1 GENERAL

1.01 PROJECT IDENTIFICATION

A. Project Name: Tahlequah Casino , located at Tahlequah, Oklahoma.

B. The Owner, hereinafter referred to as Owner: Cherokee Nation Entertainment

1.02 PROJECT DESCRIPTION

A. Summary Project Description: The site development and construction of a new free standing facilty to function as a casino, convention center and resturant. .

1.03 PROJECT CONSULTANTS

A. **Architect**
   1. James R Childers Architect, Inc.
      a. 45 South 4th Street
      b. Fort Smith, Arkansas
      c. 72901

B. **Interior Design**
   1. Jamie K Moore Interior
      a. PO Box 213
      b. Winslow, Arkansas
      c. 72959

C. **Structural**
   1. Myers - Beatty Engineering, PLLC
      a. 2411 Fayetteville, Rd. Ste B
      b. VanBuren, Arkansas
      c. 72956

D. **Civil**
   1. ADG, PC
      a. 920 West Main
      b. Oklahoma City, Oklahoma
      c. 73106

E. **MEP**
   1. MSA Engineering Consultants
      a. 370 E Windmill Lane, Ste 100
      b. Las Vegas, Nevada
      c. 89123

F. **Life Safety & Fire Protection**
   1. Terp Consulting
      a. 1604 South Marylanmd Parkway
      b. Las Vegas, Nevada
      c. 89104

G. **Food Service**
   1. Hesman Group, LLC.
      a. 7645 East 63rd Steet, Suite 201
      b. Tulsa, Oklahoma
      c. 74133

H. **Geotechnical**
   1. Building & Earth Sciences, Inc.
      a. 1403 South 70th East Avenue
      b. Tulsa, Oklahoma

c. 74112

I. **Landscape Architecture**
1. Gray Rock
   a. 5204 Village Parkway, Suite 11
   b. Rogers, Arkansas
   c. 72758

J. **Low Voltage / Audio Video / CCTV / Access Control / Fire Alarm**
1. York Electronic Systems, Inc.
   a. 2900 W Albany
   b. Broken Arrow, Oklahoma
   c. 74012

K. **Signage**
1. CNF Native American Services, LLC
   a. 11810 S Oswego Avenue
   b. Tulsa, Oklahoma
   c. 74137

L. **Survey**
1. Krohn Surveying, Inc.
   a. PO Box 146
   b. Lone Grove, Oklahoma
   c. 73443

M. **Traffic**
1. Traffic Engineering Consultants, Inc.
   a. 6000 S Western Avenue, Ste. 300
   b. Oklahoma City, Oklahoma
   c. 73139

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 00 0105
GEOTECHNICAL DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Report of Subsurface Exploration and Geotechnical Evaluation for the Cherokee Casino
   1. Location: Tahlequah, Oklahoma
   2. By: Building & Earth Sciences, Inc.
   3. Date: January 17, 2018

PART 2 PRODUCTS - NOT USED

END OF SECTION

CHILDERS ARCHITECT

REPORT OF SUBSURFACE EXPLORATION AND GEOTECHNICAL EVALUATION
CHEROKEE SPRINGS CASINO
TAHLEQUAH, OK
BUILDING & EARTH PROJECT NO.: OK170293

PREPARED FOR:
Childers Architect, Inc.

JANUARY 17, 2018

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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

January 17, 2018

Childers Architect, Inc.
45 South 4th Street
Fort Smith, AR-72901

Attention: Mr. Ralph E. Taylor, Architect

Subject: Report of Subsurface Exploration and Geotechnical Evaluation
Cherokee Springs Casino, Hotel, and Convention Center
Tahlequah, Oklahoma
Building & Earth Project No: OK170293

Dear Mr. Taylor:

Building & Earth Sciences, Inc. has completed the authorized subsurface exploration and geotechnical engineering evaluation for the proposed Cherokee Springs Casino, Hotel, and Convention Center to be constructed at the Cherokee Springs Plaza Mixed-Use Development in Tahlequah, 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 twenty-five (25) 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 6/30/2018

REGISTERED PROFESSIONAL ENGINEER
Marco V. Vicente Silvestre
21903
1/17/18
OKLAHOMA

Dharmateja Maganti, E.I.T.
Project Manager

Joseph D. Vistad, P.E. (ND)
Geotechnical Manager

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

cc: Mr. Kevin Ogle, P.E., Cherokee Nation

Table of Contents

1.0 PROJECT & SITE DESCRIPTION

The subject site is located on Seven Clans Drive at the Cherokee Springs Plaza Mixed-Use Development in Tahlequah, Oklahoma. General information relative to the proposed site and the proposed development is listed in Table 1 below. More detailed information and photographs depicting the current site conditions are presented on the following pages.

Development Item	Detail	Description
General Site	Size (Ac.)	~25
	Existing Development	None noted within proposed construction area. Paved roadways to the west of the proposed development.
	Vegetation	The project site is covered with grass and shrubs.
	Slopes	General slope is to the southeast. In addition, both north and south half of the subject area slope towards the west-east oriented swale in the middle of the project area.
	Retaining Walls	None noted
	Drainage	West-east oriented swale in the middle of the project area draining to the existing pond located in the southeast corner of the project site.
	Cuts & Fills	None noted in the borings drilled.
Proposed Buildings	No. of Buildings	Casino and Convention Center, Hotel Tower, and Maintenance Facility Building.
	Square Ft.	Casino and Convention Center (82,000 SF) Six-story hotel tower with 75 to 100 rooms Single story maintenance building (4,000 SF)
	Stories	Casino and maintenance facility buildings: one-story Hotel tower: six stories
	Construction	Casino and hotel: structural steel and light gage stud framing (assumed). Maintenance building assumed to be pre-engineered metal building.
	Column Loads	Casino building: 100 to 150 kips (assumed), Hotel tower: 900-1000 kips (assumed) Maintenance building: less than 50 kips (assumed)
	Wall Loads	3 to 5 kips per linear foot (Casino Building, assumed)
	Preferred Foundation	Casino and Hotel: Drilled Pier and Grade Beam or Spread Footings on Aggregate Piers(assumed) Maintenance Facility: Conventional Shallow Footings
	Preferred Slab	Slab on Grade (assumed)
Pavements	Traffic	Not provided
	Standard Duty	Rigid and flexible; with assumed 100,000 ESALs (assumed)
	Heavy Duty	Rigid and flexible; with assumed 450,000 ESALs (assumed)

Table 1: Project and Site Description

Reference: Revised Schematic Design prepared by Childers Architects, dated December 20, 2017

Notes:

1. ***If actual loading conditions exceed our anticipated loads, Building & Earth Sciences should be allowed to review the proposed structural design and its effects on our recommendations for foundation design.***
2. ***When a grading plan is finalized, Building & Earth should be allowed to review the plan and its effects on our recommendations.***

Figure 1: Google Earth Satellite Image, dated 10/27/2017

Figure 2: Project area - looking southeast from the west line of the property

Figure 3: Swale dividing the property – looking southeast toward the pond

Figure 4: Limestone outcrop in the southwest edge of the existing pond

Review of Google Earth historic satellite imagery indicated that a pond is located to the southeast portion of the project site. A drainage swale was noted within the central portion of the project site, traversing in east-west direction towards the existing pond.

2.0 SCOPE OF SERVICES

The authorized subsurface exploration was performed from December 26th to 28th 2017 in conformance with our proposal OK19363, dated October 19, 2017. Notice to proceed was provided by returning the signed contract on December 20, 2017. Additional boring locations were requested by Childers Architects on December 22, 2017. Pursuant to the request, ten (10) more borings were added in parking and canopy areas. These borings were conducted during the same timeline as the originally proposed borings.

Building & Earth previously performed a preliminary subsurface exploration as part of the Cherokee Springs Plaza development and issued a preliminary geotechnical report (Building & Earth Project No: OK150004, dated February 27, 2015) to Cherokee Nation Businesses, LLC. Five borings (CC-01 through CC-05) within the anchor site and two borings (H-01 and H-02) within the hotel area were drilled as part of our preliminary investigation and made part of this design-phase report. It should be noted that the location of the proposed casino and hotel has been shifted to the north from the time of our preliminary exploration.

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 twenty-five (25) test borings. The site was drilled using a CME-75 truck mounted drill rig, and a Diedrich D-50 track mounted drill rig, both equipped with hollow stem auger and automatic hammer. The D-50 drill rig was also equipped with NQ rock core tooling.

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

The soil/rock 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	78
Atterberg Limits	D4318	12
Material Finer Than No. 200 Sieve by Washing	D1140	3
Unconfined Compression Test on Rock	D7012	4

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 structures. 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 our 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 foundation design, including appropriate foundation types, bearing pressures, and depths.
- Presentation of expected total and differential settlements, and recommendations to reduce the expected movements, if appropriate.
- 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 only.
- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommended typical minimum flexible and rigid pavement sections based on stated traffic loading conditions.

We acknowledge that the Cherokee Nation Entertainment Construction Guidelines and Requirements for Geotechnical Investigation, Soil Boring, and Testing call for global stability analysis of retaining walls. However, global stability of proposed walls is excluded from this report and analysis and is beyond our scope of work as detailed information regarding site grading, wall elevations (top and bottom of wall) and wall alignment have not been provided.

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 are based on the assumption that significant changes in subsurface conditions do not occur between boreholes. However, anomalous conditions can occur due to variations in existing fill that may be present at the site, 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 GEOLOGY

Published geologic literature indicates the site is located near the boundary of the Mississippian Age Keokuk Formation and Pitkin Formation.

The Keokuk Formation consists of massive, white to bluff, gray-mottled, fossiliferous chert. Irregular stringers and masses of blue-gray, dense, finely crystalline limestone are present locally. The formation is characterized by its brittleness and brecciated character. It weathers tripolitic and locally is iron stained. The thickness ranges from about 50 to 150 feet, the upper portion having been removed by erosion over most of the area.

The Pitkin Formation is a predominantly medium- to dark-gray, dense to finely crystalline limestone that contains abundant medium- to dark-gray oolites, and in places, fine sand. Thin beds of dark gray to grayish black shale are present within the formation. The basal contact of the formation is conformable. The thickness of the Pitkin Limestone ranges from a thin edge to over 400 feet. The average thickness is about 50 feet in the west and about 200 feet in the east.

The subsurface conditions encountered in the borings correlate with the Pitkin Formation.

3.2 EXISTING SURFACE CONDITIONS

At the time of our subsurface exploration and site reconnaissance, a majority of the site was covered with grass, weeds, and brush. The site appears to be poorly drained, with standing water noted in the east-west oriented swale in the middle of the project site.

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 strata types encountered during our field investigation.

Stratum No.	Typical Thickness	Description	Typical Consistency
1	0.1' – 2.5'	Topsoil (Silty Clay and Lean Clay Soils with significant organic content)	Soft to medium stiff
2	0.8' – 3.7'	Near-surface residual soils consisting of Lean Clay (CL) (Borings B-02, B-03, B-09, B-10, CP-02, and P-01 only)	Near surface, lean clays typically exhibited medium stiff to very stiff consistencies with N-values ranging between 6 and 14
3	0.8' – 9.3'	Residual soils comprised of Fat Clay (CH), and Lean to Fat Clay (CL-CH)	Typically exhibited medium stiff to very stiff consistencies with N-values ranging between 6 and 12. Soft to medium stiff clay soils were encountered in Borings B-02, B-04, B-06, B-08, B-10, CP-01, and P-08.
4	Termination Layer [1]	Limestone and minor weathered shale associated with the Pitkin Formation	SPT Refusal of 50 blows for 0.25 to 6 inches

Table 3: Stratification Summary

Notes:

1. With exception of Borings P-07, P-09, P-10, auger refusal was encountered within the Pitkin Formation at depths of about 2 to 10.5 feet.

Subsurface profiles have also been prepared based on the data obtained at the specific boring locations and are presented in the Appendix. For specific details on the information obtained from individual borings, please refer to the Boring Logs included in the Appendix.

The elevations of the borings indicated in this report were estimated using a surveyor's scope and leveling rod. As such, the shown elevations should be considered approximate. The top of rim of a sanitary sewer manhole located to the west of the existing pond was used as a temporary benchmark. The elevation of the benchmark was reported as 802.6 on the Phase 1 Construction Plans prepared by CGA Engineers, Inc.

3.3.1 Topsoil

The topsoil thickness ranged from about 2 to 30 inches at the boring locations. The topsoil conditions reported apply only to the specific boring locations. It should be noted that topsoil thicknesses likely vary at unexplored locations of the project site. For the purpose of this report, topsoil is defined as the soil horizon which contains silty clay and lean clay

soils with significant organic content. The topsoil is predominately dark brown, dark grayish brown and dark gray in color and contained roots associated with the noted vegetation. These soils are prone to losing stability with slight increase in soil moisture contents and will likely not provide a workable platform.

Atterberg Limits tests performed on selected samples of the topsoil indicated low plasticity characteristics with liquid limit (LL) values ranging between 28 and 32, plastic limit (PL) values ranging between 18 and 20, and plasticity index (PI) values ranged between 8 and 13. As part of the preliminary subsurface exploration and evaluation, loss on ignition testing indicated organic contents ranging between roughly 3 and 5 percent.

3.3.2 Residual Clay Soils

Residual clay soils, formed by the in-place weathering of the parent rock, were encountered below the topsoil in all borings, and they extended to depths of 1 to 10 feet below existing ground surface.

Near-surface, Low to Moderate Plasticity Residual Clay Soils:

Residual lean clay soils were encountered below the topsoil in Borings B-02, B-03, B-09, B-10, CP-02, and P-01. The lean clay soils extended to depths of about 1 to 5.2 feet below current grades and were yellowish brown, light grayish brown , brown, and mottled yellow in color and encountered roots and sandstone and limestone fragments. The near-surface, clay soils typically exhibited medium stiff to very stiff consistencies with standard penetration test (SPT) N-values ranging between 6 and 14. Very soft clay soils were encountered in Boring P-08 and soft to medium stiff lean clays were encountered in Boring B-08.

Atterberg Limits tests performed on selected samples of the near surface clay soils indicated low to moderate plasticity characteristics with liquid limit (LL) values of 41 and 42, plastic limit (PL) values of 17 and 19, and plasticity index (PI) values ranged between 23 and 24. Natural moisture contents of the near-surface, residual clay soils typically ranged between 14 and 27 percent.

Moderate to High-Plasticity Residual Clay Soils:

Residual lean to fat clay (CL-CH) and fat clay (CH) soils were encountered below the topsoil and lean clay soils, and they extended to depths of about 1 to 9.8 feet below current grades. The lean to fat clay and fat clay soils were various shades and combinations of gray, light gray, dark gray, light gray, yellowish brown, brownish gray, grayish brown and reddish brown in color. Ferrous nodules, sandstone and limestone fragments were noted in the higher plasticity clays. SPT N-values typically ranged between 6 and 12 indicating medium stiff to very stiff consistencies. Soft to medium stiff clay soils were noted within this stratum in Borings B-02, B-04, B-06, B-08, B-10, CP-01, and P-08.

Atterberg Limits tests performed on select samples of the moderate to high plasticity clay soils indicated LL values of 46 to 67, PL values of 18 to 19, and PI values of 28 to 49, indicating moderate to high plasticity characteristics. Grain size analysis (No. 200 wash) performed on select samples indicated 87 through 92 percent fines (silt and clay fraction). Moisture contents of the residual higher plasticity clays typically ranged from 17 to 29 percent.

3.3.3 Pitkin Formation: Limestone and Minor Weathered Shale

A limestone unit associated within the Pitkin Formation was encountered below residual clay soils in all borings at depths of about 1 to 9.8 feet, extending to the auger refusal depths of about 2 to 10.5 feet below the existing ground surface.

The limestone was light gray, and gray, with some yellowish brown and brown in color. Dark gray, shale seams and layers were noted within the limestone unit. SPT refusal was encountered within limestone unit with 50 blows for 0.25 to 6 inches of penetration. Rock coring procedures were used at Borings B-01 through B-03, B-07, B-09, and B-10 to advance the boreholes beyond auger refusal depth and sample the limestone unit. The recovery of the core samples ranged between 68 and 100 percent. The Rock Quality Designation (RQD) within the upper 5 feet of the core samples ranged between 48 and 98 percent, indicating fair to good quality rock. The low RQD in some of the borings was due to fracturing near the top of the formation and clay seams and layers within the upper 2 feet. RQD ranging between 85 and 100 percent in the second 5-foot core runs in each boring. Rock core compressive strength tests were performed on intact rock core specimens collected from the borings. The compressive strength of a shale was 4,640 psi and of limestone ranged between 5,780 and 7,290 psi.

A 4-foot thick layer of weathered shale was encountered above the limestone unit in Boring B-10 at a depth of about 5 feet below current grades. The weathered shale was yellow, light brown and light gray in color and contained limestone seams. An N-value of 39 was recorded within the weathered shale stratum.

3.3.4 Auger Refusal

Auger refusal is the drilling depth at which the borehole can no longer be advanced using soil drilling procedures. Auger refusal can occur on boulders, buried debris or bedrock. Coring is required to sample the material below auger refusal. With exception of Borings P-07, P-09, and P-10, auger refusal was encountered in all borings. The approximate depths at which auger refusal was encountered in each boring is shown in the table below.

Boring No.	Depth (ft)	Boring No.	Depth (ft)	Boring No.	Depth (ft)
B-01	9.0	B-10	9.0	P-04	7.0
B-02	9.0	B-11	10.0	P-05	3.0
B-03	10.0	B-12	9.0	P-06	2.0
B-04	10.5	CP-01	6.5	P-07	N/A
B-05	10.0	CP-02	5.5	P-08	7.5
B-06	9.5	CP-03	9.0	P-09	N/A
B-07	8.5	P-01	6.5	P-10	N/A
B-08	7.5	P-02	7.5	---	---
B-09	9.5	P-03	5.1	---	---

Table 4: Auger Refusal Depths

3.3.5 GROUNDWATER

Groundwater seepage was encountered during drilling in Borings B-02, B-03, and B-05 at depths of 8 and 9 feet below current grades. Free water was measured at completion of drilling operations in Borings B-04 and B-11 at depths of about 5 and 6.5 feet, respectively. Water levels were measured in Borings B-03 and B-09 at depths of about 6 and 4 feet, 24 hours after completion of drilling.

Groundwater seepage was not encountered in the remaining borings during drilling and borings were dry upon the completion of drilling operations and prior to commencement of rock coring or prior to backfilling.

It should be noted that moisture contents of the topsoil (comprised of lean clays and silty clays with significant organic content) at the interface with underlying fat clays, and of the fat clays at the interface with limestone typically were relatively high. This suggests a high probability for development of perched water conditions near the surface as well as at greater depth above the rock formation.

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 prior to our final demobilization from the site.

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 20 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 5: Seismic Site Classification

4.0 SITE DEVELOPMENT CONSIDERATIONS

A site grading plan was not available for our review at the time of this proposal. Based on review of available topographic data and the provided report of preliminary subsurface exploration, we understand the site slopes steadily down from northwest to southeast. There appears to be an overall grade change of approximately 5 feet across the casino/hotel/convention center area and 14 feet across the site as a whole. For the purpose of this report, we have assumed a preliminary finished floor elevation (FFE) of 803.0 based on the elevation of Boring CC-01 of the preliminary exploration. An FFE of 803.0 will yield fill depths of up to 4 feet within the proposed Casino and Convention Center. Within the planned maintenance facility building and pavement areas, cut and fill depths of less than 3 feet are assumed for the purpose of this report.

When final site and grading plans become available, it will be necessary for Building & Earth to review the recommendations presented in this report to determine if any additional considerations would be appropriate based on the final grading and layout scheme.

The primary geotechnical concerns for this project are:

- A swale bisects the proposed building area and the site has poor drainage as evidenced by ponding water within the noted swale.
- Topsoil thickness typically ranging from about 12 to 30 inches encountered in the borings across the site.
- Soft to medium stiff clay soils (N-value $\leq$ 5) extending down from below the topsoil to depth up to 6 feet in portions of the project site, particularly within the extent of the existing swale and surrounding areas.

- The near-surface, low plasticity lean clay soils (mostly referred to as topsoil) encountered across most of the site are moisture sensitive and prone to losing strength and stability with slight increases in soil moisture content.
- The onsite residual fat clay soils exhibited high plasticity characteristics that have a high shrink-swell potential.
- The high probability for development of perched water at the interface of the topsoil and underlying residual fat clays, as well as above the rock formation.
- Groundwater seepage was encountered during drilling in Borings B-02, B-03, and B-05 at depths of 8 and 9 feet below current grades. Free water was measured at completion of drilling operations in Borings B-04 and B-11 at depths of about 5 and 6.5 feet, respectively. Water levels were measured in Borings B-03 and B-09 at depths of about 6 and 4 feet, 24 hours after completion of drilling.
- With exception of Borings P-07, P-09, and P-10, auger refusal was encountered on limestone at depths of about 2 to 10 feet below current grades.
- The top of the limestone formation was fractured and clay seams and layers were noted in the upper 2 feet of the rock unit.

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

4.1 Initial Site Preparation

All trees, vegetation, roots, topsoil, and any other deleterious materials, should be removed from the proposed construction areas. Approximately 2 to 30 inches of topsoil was observed in the borings; however, topsoil could extend to greater depths in unexplored areas of the site.

For the purpose of this report, topsoil is defined as the soil horizon which contains silty clay and lean clay soils with significant organic content. The topsoil is predominately dark brown, dark grayish brown and dark gray in color and contained roots associated with the noted vegetation. These types of soil are prone to losing stability with slight increase in soil moisture contents and will likely not provide a workable platform; therefore, we recommend full-depth removal within areas proposed for construction.

Grubbing of trees should include removal of the tree stumps and the root systems. Desiccated clay soils may be present in the zone surrounding the trees. Desiccated clay soils should be undercut and replaced with structural fill.

Materials disturbed during clearing operations should be undercut to undisturbed materials and backfilled with properly compacted, approved structural fill. A geotechnical engineer should observe stripping and grubbing operations to evaluate that all unsuitable materials are removed from locations for proposed construction.

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 Swale Areas

As previously mentioned, a drainage swale was noted within the central portion of the project site, extending in west-east direction towards the existing pond. Moist to wet, soft/loose soils are commonly present within and adjacent to swales. Borings B-08 and P-08 drilled near the swale encountered soft to medium stiff soils with relatively high soil moisture contents to depth of about 6 feet. Soft, wet and unstable soil conditions should be anticipated within and adjacent to the swale alignment. Figure 5 below shows an estimated area which likely will pose stability concerns during construction. It should be noted that the shaded area in the figure is solely provided to obtain a general understanding on the extent of the area of concern and should not be considered an accurate depiction. The actual lateral extent of soft and unstable soils must be field verified by a representative of the geotechnical engineer following stripping of the topsoil at the time of construction.

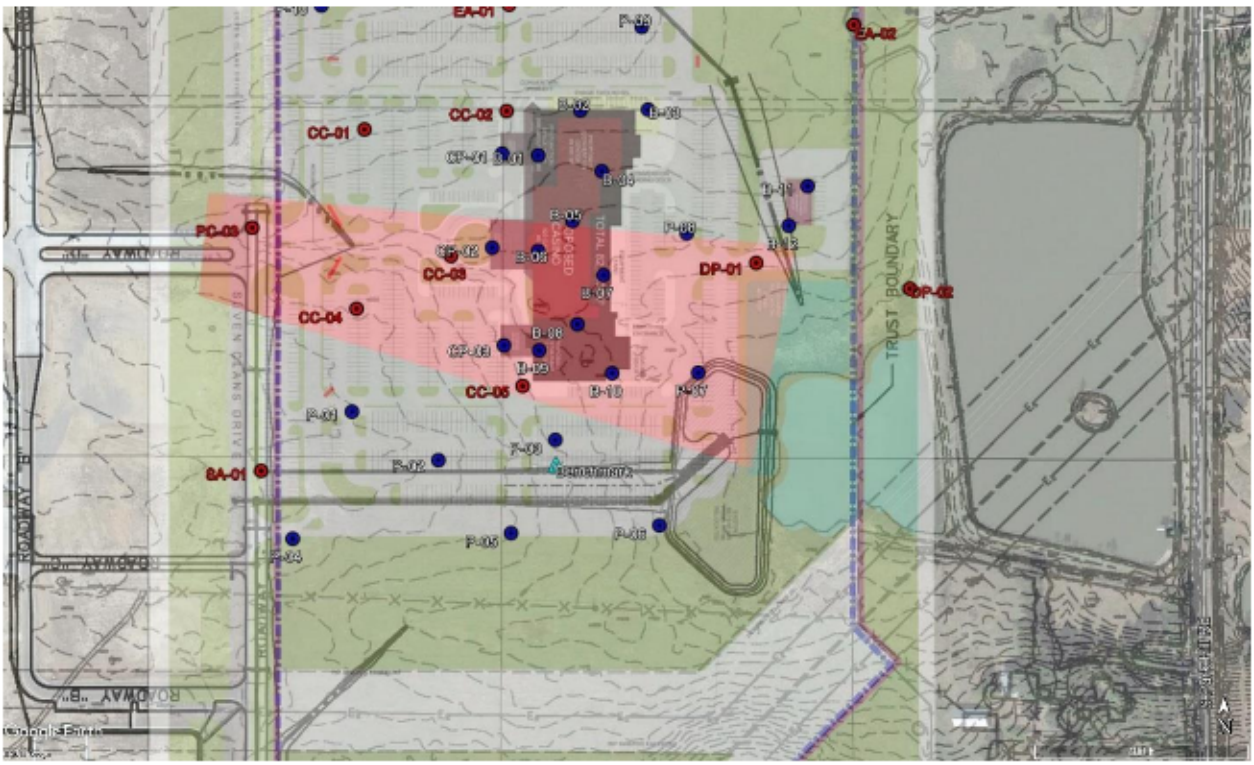


Figure 5: Shaded area in red showing the estimated extent of soft and unstable soils associated with the noted swale (actual extent to be field verified)

4.3 Moisture Sensitive Soils

Near-surface, moisture sensitive, low plasticity, lean clay (CL) soils (referred to as topsoil in this report) were encountered within most of the proposed development and extended to depths of about 1 to 2.5 feet below current grades.

The site is prone to development of near-surface perched water within the moisture sensitive low plasticity clay soils at the interface with underlying, high plasticity clay soils during wet weather conditions. These near-surface 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 during construction. Increased moisture levels will further soften the subgrade. The soils are unstable and should be expected to rut and pump under the influence of construction traffic.

4.3.1 Full Depth Removal of Topsoil

The topsoil thickness across the site generally ranged from about 2 to 30 inches, with thicknesses ranging from about 12 to 24 inches encountered across the majority of the site. The topsoil encountered across the building and pavement areas must be removed full-depth. Average undercut depths on the order of 1.5 to 2 feet should be anticipated across the proposed development. A geotechnical engineer should observe stripping and grubbing operations to evaluate that all unsuitable materials are removed from proposed construction areas.

4.4 Building Pad Preparation

Following initial site preparation and full-depth removal of topsoil, moderate to high plasticity clay soils are anticipated to be exposed. It should be noted that onsite residual clay soils in portions of the proposed building areas exhibited low consistencies. Also, of primary concern is the presence of an existing swale extending through the central portion of the proposed casino/hotel tower building (refer to Figure 5 earlier this report).

As a minimum, the following recommendations presented in this section of the report should be implemented to provide a stable platform suitable for support of proposed structures.

4.4.1 Undercutting of Higher Plasticity Soils

Materials with a liquid limit value greater than 50 and a plasticity index value greater than 25 are considered highly plastic and they tend to undergo volume changes when subjected to moisture variations.

The swell potential of the higher plasticity clay soils 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, dry soil moisture conditions, thickness of the clay soil strata, and surcharge loads. For this project site, an active zone of 8 feet was used in the calculations. The TexDOT method estimates a maximum PVR of 2 inches for soil moisture contents in a dry condition as defined by the PVR methodology.

It is an accepted local practice to tolerate a maximum PVR of 1 inch for conventionally reinforced concrete slabs-on-grade. ***In order to reduce the PVR to 1 inch or less, it is recommended that all grade supported slabs of the proposed buildings be supported on at least 36 inches of properly compacted and approved lower plasticity structural fill***.

All undercutting within the building areas should extend at least 5 feet beyond the perimeter of the proposed buildings. Once the undercut is complete and prior to structural fill placement, the planned building areas should be carefully evaluated and prepared in accordance with *Cut Subgrade Evaluation and Preparation* section of this report.

4.4.2 Cut Subgrade Evaluation and Preparation

Following the recommended amount of undercutting and prior to placement of fill, we anticipate that onsite residual clay soils will be exposed across the proposed construction areas.

We recommend that the condition of the exposed subgrade be evaluated by the geotechnical engineer or their designated representative at the time of construction, following completion of the recommended undercut to allow for placement of at least 36 inches of structural fill. Evaluation should include proofrolling of the exposed subgrade with a loaded tandem-axle dump truck.

Depending on the time of year and prevailing weather conditions, we anticipate that most of the north half of the casino building will be firm and will provide a stable platform for start of structural fill placement. However, as previously outlined in the *Swale Area* section of this report, soft and unstable soils are anticipated within most of the south half of the casino and the hotel tower areas (refer to the red shaded area in Figure 5 presented earlier in this report).

Preparation of Stable Subgrade Areas

Following the recommended subgrade evaluation as previously outlined and prior to start of structural fill placement, we recommend scarifying of the cut subgrade soils to a depth of 12 inches, moisture conditioning within range of 1 percent below to 3 percent above the optimum moisture content, and recompacting to at least 95 percent of the standard Proctor maximum dry density.

Preparation of Unstable Subgrade Areas

Any soft/unstable areas identified during proofrolling should be undercut full-depth to a stable, suitable subgrade and replaced with properly compacted and approved structural fill. The subsurface conditions encountered in some of the borings drilled as part of this design-phase and the preliminary scope of work completed in 2015 indicated presence of low consistency soils with elevated soil moisture contents extending to depth up to 6 feet below current grade.

The undercutting should be conducted under the observation of the geotechnical engineer or his representative. Once undercut is complete, areas planned for construction should be evaluated to verify that the soft/unstable materials were removed full-depth.

As previously stated, undercut depth of as much as 6 feet may be required in parts of the site for full-depth removal of the soft and unstable soils, particularly in the alignment of the swale and its surrounding areas. In lieu of full-depth removal of soft/unstable soils, consideration can be given to in-place stabilization of the soft soils that will remain in-place once the undercut of 36 inches below finished subgrade has been completed.

In-place stabilization methods can include tracking of surge stone (crushed aggregate with particle size ranging between 3 and 6 inches) into the unstable soils, or using a composite system of geogrid and crushed aggregate to establish a stable platform for start of fill placement. *Building & Earth can provide further detailed recommendations during construction depending on the conditions encountered at that time.*

4.5 General Proofroll Considerations

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 fully loaded, tandem-axle dump truck (25-ton minimum), at the following times.

- After an area has been stripped and undercut as recommended, and 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.

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, or pavement and floor slab construction. All unsuitable material identified during the construction shall be removed and replaced in accordance with the *Structural Fill* section of this report.

4.6 PAVEMENT SUBGRADE PREPARATION

Following full-depth removal of topsoil and depending on final design grades, new structural fill and residual high plasticity clay soils are anticipated to be exposed at finished subgrade level across the pavement areas.

Considering the anticipated subgrade conditions include high plasticity clay soils and our recommendation to provide for uniform subgrade conditions across all pavement areas, the proposed pavement section should either be supported on at least 12 inches thick low plasticity structural fill or 8 inches thick chemically stabilized onsite higher plasticity clay soils as outlined in the *Chemical Stabilization* section of this report.

Chemical stabilization will reduce the shrink-swell potential of the onsite clays, improve their pavement support properties, improve durability, and provide for a stable subgrade less susceptible to loss of strength and stability with soil moisture content increases.

Following grading and prior to fill placement or chemically stabilizing the subgrade soils, we recommend that the exposed subgrade be carefully evaluated and prepared in accordance with the *Cut Subgrade Evaluation and Preparation* section of this report.

4.7 Structural Fill

Requirements for each of the listed structural fill materials are as follows:

Soil Type	USCS Classification	Property Requirements	Placement Location
Imported Lean Clay, Sandy Lean Clay, or Clayey Gravel	CL, GC	LL<40, PI<18, γ_d>100 pcf, P200>30%, Maximum 3" particle size in any dimension CBR ≥ 5.0 for pavement areas	**Lower Plasticity Structural Fill** to be used for construction of building pads (min. 36") and in pavement areas (min. 12")
On-site near-surface, Lean Clays and Silty Clays	CL, CL-ML (topsoil)	As listed above	***Not Suitable*** for placement as lower plasticity structural fill in building and pavement areas due to the significant silt fraction and organic content. ***Likely suitable*** for use as general fill material in landscaped areas only
Chemically Stabilized Onsite Lean to Fat Clay and Fat Clay [1]	CL-CH, CH	Not Applicable	**Suitable** for use as structural fill in building and pavement areas when chemically stabilized with lime to lower PI≤15. [1]
In-Situ Onsite Lean to Fat Clay and Fat Clay	CL-CH, CH	Not Applicable	**Not suitable** for use as structural fill in building areas due to the high plasticity characteristics **Suitable** for use as structural fill *in pavement areas only*, at depths greater than 8 inches below the finished subgrade elevation. [2]

Table 6: Structural Fill Requirements

Notes:

1. The fat clay soils exhibited high plasticity characteristics and they are not considered appropriate for use as structural fill in building and pavement areas. In lieu of importing lower plasticity structural fill for construction of the building pad and pavement areas, consideration can be given to chemically stabilizing the onsite higher plasticity clay soils per the *Chemical Stabilization* section of this report.
2. If on site high plasticity clay soils are used as structural fill in pavement areas, care must be taken to limit clod sizes to a maximum of 3 inches in any dimension to allow for proper moisture conditioning.
3. 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.

4. 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.
5. Laboratory testing of the materials proposed for fill must be performed in order to verify their conformance with the above recommendations.
6. Any fill to be placed at the site should be reviewed by the geotechnical engineer.
7. The contractor needs to anticipate the need to import lower plasticity structural fill from an approved offsite borrow source for construction of building pads unless consideration is being given to lime stabilizing the onsite higher plasticity clay soils.
8. Material native to the region that may not meet the above structural fill criteria may be used if it contains more than 60% cherty sand and gravel retained on a No. 200 sieve (with maximum particle size of 3 inches in the upper 30 inches of the building/structure pad, and 6 inches elsewhere) 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.

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	95% of the standard Proctor maximum density
Moisture	**Imported Lean Clay and Shale:** 2% below to 2% above the optimum moisture content as determined by ASTM D698 **On-site High Plasticity Clays (Pavement Areas only):** 0 to 4% above the optimum moisture content as determined by ASTM D698
Density Testing Frequency	**Building 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 two tests performed per lift

Table 7: Structural Fill Placement Requirements

4.7.1 CHEMICAL STABILIZATION

In lieu of importing lower plasticity structural fill for construction of building pads and pavements, consideration can be given to chemically stabilizing the onsite higher plasticity fat clay soils with lime to reduce the plasticity index (PI) to 15 or less.

Based on experience with soils similar to those encountered at the project site, estimated quantities of lime based on soil dry weight are tabulated below. Laboratory tests should be performed on bulk samples of onsite clay soils and a chemical additive provided by the supplier at the start of the construction phase to evaluate the optimum amount of stabilizing agent. We further recommend that the supplier of the proposed chemical additive submit a current chemical analysis report for review and approval by the geotechnical engineer.

Lime Stabilizing Agent	ODOT Specification [1]	Estimated Quantity of Stabilizing Agent, % of Soil Dry Weight
Quick Lime	307 & 706.02	4-5
Hydrated Lime	307 & 706.01	6-7

Notes:

1. ODOT – Oklahoma Department of Transportation, 2009 edition

Table 8: Lime Stabilization Alternates

Lime stabilization of the higher plasticity clay soils should be performed in accordance with the applicable specifications of the Oklahoma Standard Specifications for Highway Construction, 2009 edition.

4.8 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.

4.8.1 Difficult Excavation

Based on the subsurface conditions encountered in the test borings, we anticipate the overburden soils can be excavated using a backhoe in good working condition.

Hard rock excavation techniques should be anticipated within the underlying limestone units encountered in the borings at depths ranging from about 2 to 10 feet across the site. Excavation of this limestone unit will require a hydraulic hoe ram attachment and a large trackhoe similar to a Caterpillar 690 equipped with rock teeth. The bedding thickness of the limestone will increase with increasing depth, likely requiring blasting for excavations extending into the limestone formation.

The ability to excavate hard 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 boring logs and should use his own method to evaluate excavation difficulty.

4.8.2 GROUNDWATER

Groundwater seepage was encountered during drilling in Borings B-02, B-03, and B-05 at depths of 8 and 9 feet below current grades. Free water was measured at completion of drilling operations in Borings B-04 and B-11 at depths of about 5 and 6.5 feet, respectively. Water levels were measured in Borings B-03 and B-09 at depths of about 6 and 4 feet, 24 hours after completion of drilling.

Also, based on the subsurface conditions encountered, there is a high probability for development of a perched water condition at the interface of the near-surface lean clays and fat clays and at the interface with limestone.

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.

4.9 DRAINAGE CONSIDERATION

The primary drainage concerns for the project site include the following:

- The planned building and pavement areas are located within the low-lying area of the Cherokee Springs Plaza development.
- A swale bisects the proposed building area in general west-east direction and the site has poor drainage as evidenced by ponding water within the noted swale.
- Periods of heavier precipitation can cause potential development of perched water conditions at the interface of the near-surface lean clay soils and underlying higher plasticity clay soils and at interface of limestone.
- During Phase 1 construction of the Cherokee Springs Plaza development, including roadways and underground utilities, interconnected lenses of higher permeability clay soils with varying amount of sand were identified through which groundwater seepage occurred. Phase I construction of the development started in Spring 2015 during a period of time with record high precipitation. The subject site is also at risk for similar subsurface water seepage through the fat clay strata, depending on the weather conditions.

Taking into account the above listed concerns, we recommend installation of perimeter foundation drains around the proposed buildings. All subdrains should consist of 4-inch diameter, high density polyethylene (HDPE) perforated pipe and should be surrounded by at least 6 inches of ASTM No. 57 stone and wrapped with a suitable geotextile drainage fabric consisting of either Mirafi 140N or equivalent. The bottom of the pipe should be located at or slightly below bottom of shallow footing or grade beam, depending on the foundation system used for the building. The perimeter drain system should allow for gravity flow of water to a suitable point of discharge.

The structural and civil engineer of records must be consulted and construction documents should include plans, profiles, and details related to the recommended foundation perimeter drains.

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.

4.11 Landscaping and Grading Consideration

The potential for soil moisture fluctuations within building areas and pavement subgrades should be lessened in order to reduce the potential of subgrade movement. Site grading should include positive drainage away from buildings and pavements. Ponding of water adjacent to buildings and pavements could result in soil moisture increases and subsequent swelling of higher plasticity clay soils.

Landscaping and irrigation immediately adjacent to buildings and pavements should be limited. Trees can develop large root systems which can draw water from subgrade soils, resulting in subsequent shrinkage of the soils. Periodic irrigation of landscaping poses a risk of saturating and softening soils below shallow footings and pavements, which could result in settlement of 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. 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; however, based on structures of this size and type, we assume the maximum column and bearing wall loads to be on the order of 100 to 150 kips and 3 to 5 kips per linear foot (klf), respectively within the casino and convention center structures. We assumed the hotel tower to have maximum column loads on the order of 900 to 1,000 kips. ***If these assumptions concerning structural loading are incorrect, our office should be contacted, such that our recommendations can be reviewed.***

The maintenance facility structure planned as part of the development is assumed to be a pre-engineered metal building with light column loads. Consideration can be given to supporting the lightly loaded building on shallow continuous footings and spread footings.

Based on the subsurface conditions encountered and due to the anticipated moderate to high column loads and risk for excessive total and differential settlements, a shallow foundation system is not recommended for support of the casino, conference center, and hotel tower.

The proposed casino and hotel tower should be supported on a deep foundation system consisting of drilled piers extending into the limestone unit or shallow strip and spread footings resting on existing soils reinforced with aggregate piers.

5.1 Conventional Shallow Footings (Maintenance Facility)

Based on the conditions encountered in Borings B-11 and B-12, and after our site preparation recommendations are implemented, the proposed maintenance facility structure can be supported on conventional shallow footings.

The building pad should be constructed of at least 36 inches of lower plasticity structural fill and the bottom of the shallow footings should remain at least 12 inches above the base of the structural fill section.

Footings founded on at least 12 inches of lower plasticity structural fill can be designed using a maximum net allowable soil bearing capacity of 2,000 psf.

It should be noted that the on-site clay soils exhibited moderate to high 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 moderate to high plasticity 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.

Upon excavation to footing bearing elevation, and prior to the placement of concrete for foundations, the materials exposed in the footing excavation should be thoroughly evaluated by the geotechnical project engineer or their qualified representative. Evaluation of the exposed materials should include hand auger borings and dynamic cone penetrometer (DCP) testing to a depth at least one footing width below the bearing elevation. DCP testing will aid with verification of the in-place allowable bearing capacity of the bearing materials at the time of construction.

Materials that do not meet the recommended bearing capacity should be delineated and undercut to suitable material or a depth equivalent to at least one footing width, whichever occurs first. Lateral over-excavation of unsuitable soils should extend 8 inches beyond the edges of the footing for each foot of undercut depth below design bearing elevation. The footings should then be brought back up to design bearing elevation with properly compacted and approved structural fill (placed in loose lifts of no more than 6 inches thick and compacted to at least 95 percent of the standard Proctor maximum dry density) or controlled low-strength material (CLSM, Section 701.19 of Oklahoma Department of Transportation Standard Specifications, 2009).

Even though computed footing dimensions may be less, 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. ***All exterior footings should bear at least 24 inches below the adjacent exterior grade.***

Total settlement of footings designed and constructed as recommended above is estimated to be less than 1 inch. Differential settlement between any two points spaced 40 feet across the slab, or along continuous footings is estimated to be ½-inch or less.

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.
- 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.
- All bearing surfaces must be free of soft or loose soil prior to placing concrete.
- 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.
- Roof drains should be routed away from the foundation soils.
- The building pad should be sloped to drain away from the building foundations.

5.2 Drilled Piers (Casino and Hotel Tower)

The proposed casino and hotel buildings supported on drilled piers should be socketed into the hard limestone unit, free of voids and clay layers. Drilled piers extended through weathered rock with clay lenses, and socketed into competent rock can be used to support the proposed structures. Using this approach, an auger is used to excavate soil; and rock removal techniques are used to remove broken or discontinuous rock to reach competent bearing strata.

A design decision to be addressed when using rock sockets is whether to neglect one or the other component of resistance (side or base), for the purpose of evaluating the drilled pier capacity. For strong rock, the Federal Highway Administration (FHWA) recommends to use either side friction or end bearing resistance only, but not both. It is our opinion that the use of drilled piers sized for only end bearing is appropriate for the site for the following reasons:

- The drilled pier base will be bearing in rock which is either massive or tightly jointed. The unconfined compressive strength of the limestone is high.
- The conditions are suitable for the preparation of a clean base. This can be verified by visual observation prior to concrete placement.

- The amount of rock removal is a major factor in the drilled pier foundation costs. The use of a high allowable end bearing capacity will reduce the amount of rock removal required for the shafts.

The piers must extend through the overburden soils, highly weathered to weathered shale (where present above the limestone unit), and the fractured zone of limestone containing clay seams and layers, and socketed at least 1.5 times the pier diameter into the continuous and competent limestone unit. The contractor must understand that removal of the upper zone of limestone may be required prior to start of the rock socket in order to ensure all fractured rock and clay has been removed from the base of the drilled shaft.

The top of the limestone unit recommended for the pier socket was encountered within the casino and hotel tower at depths of about 8 to 12 feet below the existing ground surface.

Drilled piers socketed into the recommended continuous and competent limestone unit and using concrete with a compressive strength of at least 3,500 psi can be designed using the recommended maximum allowable end bearing pressures and allowable skin friction for uplift resistance for that portion of the circumference of the pier in direct contact with the recommended limestone unit per the recommended allowable values presented in the table below. A factor of safety of 2.0 was used for the drilled pier analysis.

Parameter	Value
Minimum Diameter	24 in.
Minimum Socket into Competent Rock	1.5 x Pier Diameter
Allowable End Bearing Pressure (Compression Loads)	100 ksf [1]
Allowable Skin Friction (Uplift Resistance only)	5 ksf [1] (circumference of drilled pier portion socketed in competent rock)
Minimum Spacing	2.5 x Pier Diameter
Group Reduction Factor	Refer to Section 5.2.1

Table 9: Design Parameters for Drilled Piers

Notes:

1. Concrete used for construction of the piers must have a 28-day compressive strength of at least 3,500 psi.

The analysis of uplift effects was not included in our scope of services. The length and diameter required to resist uplift loads should be determined by the structural engineer of record, applying the provided skin friction uplift resistance.

When installing the piers, it is imperative to expose intact limestone across the entire base of the drilled shaft. The bottom of shafts must be free of soil, broken rock fragments, and water immediately prior to placement of fresh concrete.

It should be noted that the depth to the recommended limestone unit varies across the project area and that actual depths encountered during construction could be greater within unexplored areas of the site than those reported on the boring logs. The geotechnical engineer of record must verify the actual depths to the limestone unit during installation of the drilled piers.

Groundwater seepage was encountered during drilling in Borings B-02, B-03, and B-05 at depths of 8 and 9 feet below current grades. Free water was measured at completion of drilling operations in Borings B-04 and B-11 at depths of about 5 and 6.5 feet, respectively. Water levels were measured in Borings B-03 and B-09 at depths of about 6 and 4 feet, 24 hours after completion of drilling. When water is encountered during drilled pier installations, dewatering or temporary casing will be required to seal off the groundwater. The contractor should maintain an adequate head of concrete within the temporary casing above the groundwater level during its extraction from the drilled shaft to reduce the risk of contaminating the fresh concrete with groundwater. 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, the bearing surfaces should be re-evaluated prior to concrete placement.

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.

Settlement for piers designed and constructed as outlined above is estimated to be less than ½ inch.

Proper installation of drilled piers is essential to the success of the foundation system. In addition to structural considerations, certain safety hazards to personnel exist during construction and observation. The following guidelines should be observed during the installation of drilled piers:

- Prior to shaft entry or inspection:
  - Install metal casing in excavations over 4 feet or where the risk of sidewall collapse is present.
  - Monitor subsurface atmosphere with appropriate gas detection equipment.
  - Outfit personnel with OSHA (or MSHA) approved safety equipment including harness and separate safety line.

- Concrete Placement:
  - Concrete slump of 5 to 8 inches.
  - The concrete may be placed by "free-fall" if the concrete is not allowed to strike the reinforcement or the sides of the temporary casing. Otherwise, tremies or centering chutes should be used.
  - Clean bearing and socket surface of loose debris.
  - Place concrete the same day excavation is completed.
  - Maintain positive head of concrete during casing removal to prevent contamination.
- Should water enter the excavation:
  - Maintain a maximum water level of less than 2 inches deep.
  - Continue dewatering until concrete is placed.
- Should water infiltration exceed pump limits:
  - Allow water to attain static level.
  - Pump or tremie concrete to bottom of excavation.
  - Maintain a minimum 5 feet hose tremie embedment into the concrete during placement

5.2.1 Group Reduction Factors

There is no minimum pier spacing for vertically loaded piers socketed in limestone for design purposes. There might be some limitations on how close piers can be constructed. There is a risk that if two piers close together are opened and concrete is poured into one of the open drilled shafts, concrete could blow out into the adjacent open shaft. Typically, piers spaced closer than two diameters should not be opened until the concrete in the adjacent pier has set.

With respect to lateral loads, group reduction factors should be considered when the pier spacing in the direction of loading is less than six (6) pier diameters (D). The reduction factors are applied to the horizontal subgrade reactions and vary as shown in the following table. These reductions do not apply for loads perpendicular to the pier spacing.

Pier Spacing, Center-To-Center	Lateral Load Factor
≥ 6.0 D	1.00
5.0 D	0.85
4.0 D	0.65
3.0 D	0.50
2.5 D	0.35

Table 10: Recommended Group Reduction Factors

Notes:

1. D=Pier Diameter

The group reduction factors can be determined by linear interpolation for pier spacing between those listed in the table above.

5.2.2 Grade Beams

Structural grade beams spanning over the drilled piers can be used to support load bearing walls or other movement sensitive walls of the proposed structure.

Considering the presence of highly plastic clay soils with a high shrink-swell potential, a minimum 4-inch void space should be provided between the bottom of the grade beams and the underlying residual clay soils. Voids can be provided by cardboard forms.

5.3 In-Place Soil Improvement Using Aggregate Piers (Casino and Hotel Tower)

Based on the structural loading and subsurface conditions within the casino hotel building area, consideration can be given to supporting the proposed structures on shallow strip and spread footings resting on existing soil reinforced with aggregate piers. We recommend that aggregate piers be supported on top of the limestone encountered at depths ranging from about 6 to 10 feet below existing ground surface.

The aggregate pier elements are typically constructed by drilling 24- to 36-inch diameter holes to suitable material (limestone encountered at depths of about 6 to 10 feet in the casino and hotel borings) then building a bottom bulb of clean, open-graded stone. The aggregate pier shaft is built on top of the bottom bulb, using well-graded crushed stone placed in thin lifts (typically 12-inches compacted thickness). Compaction densifies the aggregate and increases the lateral stress in the surrounding soil matrix. The system serves to reduce settlement by replacing and reinforcing the residual clay soils in the 6 to 10 feet below the footing with a stiffer composite soil matrix. The structure is then supported on a shallow foundation system typically sized for allowable bearing pressure in the range of 4 to 6 ksf. The design and performance criteria for these systems are typically provided by the installation contractor.

Aggregate pier systems are proprietary foundation systems and should be designed and constructed by a licensed company. The installer should provide detailed design calculations sealed by a professional engineer licensed in the State of Oklahoma. Estimates from the design calculations should demonstrate that soil reinforcement from the particular method selected will control long-term settlements to less than 1-inch total and ½ inch differential. The design parameters should be verified by a full-scale "load" test performed in the field. Building & Earth should be retained to monitor the modulus test and subsequent production aggregate pier installations. Other factors, such as damage to existing structures due to vibrations or displacement stresses, should also be addressed.

After the overburden soils have been improved utilizing aggregate pier systems, the proposed building can be supported on conventional spread and continuous wall footings. An allowable bearing pressure will be developed by the installer as part of the design of the aggregate pier systems, but as stated previously, could be on the order of 4 to 6 ksf.

6.0 FLOOR SLABS

Site development recommendations presented in this report should be followed to provide for subgrade conditions suitable for support of grade supported slabs. Floor slabs will be supported on new, well compacted, lower plasticity structural fill with a thickness of at least 36 inches.

Floor slabs for the proposed buildings should be supported on a minimum six (6) inches thick compacted layer of free-draining, granular material, such as ASTM No. 57 stone. The purpose of this layer is to serve as a leveling course and act as a capillary break for moisture migration through the subgrade soil.

Consideration should be given to the use of a polyethylene vapor barrier. The slabs should be appropriately reinforced (if required) to support the proposed loads.

With addition of the granular material, an effective modulus of subgrade reaction of 150 pci can be used in the design of grade supported building floor slabs.

7.0 PAVEMENT CONSIDERATIONS

Based on the materials encountered at the boring locations and after construction and evaluation subgrade as described in the *Pavement Subgrade Preparation* section of this report, the subject site may be designed based on a California Bearing Ratio (CBR) of 2.5, or an estimated resilient modulus, M_r of 3,750 psi. Note that no CBR or plate load testing was completed to develop these recommendations.

7.1 Assumed Traffic and Design Parameter Values

Specific traffic information was not provided. For pavement design purposes, we have assumed two levels of traffic: standard duty pavements for parking stalls will be subjected to passenger cars, pick-up trucks, and light delivery box trucks with 18-kip Equivalent Single Axle Loads (ESALs) of 100,000. The access drives will be subjected to more frequent delivery trucks and occasional trash collection trucks with ESALs of 450,000.

It has been our experience that parking lots experience a certain level of wear and stress greater than roadways designed for similar traffic volumes. Therefore, parking lots are typically designed using the AASHTO method and adjusted based on experience. If the owner would like Building & Earth to assess other likely traffic volumes, we will gladly review other options.

In addition, we have assumed the following design parameters:

Design Criteria	Value
Design life (Years)	20
Terminal Serviceability	2.0
Reliability	85%
Initial Serviceability	4.2 (Flexible), 4.5 (Rigid)
Standard Deviation	0.45(Flexible), 0.35(Rigid)

Table 11: Assumed 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 2009. The applicable sections of the specifications are identified as follows:

Material	Specification Section
Portland Cement Concrete Pavement	414 & 701
Plant Mix Asphalt Concrete Pavement	411 & 708
Mineral Aggregate Base Materials	303 &703.01

Table 12: ODOT Specification Sections

7.2 Typical Minimum Pavement Sections

7.2.1 Flexible Pavement

The asphalt pavement sections described herein were designed using the "AASHTO Guide for Design of Pavement Structures, 1993". Alternative pavement sections were designed by establishing the structural numbers used for the AASHTO design system and substituting materials based upon structural equivalency as follows:

Material	Structural No.
Asphalt Concrete	0.42
Crushed Stone Base	0.14
Lime Stabilized Subgrade	0.08

Table 13: Structural Equivalent Coefficient

The following flexible pavement sections are based on the design parameters presented above:

Pavement Subgrade Preparation Alternates	Minimum Recommended Thickness (in)		Material
	Standard Duty	Heavy Duty	
Structural Fill Subgrade	2.0	2.0	HMAC Surface Course (Superpave "S4")
	2.5	4.0	HMAC Binder Course (Superpave "S3")
	6.0	6.0	Crushed Aggregate Base (ODOT Type "A")
	12.0	12.0	12-inch minimum Select Fill Subgrade
Lime Stabilized Subgrade	1.5	2.0	HMAC Surface Course (Superpave "S4")
	2.5	3.5	HMAC Binder Course (Superpave "S3")
	4.0	6.0	Crushed Aggregate Base (ODOT Type "A")
	8.0	8.0	Lime Stabilized Subgrade

Table 14: Asphalt Pavement Recommendations

In accordance with the ODOT specifications, asphaltic concrete should be compacted within 92 to 97 percent of the theoretical maximum specific gravity of the asphaltic concrete mix. The underlying aggregate base course should be compacted to at least 98 percent of the material's standard Proctor maximum dry density with a moisture content range of ± 2 percent of the optimum moisture content at the time of placement.

7.2.2 RIGID PAVEMENT

The following rigid pavement sections are based on the design parameters presented above. We assume an effective modulus of subgrade reaction (k) of 75 pci. We have assumed concrete elastic modulus (Ec) of 3.1 X 10^6 psi, and a concrete modulus of rupture (S'c) of 600 psi.

Pavement Subgrade Preparation Alternates	Minimum Recommended Thickness (in)		Material
	Standard Duty	Heavy Duty	
Structural Fill Subgrade	5.0	6.0	Portland Cement Concrete, f'_c=3,500 psi
	4.0	4.0	Crushed Aggregate Base (ODOT Type "A")
	12.0	12.0	12-inch minimum Select Fill Subgrade
Option2: Lime Stabilized Subgrade	5.0	6.0	Portland Cement Concrete, f'_c=3,500 psi
	4.0	4.0	Crushed Aggregate Base (ODOT Type "A")
	8.0	8.0	Lime Stabilized Subgrade

Table 15: Rigid Pavement Recommendations

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

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.

With the use of aggregate base course, the aggregate should have uniform thickness and the subgrade graded such as to provide positive drainage from the granular base. The aggregate base section should grade toward a storm sewer or drainage ditch to provide drainage from the aggregate base.

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 concrete pavements, the recommended aggregate base course will serve as a leveling course, improve the subgrade support properties, and reduce the risk of pumping of fine-grained subgrade soils through the joints.

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. Additionally, we recommend the joints be sealed in order to further preclude surficial moisture migration into the underlying supporting soils.

For concrete pavements, consideration should be given to providing reinforcement each way. The civil engineer of record will need to determine the appropriate amount of reinforcing steel required for the various concrete pavements. Typically, two-way reinforcement will consist of No. 3 or No. 4 size reinforcing steel spaced at 12 to 24 inches on center depending on the anticipated traffic loading conditions.

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 as a result 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 and prior to stone placement to verify that the subgrade is suitable to receive pavement base or floor slabs. The final evaluation may include proofrolling or density tests.

Subgrade rehabilitation can become a point of controversy when different contractors are responsible for mass and final grading. The construction documents should specifically state which contractor will be responsible for maintaining and rehabilitating the subgrade. Rehabilitation may include wetting, mixing, and re-compacting soils that have dried excessively or drying soils that have become wet.

9.0 CONSTRUCTION MONITORING

Field verification of site conditions is an essential part of the services provided by the geotechnical consultant. In order 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.
- Periodic observation and verification of the bearing surfaces exposed after foundation excavation.
- Continuous observation of foundation installation.
- Drilled pier inspections.
- Molding and testing of concrete cylinders.
- Reinforcing steel inspections.
- Structural steel inspections.
- Structural masonry inspections.
- Fireproofing inspections.
- Sampling of asphalt for mix verification and coring for determination of in-place thickness and density.

10.0 CLOSING AND LIMITATIONS

This report was prepared for Childers Architects, for specific application to the Cherokee Springs Casino, Hotel and Convention Center project located in Tahlequah, 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 in regards to conditions between borings. It will be necessary to confirm the anticipated subsurface conditions during construction.

This report has been prepared in accordance with generally accepted standards of geotechnical engineering practice. No other warranty is expressed or implied. In the event that 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.

Appendix Table of Contents

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.

ROCK CORING

Rock coring was performed in accordance with ASTM Specification D2113. During the coring operations, the rock cores were placed in core boxes at the site and transported to our laboratory for identification and classification. At the laboratory, the rock type was identified and the "recovery" and "rock quality designation" (RQD) was determined. The recovery is the ratio of the length of sample obtained to the length of the run cored, as a percent. The RQD is the percentage of the length of the core run which has rock segments of moderately hard or harder rock four inches or greater in length, compared to the total length of the run. Generalized rock descriptions, percent recovery, and RQD values are shown on the boring logs.

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.

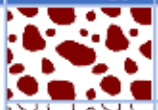
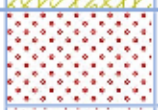
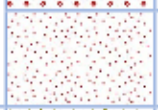
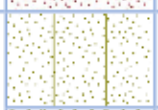
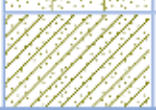
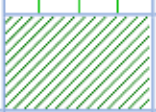
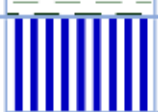
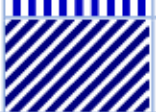
Major Divisions			Symbols		Group Name & Typical Description
			Lithology	Group	
Coarse Grained Soils *More than 50% of material is larger than No. 200 sieve size*	**Gravel and Gravelly Soils** *More than 50% of coarse fraction is larger than No. 4 sieve*	**Clean Gravels** *(Less than 5% fines)*		**GW**	*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 sieve*	**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)

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.

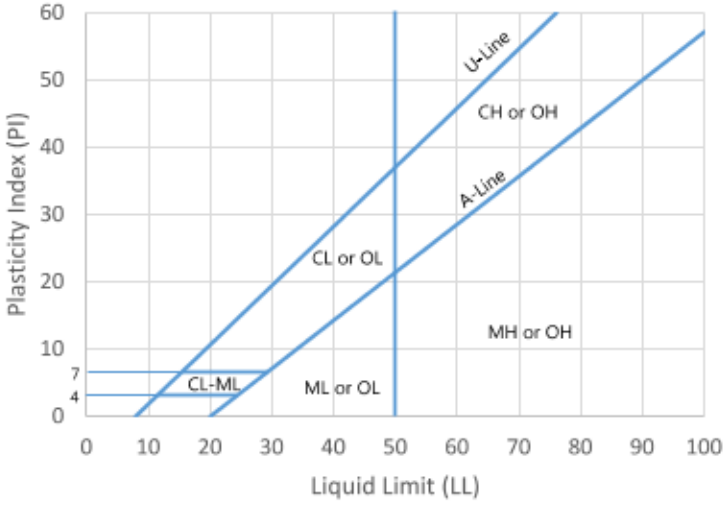


Figure 1: Plasticity Chart (based on ASTM D2487)

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 90% hammer efficiency

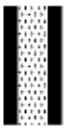
	Standard Penetration Test ASTM D1586 or AASHTO T-206		Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399
	Shelby Tube Sampler ASTM D1587		No Sample Recovery
	Rock Core Sample ASTM D2113		Groundwater at Time of Drilling
	Auger Cuttings		Groundwater as Indicated

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

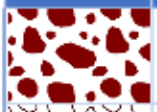
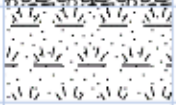
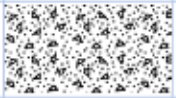
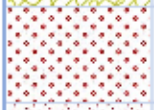
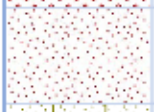
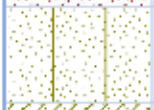
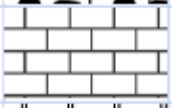
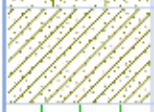
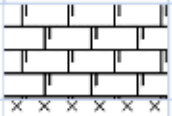
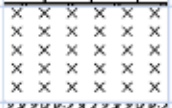
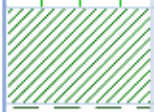
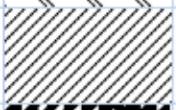
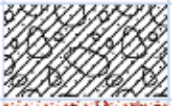
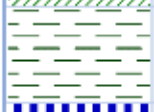
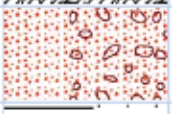
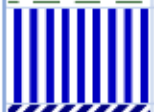
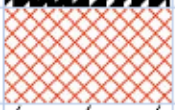
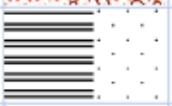
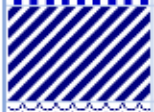
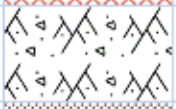
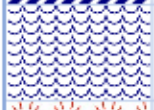
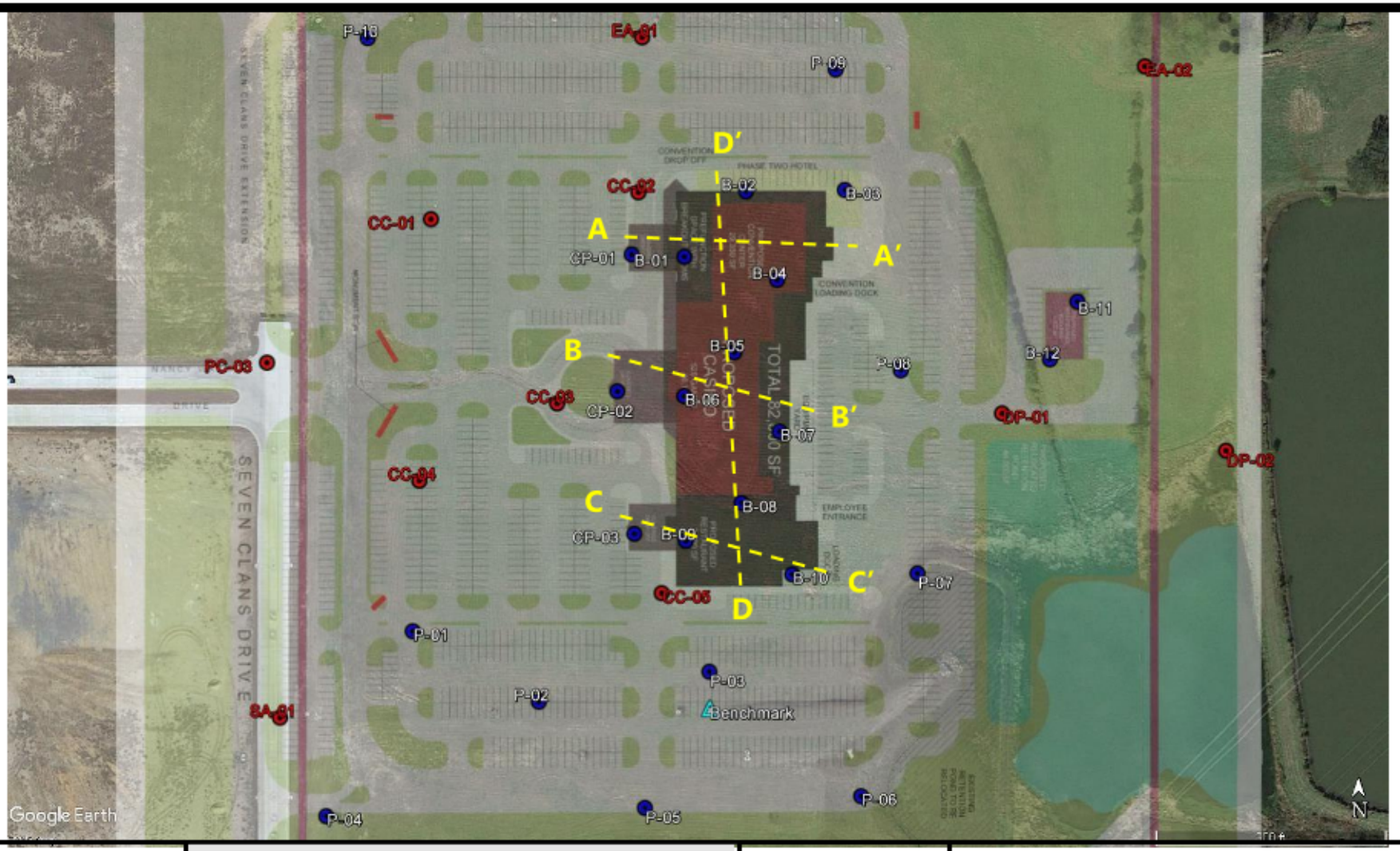
Hatch	Description	Hatch	Description	Hatch	Description
	**GW** - *Well-graded gravels, gravel – sand mixtures, little or no fines*		*Asphalt*		*Clay with Gravel*
	**GP** - *Poorly-graded gravels, gravel – sand mixtures, little or no fines*		*Aggregate Base*		*Sand with Gravel*
	**GM** - *Silty gravels, 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 10/27/2017 and Site Plan Dated 12/20/2017 by Childers Architect, Inc.

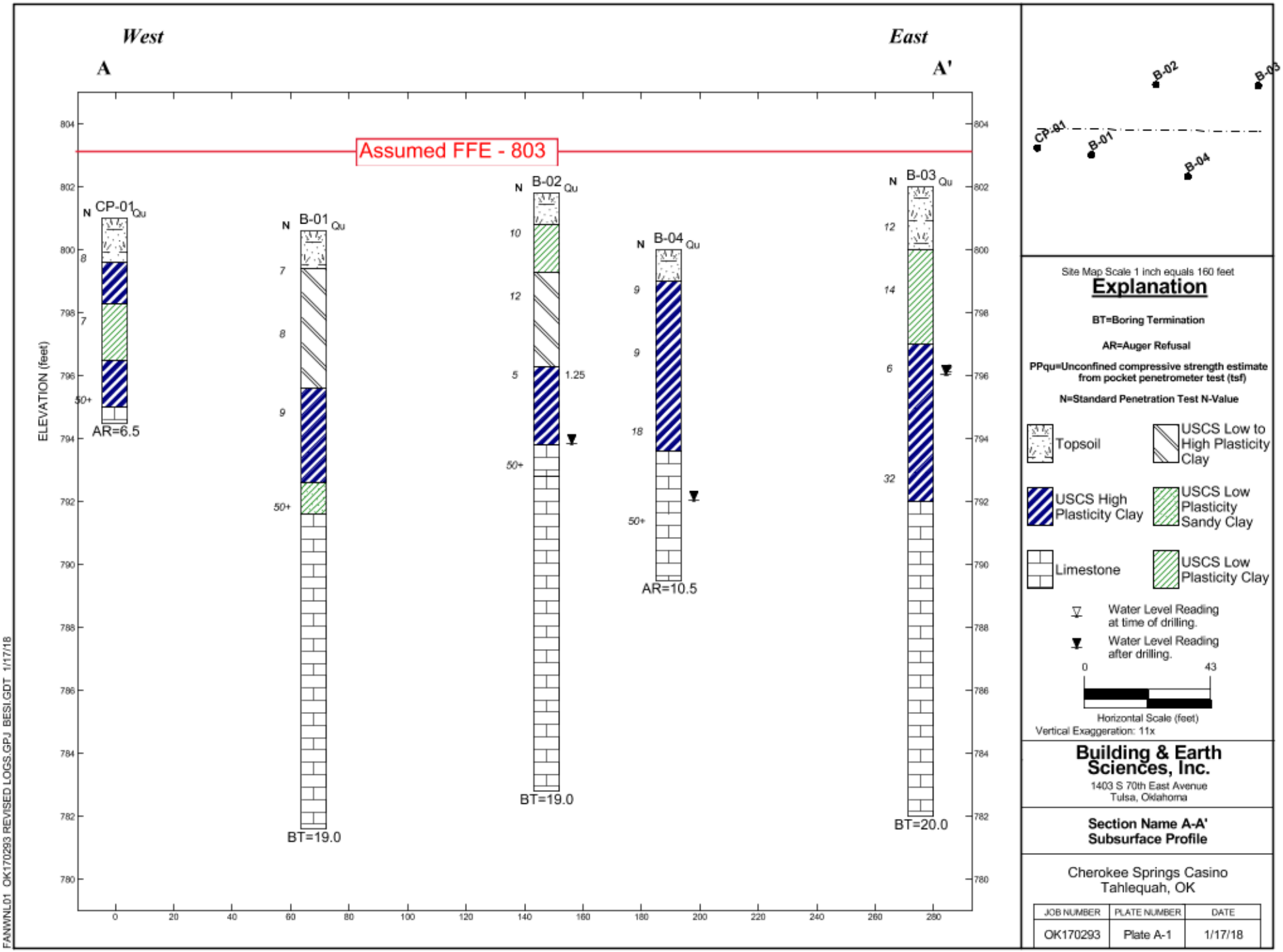
BORING LOCATION PLAN

DATE: 1/11/2018

PROJECT NO.	PROJECT NAME / LOCATION:	SCALE:
OK170293	Cherokee Springs Casino, Hotel, and Convention Center Tahlequah, OK	As Shown

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

SUBSURFACE SOIL PROFILES



Site Map Scale 1 inch equals 160 feet

Explanation

BT=Boring Termination

AR=Auger Refusal

PPqu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)

N=Standard Penetration Test N-Value

- Topsoil
- USCS Low to High Plasticity Clay
- USCS High Plasticity Clay
- USCS Low Plasticity Sandy Clay
- Limestone
- USCS Low Plasticity Clay
- Water Level Reading at time of drilling.
- Water Level Reading after drilling.

0 — 43

Horizontal Scale (feet)

Vertical Exaggeration: 11x

Building & Earth Sciences, Inc.

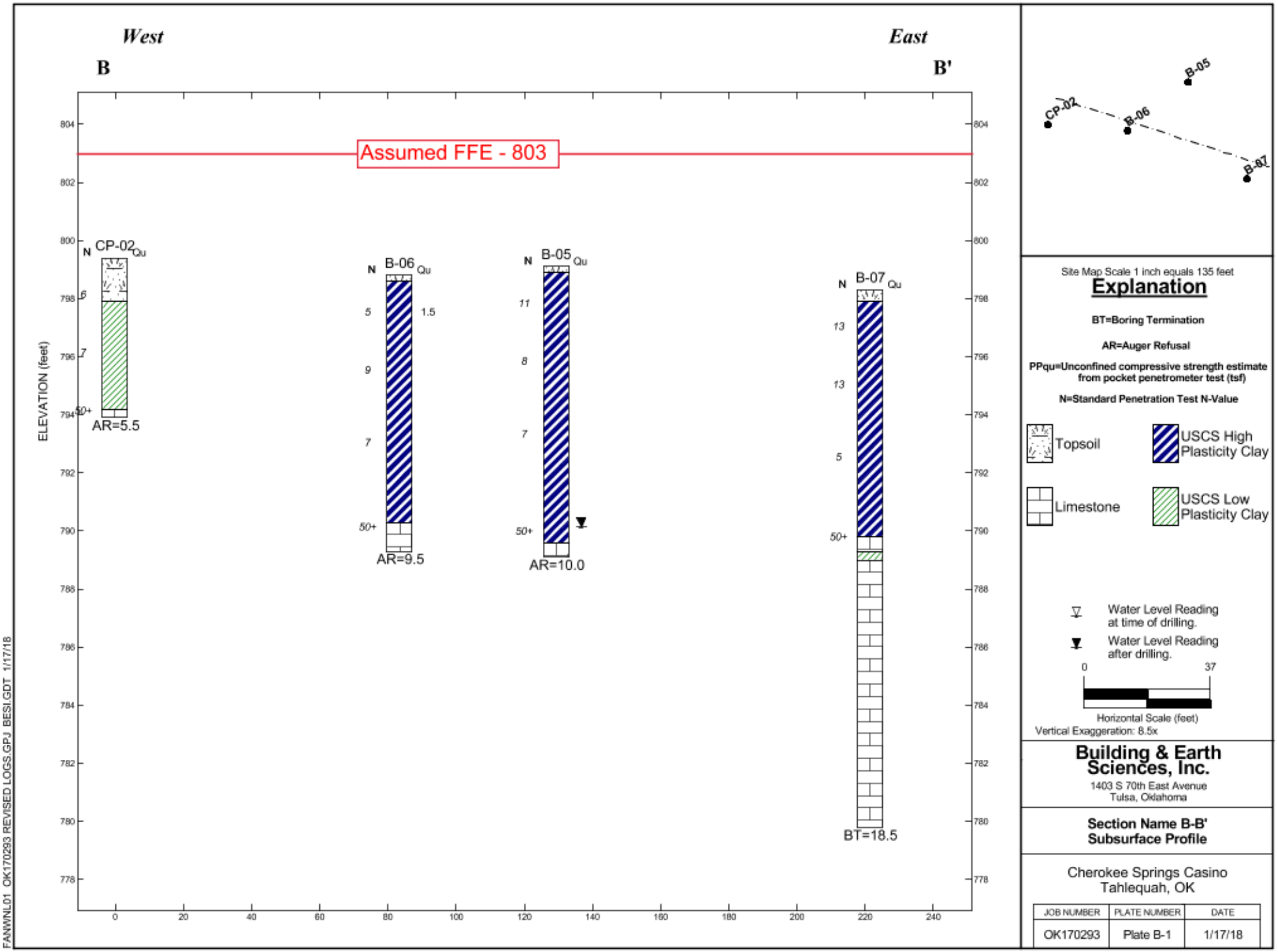
1403 S 70th East Avenue
Tulsa, Oklahoma

Section Name A-A'
Subsurface Profile

Cherokee Springs Casino
Tahlequah, OK

JOB NUMBER	PLATE NUMBER	DATE
OK170293	Plate A-1	1/17/18

FANWNL01 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18



Site Map Scale 1 inch equals 135 feet

Explanation

BT=Boring Termination

AR=Auger Refusal

PPqu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)

N=Standard Penetration Test N-Value

- Topsoil
- USCS High Plasticity Clay
- Limestone
- USCS Low Plasticity Clay

Water Level Reading at time of drilling.

Water Level Reading after drilling.

0 37

Horizontal Scale (feet)

Vertical Exaggeration: 8.5x

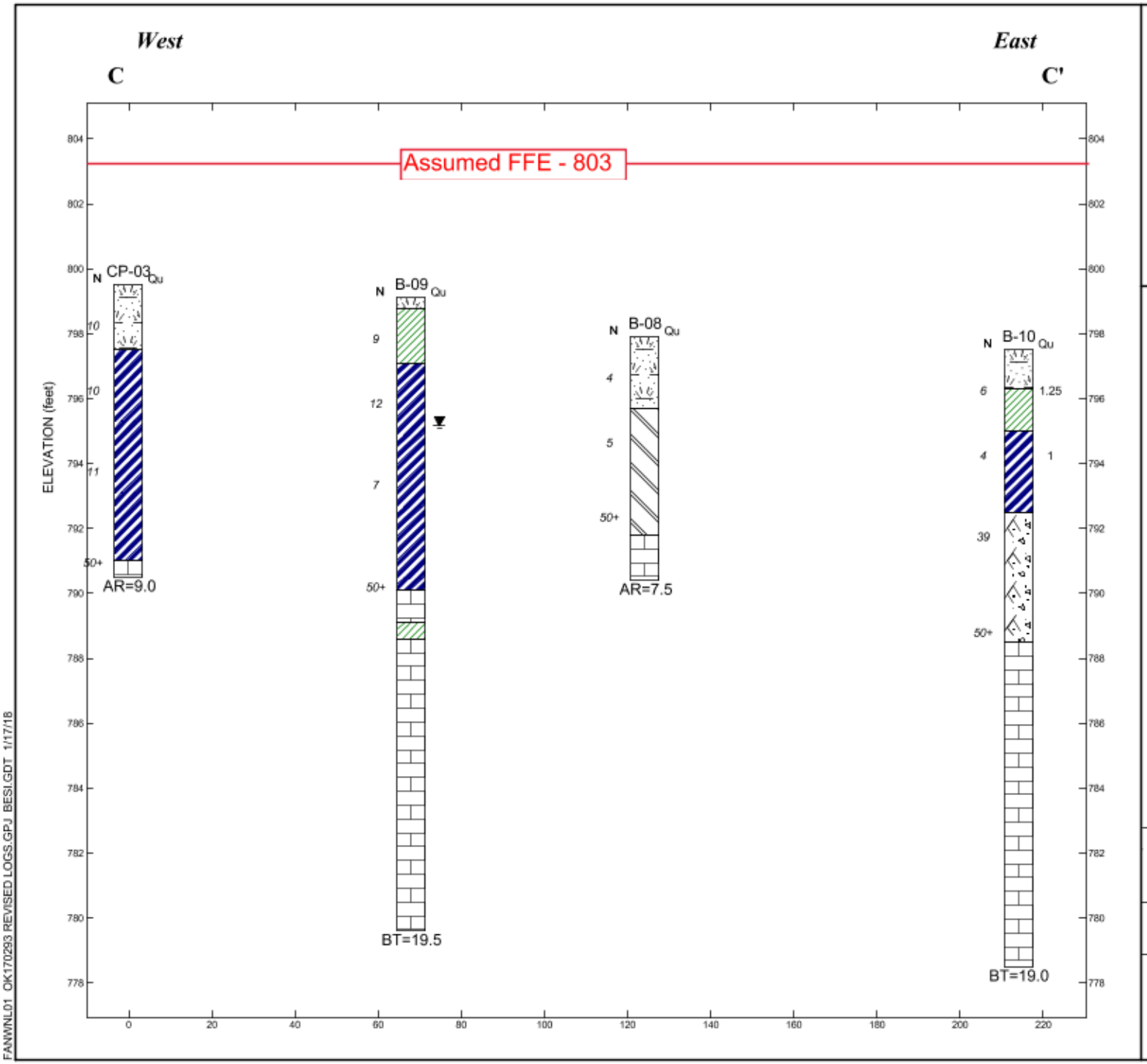
Building & Earth Sciences, Inc.
1403 S 70th East Avenue
Tulsa, Oklahoma

Section Name B-B'
Subsurface Profile

Cherokee Springs Casino
Tahlequah, OK

JOB NUMBER	PLATE NUMBER	DATE
OK170293	Plate B-1	1/17/18

FANWNL01 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18



Site Map Scale 1 inch equals 125 feet

Explanation

BT=Boring Termination

AR=Auger Refusal

PPqu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)

N=Standard Penetration Test N-Value

- Topsoil
- USCS Low to High Plasticity Clay
- Limestone
- USCS Low Plasticity Clay
- USCS High Plasticity Clay
- Weathered Rock
- Water Level Reading at time of drilling.
- Water Level Reading after drilling.

0 — 34

Horizontal Scale (feet)

Vertical Exaggeration: 8x

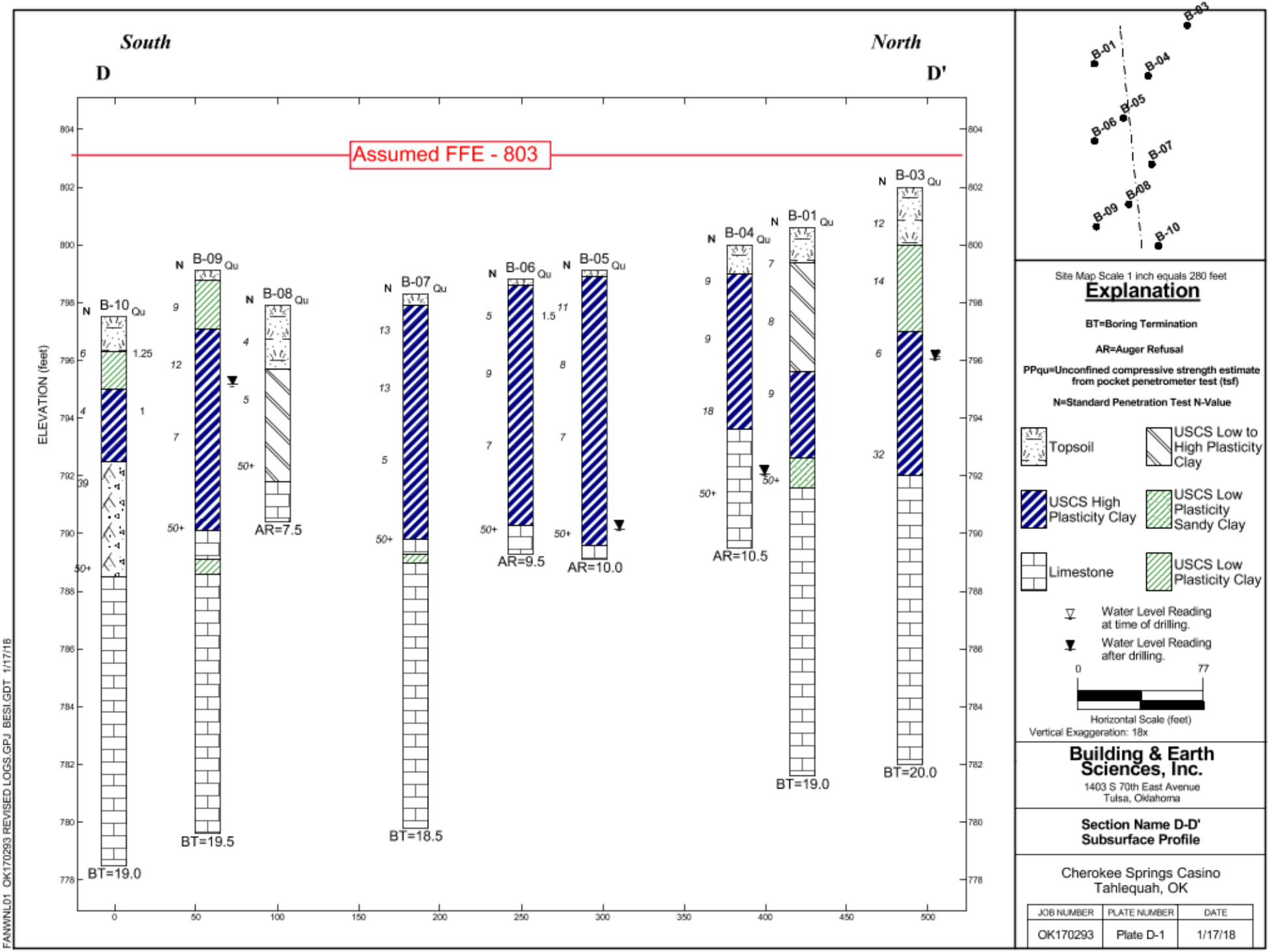
Building & Earth Sciences, Inc.
1403 S 70th East Avenue
Tulsa, Oklahoma

Section Name C-C'
Subsurface Profile

Cherokee Springs Casino
Tahlequah, OK

JOB NUMBER	PLATE NUMBER	DATE
OK170293	Plate C-1	1/17/18

FANWNL01 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18



Building & Earth Sciences, Inc.
1403 S 70th East Avenue
Tulsa, Oklahoma

Section Name D-D'
Subsurface Profile

Cherokee Springs Casino
Tahlequah, OK

JOB NUMBER	PLATE NUMBER	DATE
OK170293	Plate D-1	1/17/18

FAN\WNL01 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-01

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger & Core
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 800.6
Drill Crew: Mohawk
Logged By: Cassidy

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
	800					TOPSOIL = 14 inches		
			1	3-3-4		1.2 / 799.4 LEAN TO FAT CLAY (CL-CH): stiff, grayish brown, brown, with fine roots, moderate to high plasticity, moist		Sample #1 Liquid Limit (LL) = 46 Plastic Limit (PL) = 18 Plasticity Index (PI) = 28
			2	3-4-4				
5						5.0 / 795.6 FAT CLAY (CH): stiff, gray, light gray, and some mottled yellow, with sandstone fragments, high plasticity, moist		
	795		3	3-4-5		8.0 / 792.6 SANDY LEAN CLAY (CL): medium stiff, yellowish brown, brown, and black, with lots of ferrous staining, low plasticity, moist to wet - gray and light gray, wet		Perched water at 8.5 feet. Boring dry prior to rock coring Auger refusal at 9 feet. Switched to Rock Coring Run #1 (9'-14')
			4	2-50/4"	>>	9.0 / 791.6 (RESIDUAL) LIMESTONE: hard, light gray, gray, crystalline, fractured, with closed to slightly open bedding joints		
10	790		1	REC=87 RQD=52		- dark gray, shale layer, between 12.5 to 13.2 feet		Run #2 (14'-19')
15	785		2	REC=98 RQD=88		- dark gray, shale layer, between 15 to 16 feet		Unconfined Compression = 7,290 psi
						19.0 / 781.6 (PITKIN FORMATION) Rock Coring terminated at 19 feet		Boring backfilled on 12/26/17 Consistency/Relative density based on correction factor for automatic hammer
20	780							

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-02

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger & Core
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 801.8
Drill Crew: Mohawk
Logged By: Cassidy

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	GRAPHIC	REMARKS
					TOPSOIL = 30 inches		
	800		1	4-5-5			
2.5					799.3		
			2	4-5-7	LEAN TO FAT CLAY (CL-CH): stiff to very stiff, light grayish brown and yellowish brown, with sandstone fragments, moderate to high plasticity, moist		Sample #2 Liquid Limit (LL) = 46 Plastic Limit (PL) = 18 Plasticity Index (PI) = 28
5							
5.5					796.3		
	795		3	1-3-2	FAT CLAY (CH): medium stiff, light yellowish brown, gray, and some grayish brown, with lots of ferrous staining and nodules, high plasticity, moist		
8.0					(RESIDUAL) 793.8		
			4	50/3"	WEATHERED LIMESTONE: moderately		Groundwater was encountered at a depth of about 8 feet during drilling
9.0					hard, gray, with clay layers, wet 792.8		Auger refusal at 9 feet. Switched to Rock Coring
10					LIMESTONE: hard, light gray, gray, medium bedding with shale partings, slightly open bedding joints		Run #1 (9'-14')
	790		1	REC=87 RQD=83			
							Run #2 (14'-19')
15							
	785		2	REC=100 RQD=88	- shale layer, between 16 to 17 feet		
19.0					(PITKIN FORMATION) 782.8		
					Rock Coring terminated at 19 feet		Boring backfilled on 12/26/17
20							Consistency/Relative density based on correction factor for automatic hammer
	780						

N-Value: 10 20 30 40
Qu (tsf): 1 2 3 4
Atterberg Limits: 20 40 60 80
% Moisture: 20 40 60 80

SAMPLE TYPE: Split Spoon; Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-03

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger & Core
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 802.0
Drill Crew: Mohawk
Logged By: Cassidy/Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 24 inches		
	800		1	4-5-7		2.0 / 800.0		Sample #1 Liquid Limit (LL) = 29 Plastic Limit (PL) = 18 Plasticity Index (PI) = 11
			2	4-5-9		LEAN CLAY (CL): very stiff, grayish brown and yellowish brown, moderate plasticity, moist		
5						5.0 / 797.0		
			3	3-3-3		FAT CLAY (CH): medium stiff to stiff, yellow, yellowish brown, and light gray, with ferrous staining, high plasticity, moist ▽		Free water was measured at 6 feet, prior to rock coring on the next day
	795							
			4	1-20-12		9.0 - moist to wet / 793.0 (RESIDUAL)		Groundwater encountered at 8.5 feet at time of drilling
10						10.0 WEATHERED LIMESTONE: soft, gray and yellow / 792.0 LIMESTONE: hard, light gray and gray, thin bedding		Auger refusal at 10 feet. Switched to Rock Coring Run #1 (10'-15')
	790		1	REC=68 RQD=48		- with shale layer, between 12.5 to 13.5 feet		Unconfined Compression = 4,640 psi
15								Run #2 (15'-20')
	785		2	REC=100 RQD=100				
20						20.0 (PITKIN FORMATION) / 782.0 Rock Coring terminated at 20 feet		Boring backfilled on 12/28/17 Consistency/Relative density based on correction factor for automatic hammer
	780							

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-04

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 800.0
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	GRAPHIC	REMARKS
	800				TOPSOIL = 12 inches		
					1.0 799.0		
		⊠	1	1-4-5	FAT CLAY (CH): stiff, dark gray, with roots and sandstone fragments, high plasticity, moist		
		⊠	2	3-4-5	- yellowish brown, olive-gray		
					- with ferrous nodules		
5	795	⊠	3	3-4-14			
					6.4 - moist to wet 793.6		
					(RESIDUAL) LIMESTONE: moderately hard to hard, light gray and gray, fractured		
		⊠	4	50/2.75" >>			Free water measured at 8 feet prior to backfilling
10	790				10.5 (PITKIN FORMATION) 789.5		
					Auger Refusal at 10.5 feet`		
15	785						
20	780						

N-Value: 10 20 30 40
Qu (tsf): 1 2 3 4
Atterberg Limits: 20 40 60 80
% Moisture: 20 40 60 80

Groundwater was not encountered at time of drilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ⊠ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

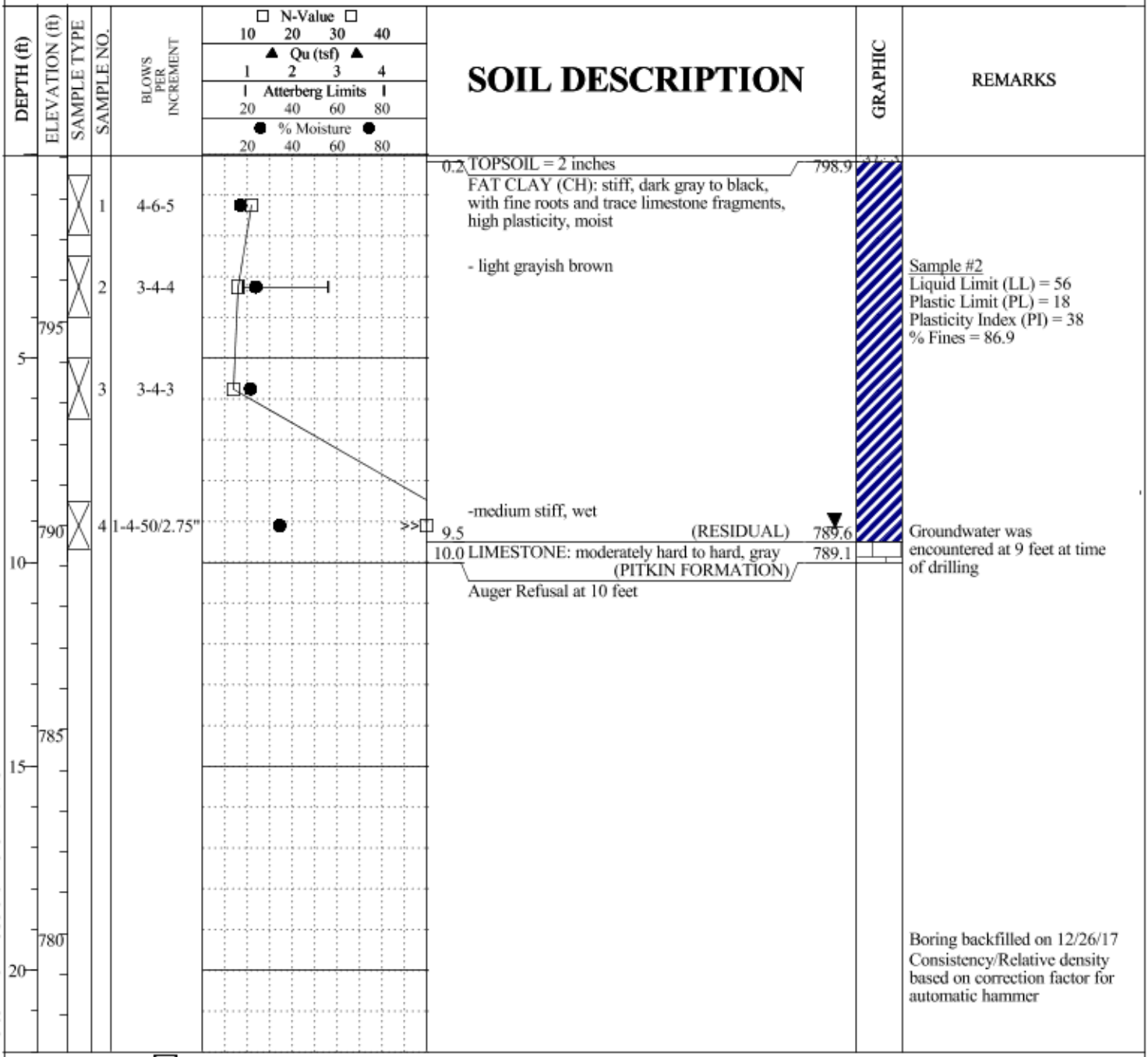
Designation: B-05

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 799.1
Drill Crew: Mohawk
Logged By: Taru



SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-06

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 798.8
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
0						0.2 TOPSOIL = 2 inches 798.6		
						FAT CLAY (CH): medium stiff, dark gray, with roots, high plasticity, moist		
			1	2-3-2				
						- stiff, light grayish brown and some yellowish brown, with limestone fragments and ferrous nodules		
	795		2	3-5-4				
5						- yellow, light gray, mottled yellow		
			3	4-4-3				
						(RESIDUAL)		
						8.5 790.3		
	790		4	50/3.5"	>>	LIMESTONE: moderately hard, gray, with yellowish brown shale lenses		
						9.5 789.3 (PITKIN FORMATION)		
10						Auger Refusal at 9.5 feet		
	785							
15								
	780							
20								

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

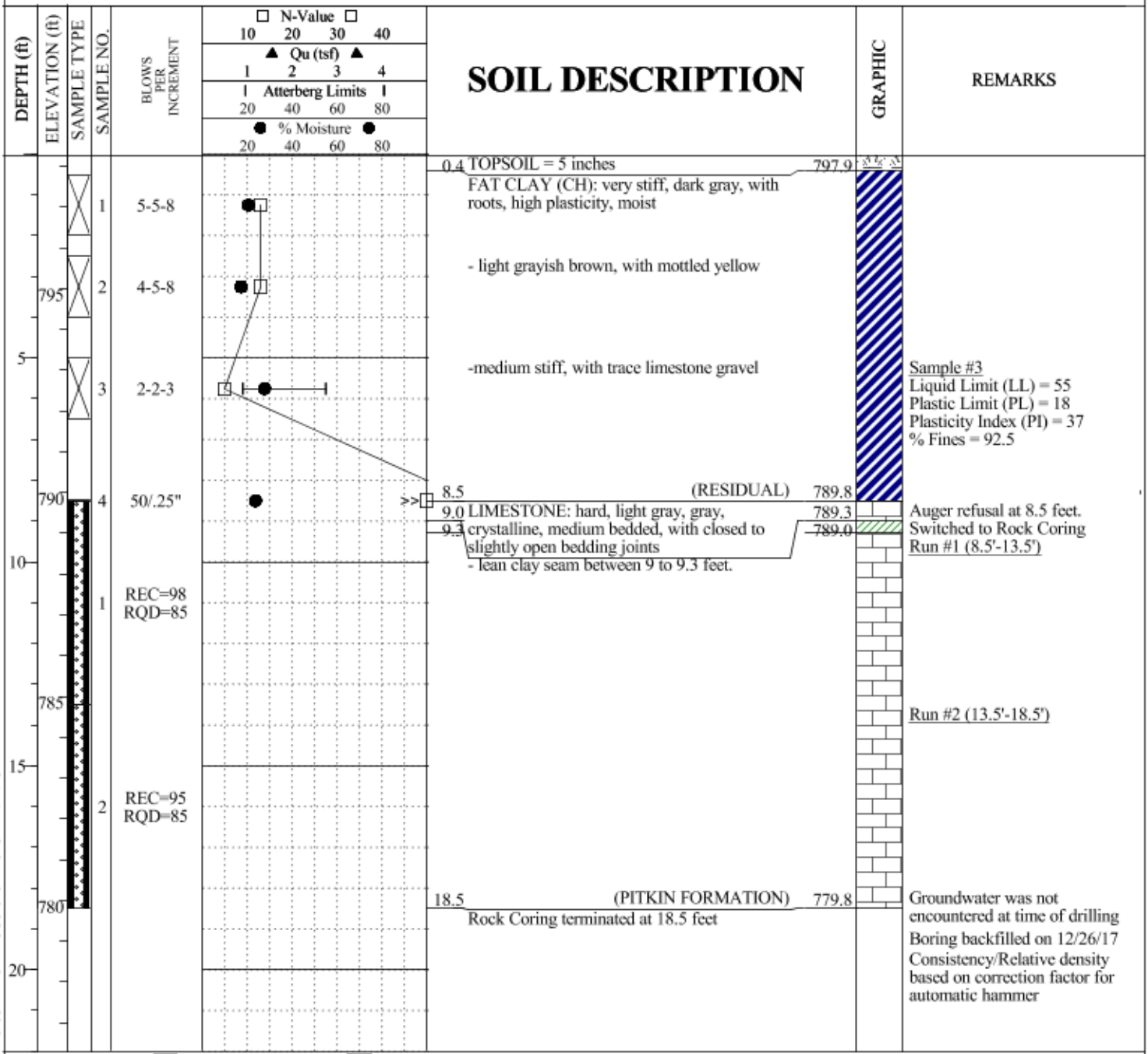
LOG OF BORING

Designation: B-07

Sheet 1 of 1

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger & Core
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 798.3
Drill Crew: Mohawk
Logged By: Cassidy



SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-08

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 797.9
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 26 inches		
		X	1	1-2-2				
	795	X	2	2-2-3		2.2 795.7 LEAN TO FAT CLAY (CL-CH): medium stiff, light grayish brown, yellowish brown, with ferrous nodules, moderate to high plasticity, moist to wet		
5		X	3	1-2-50/2"	>>	6.1 (RESIDUAL) 791.8 LIMESTONE: hard, light gray, gray		
	790					7.5 (PITKIN FORMATION) 790.4 Auger Refusal at 7.5 feet		
10								
	785							
15								
	780							
20								

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-09

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger & Core
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 799.1
Drill Crew: Mohawk
Logged By: Cassidy

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
			1	3-4-5		0.3 TOPSOIL = 4 inches (798.8) LEAN CLAY (CL): stiff, light grayish brown, grayish brown, with roots, low to moderate plasticity, moist 2.0 (797.1)		
			2	4-5-7		FAT CLAY (CH): stiff to very stiff, light gray, mottled yellow, with trace roots, high plasticity, moist		Sample #2 Liquid Limit (LL) = 51 Plastic Limit (PL) = 18 Plasticity Index (PI) = 33 Free water measured at depth of about 4 feet prior to backfilling
795								
5			3	2-3-4		- stiff - with sand		
			4	2-50/3.25"		9.0 (RESIDUAL) (790.1)		
790						LIMESTONE: hard, light gray, gray, crystalline, medium bedded, with slightly open bedding joints 10.0 (789.1) 10.5 (788.6) -apparent clay seam (core loss) between 10 to 10.5 feet.		Auger refusal at 9.5 feet. Switched to Rock Coring Run #1 (9.5'-14.5')
10			1	REC=83 RQD=74				
785								Run #2 (14.5'-19.5')
15			2	REC=100 RQD=89				Unconfined Compression = 6,450 psi Groundwater was not encountered at time of drilling Boring backfilled on 12/26/17 Consistency/Relative density based on correction factor for automatic hammer
780						19.5 (PITKIN FORMATION) (779.6) Auger Refusal at 19.5 feet		
20								

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-10

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 797.5
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 14 inches		
		X	1	3-3-3		1.2 — 796.3 LEAN CLAY (CL): medium stiff to stiff, dark brownish gray, with fine roots, moderate plasticity, moist		Sample #1 Liquid Limit (LL) = 42 Plastic Limit (PL) = 19 Plasticity Index (PI) = 23
	795	X	2	1-2-2		2.5 — 795.0 FAT CLAY (CH): medium stiff, brownish gray, yellowish brown, with limestone fragments and fine roots, high plasticity, moist		
5		X	3	20-8-31		5.0 (RESIDUAL) — 792.5 WEATHERED SHALE: soft, yellow, light brown and light gray, with limestone lenses		
	790	X	4	50/4.5"	>>	9.0 — 788.5 LIMESTONE: hard, light gray, gray, crystalline, medium bedded, with slightly open bedding joints		Auger refusal at 9 feet. Switched to Rock Coring Run #1 (9'-14')
10			1	REC=98 RQD=98				
	785							Unconfined Compression = 5,780 psi Run #2 (14'-19')
15			2	REC=95 RQD=95				
	780					19.0 (PITKIN FORMATION) — 778.5 Rock Coring terminated at 19 feet		Groundwater was not encountered at time of drilling Boring backfilled on 12/27/17 Consistency/Relative density based on correction factor for automatic hammer
20								

SAMPLE TYPE: X Split Spoon; Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-11

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 801.1
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 24 inches		
	800	☒	1	3-3-3		2.0 / 799.1		
		☒	2	3-4-4		FAT CLAY (CH): stiff, light brown, reddish brown, and yellowish brown, with ferrous nodules, high plasticity, moist		
5		☒	3	4-5-9		- with sandstone lenses		Free water measured at 6.5 feet prior to backfilling
	795	☒	4	0-0-7		- soft, with sand, moist to wet		
10						10.0 (RESIDUAL) 791.1		
	790					Auger Refusal at 10 feet on apparent limestone		
15	785							Groundwater was not encountered at time of drilling
								Boring backfilled on 12/27/17
20	780							Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

LOG OF BORING

Designation: B-12

Sheet 1 of 1

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 799.5
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 24 inches		
			1	3-3-4		2.0 797.5		
			2	3-3-5		FAT CLAY (CH): stiff, light brown, gray, and yellowish brown, with ferrous nodules and trace roots, high plasticity, moist		Sample #2 Liquid Limit (LL) = 53 Plastic Limit (PL) = 19 Plasticity Index (PI) = 34 % Fines = 87.5
5	795		3	3-4-5		- with limestone fragments		
			4	50/4"	>>	8.5 (RESIDUAL) 791.0 9.0 LIMESTONE: moderately hard, dark gray, gray, light brown, and yellow brown 790.5 (PITKIN FORMATION) Auger Refusal at 9 feet		
10	790							
15	785							
20	780							Groundwater was not encountered at time of drilling and prior to backfilling Boring backfilled on 12/27/17 Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: CP-01

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 801.0
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	800	⊠	1	3-4-4		TOPSOIL = 17 inches		
						1.4 — 799.6		
						FAT CLAY (CH): stiff, grayish brown, yellowish brown, with roots and sandstone fragments, high plasticity, moist		
		⊠	2	0-3-4		2.7 — 798.3		
						LEAN CLAY (CL): stiff, light grayish brown, silty, low plasticity, moist - with soft lenses		
						4.5 — 796.5		
5						FAT CLAY (CH): stiff, light gray, reddish brown, dark brown, with limestone gravel, high plasticity, moist		
	795	⊠	3	3-5-50/6"	>>	6.0 — 795.0 (RESIDUAL)		
						6.5 — 794.5		
						LIMESTONE: moderately hard, gray (PITKIN FORMATION)		
						Auger Refusal at 6.5 feet		
10	790							
15	785							
20	780							

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/27/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ⊠ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

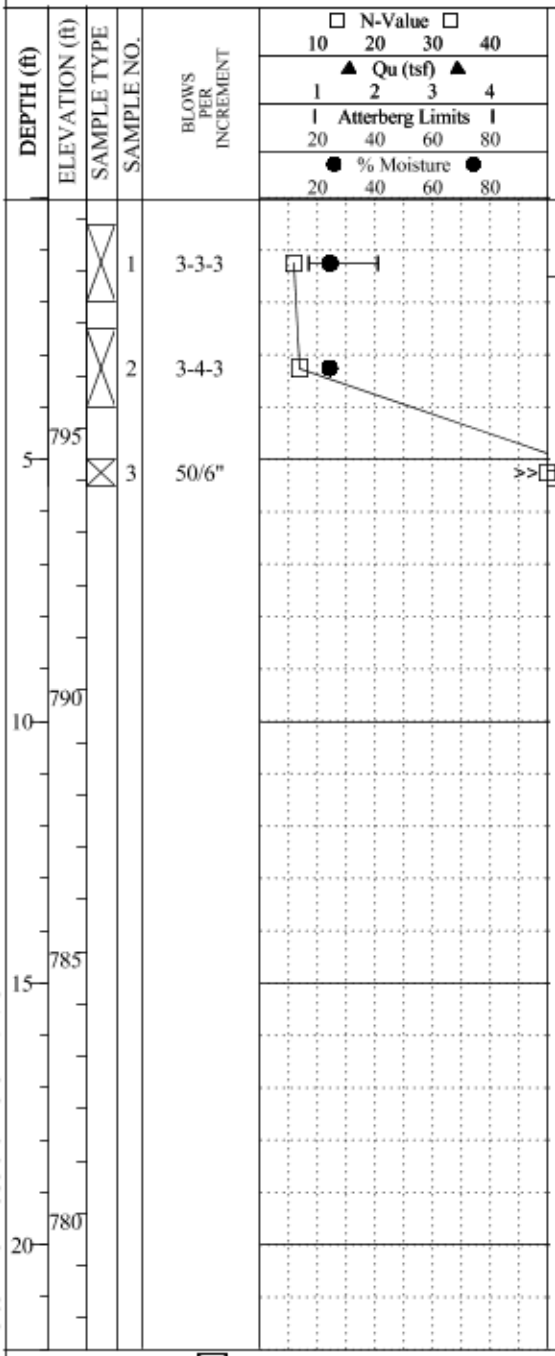
Designation: CP-02

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 799.4
Drill Crew: Mohawk
Logged By: Taru



SOIL DESCRIPTION

TOPSOIL = 18 inches

1.5 797.9

LEAN CLAY (CL): medium stiff to stiff, dark gray and brown, with fine roots, ferrous nodules, and limestone fragments, moderate plasticity, moist
- stiff, light grayish brown and yellowish gray, with ferrous nodules

5.2 (RESIDUAL) 794.2

5.5 LIMESTONE: moderately hard, gray, dark gray 793.9

(PITKIN FORMATION)

Auger Refusal at 5.5 feet

GRAPHIC

REMARKS

Sample #1
Liquid Limit (LL) = 41
Plastic Limit (PL) = 17
Plasticity Index (PI) = 24

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: CP-03

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 799.5
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 24 inches		
			1	6-7-3		2.0 797.5 FAT CLAY (CH): stiff, gray, reddish brown, yellowish brown, with ferrous nodules and sandstone fragments, high plasticity, moist		
			2	3-4-6				
5	795		3	3-5-6				
			4	50/1.5"	>>	8.5 (RESIDUAL) 791.0		
						9.0 LIMESTONE: moderately hard, light gray and gray 790.5		
10	790					(PITKIN FORMATION) Auger Refusal at 9 feet in limestone		
15	785							
20	780							Groundwater was not encountered at time of drilling and prior to backfilling. Boring backfilled on 12/26/17. Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-01

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/28/17
Weather Conditions:
Surface Elevation: 803.2
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	803					TOPSOIL = 30 inches		Sample #1 Liquid Limit (LL) = 28 Plastic Limit (PL) = 20 Plasticity Index (PI) = 8
2.5	800.7							
	800	☒	1	5-5-5		FAT CLAY (CH): stiff, reddish yellow, light brown, red, and yellowish brown, with ferrous nodules, high plasticity, moist		
		☒	2	5-5-6				
5						- light gray, yellowish brown		
6.0	797.2	☒	3	4-8-50/5"	>>	(RESIDUAL)		
6.5	796.7					LIMESTONE: moderately hard, gray (PITKIN FORMATION)		
	795					Auger Refusal at 6.5 feet		
10								
	790							
15								
	785							Groundwater was not encountered at time of drilling and prior to backfilling Boring backfilled on 12/28/17 Consistency/Relative density based on correction factor for automatic hammer
20								

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-02

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/28/17
Weather Conditions:
Surface Elevation: 802.1
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 17 inches		
						1.8 / 800.3		
	800		1	3-4-4		FAT CLAY (CH): stiff, brown, reddish brown, with sandstone fragments, high plasticity, moist - with ferrous nodules		
			2	3-5-6		- reddish yellow, light gray		
5			3	15-15-10		- hard, shaley, blocky		
	795					7.5 (RESIDUAL) 794.6		
						Auger Refusal at 7.5 feet		
10								
	790							
15								
	785							
20								

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/28/17
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
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-03

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 799.0
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL = 12 inches		
1.0	798.0							
		X	1	2-3-6		FAT CLAY (CH): stiff, reddish brown, light brown, with ferrous nodules, high plasticity, moist		
		X	2	3-5-50/2"	>>	3.5 (RESIDUAL) 795.5		
	795					LIMESTONE: moderately hard, gray		
5		=	3	50/1"	>>	5.1 (PITKIN FORMATION) 793.9		
						Auger Refusal at 5.1 feet		
	790							
10								
	785							
15								
	780							
20								

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-04

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/28/17
Weather Conditions:
Surface Elevation: 801.7
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	801.7					0.2 TOPSOIL = 2 inches 801.5		
	800		1	3-6-6		1.0 LEAN CLAY (CL): stiff, brown, yellowish brown, grayish brown, with roots and limestone fragments, low plasticity, moist 800.7		
			2	3-4-6		FAT CLAY (CH): stiff to very stiff, brown, light brown, yellowish brown, reddish brown, with ferrous nodules and fine roots, high plasticity, moist - stiff, light brown, light yellow		Sample #2 Liquid Limit (LL) = 67 Plastic Limit (PL) = 18 Plasticity Index (PI) = 49
5			3	4-5-6		- with ferrous nodules and staining		
	795					7.0 (RESIDUAL) 794.7 Auger Refusal at 7 feet on apparent limestone		
10	790							
15	785							
20	780							Groundwater was not encountered at time of drilling and prior to backfilling Boring backfilled on 12/28/17 Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-05

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/28/17
Weather Conditions:
Surface Elevation: 800.1
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	800					TOPSOIL = 18 inches		
		X	1	3-3-3		1.5	798.6	
		X	2	50/6"	>>	FAT CLAY (CH): medium stiff to stiff, brown, reddish brown, and red, with ferrous nodules, high plasticity, moist (RESIDUAL)		
						3.0	797.1	
						Auger Refusal at 3 feet on apparent limestone		
5	795							
10	790							
15	785							
20	780							

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/28/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-06

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 795.6
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	795	☒	1	9-50/0.5"	● >>	0.2 TOPSOIL = 2 inches (795.4)		
						1.0 FAT CLAY (CH): stiff, dark brown and grayish brown, with roots, high plasticity, moist (RESIDUAL) (794.6)		
						2.0 LIMESTONE: hard, light gray, gray (PITKIN FORMATION) (793.6)		
						Auger Refusal at 2 feet		
5	790							
10	785							
15	780							
20	775							

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-07

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: CME-75
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/26/17
Weather Conditions:
Surface Elevation: 796.7
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	796.7					0.2 TOPSOIL = 2 inches		
						FAT CLAY (CH): medium stiff to stiff, dark brownish gray, with fine roots, high plasticity, moist to wet		
	795	☒	1	2-2-4				
		☒	2	2-4-5		- stiff, yellowish brown, with ferrous nodules and trace limestone fragments		
5		☒	3	4-4-5		- light gray and some reddish brown		
	790	☒	4	5-50/3"		9.0 (RESIDUAL) 787.7		
						9.3 LIMESTONE: moderately hard, gray (PITKIN FORMATION) 787.5		
10						Boring Terminated at 9.25 feet		
	785							
15								
	780							
20								
	775							

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/26/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-08

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 798.0
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	795	☒	1	0-0-0	●	TOPSOIL = 30 inches - moist to wet		Sample #1 Liquid Limit (LL) = 32 Plastic Limit (PL) = 19 Plasticity Index (PI) = 13
2.5	795.5							
		☒	2	0-0-2	●	FAT CLAY (CH): very soft to soft, light gray, yellowish brown, and reddish brown, with limestone fragments and gravel, ferrous nodules, high plasticity, moist		
5		☒	3	3-3-50/5"	● >>			
6.0	792.0					(RESIDUAL)		
						LIMESTONE: soft, light gray, gray, medium grained, weathered		
7.5	790.5					(PITKIN FORMATION)		
10	790					Auger Refusal at 7.5 feet		
15	785							
20	780							Groundwater was not encountered at time of drilling and prior to backfilling Boring backfilled on 12/27/17 Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

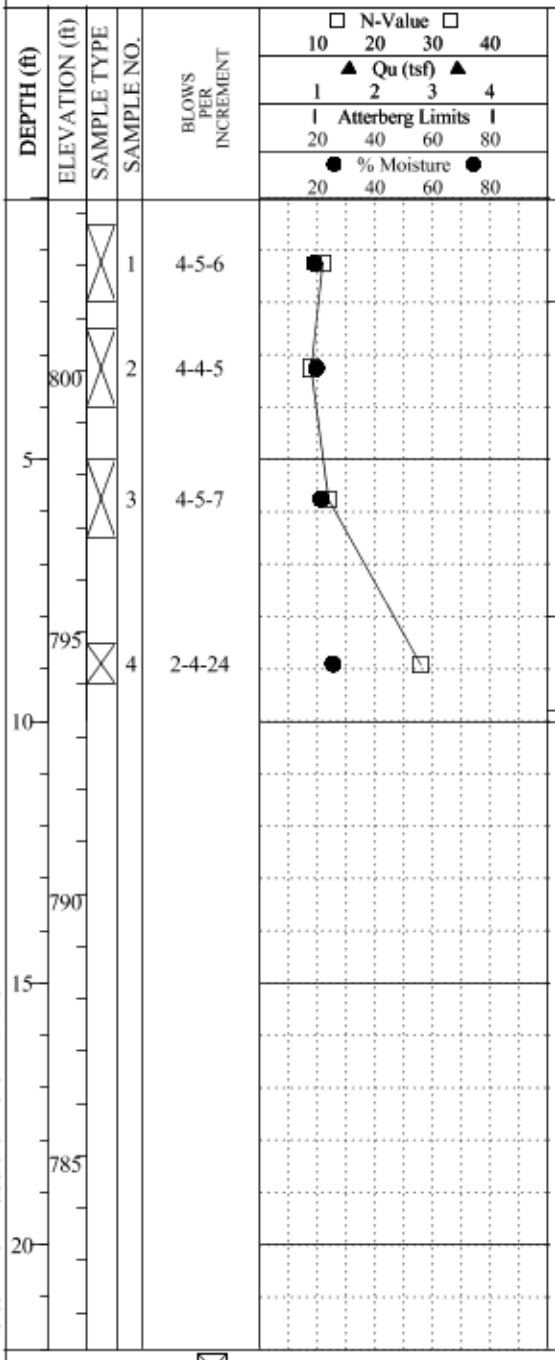
Designation: P-09

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/27/17
Weather Conditions:
Surface Elevation: 803.3
Drill Crew: Mohawk
Logged By: Taru



SOIL DESCRIPTION

TOPSOIL = 24 inches

2.0 — 801.3

LEAN TO FAT CLAY (CL-CH): stiff, gray, reddish brown, with fine roots and limestone fragments and gravel, moderate plasticity, moist

- yellowish brown, with ferrous nodules

8.0 — 795.3

FAT CLAY (CH): stiff, light brown, reddish brown, and yellowish brown, with ferrous nodules and small limestone fragments

9.8 (RESIDUAL) 793.5

10.0 — 793.3

LIMESTONE: soft to moderately hard, gray and light brown

(PITKIN FORMATION)

Boring Terminated at 10 feet

GRAPHIC

REMARKS

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/27/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: P-10

Sheet 1 of 1

1403 S 70th East Avenue
Tulsa, Oklahoma
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Cherokee Springs Casino
Project Number: OK170293
Drilling Method: Hollow Stem Auger
Equipment Used: D-50
Hammer Type: Automatic
Boring Location: See Boring Location Plan

Project Location: Tahlequah, OK
Date Drilled: 12/28/17
Weather Conditions:
Surface Elevation: 808.0
Drill Crew: Mohawk
Logged By: Taru

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0						TOPSOIL = 24 inches		
2.0	806.0							
	805		1	3-5-5		FAT CLAY (CH): very stiff, light brown, yellowish brown, light gray, with ferrous nodules and staining, high plasticity, moist		
			2	5-6-7				
5			3	4-5-6		- stiff, more light gray, some reddish brown		
8.5	799.5					(RESIDUAL)		
	800		4	50/1.5"	>>			
8.6	799.4					LIMESTONE: hard, light gray, gray (PITKIN FORMATION)		
10						Boring Terminated at 8.6 feet		
	795							
15								
	790							
20								
	785							
25								
	780							

Groundwater was not encountered at time of drilling and prior to backfilling
Boring backfilled on 12/28/17
Consistency/Relative density based on correction factor for automatic hammer

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK170293 REVISED LOGS.GPJ BESI.GDT 1/17/18

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).

POCKET PENETROMETER

Pocket Penetrometer tests were performed on cohesive soil samples. The pocket penetrometer provides a consistency classification, and an indication of the soils unconfined compressive strength (Qu).

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.

UNCONFINED COMPRESSION TEST ON ROCK SAMPLES (ASTM D7012)

Unconfined compression tests are performed to evaluate the compressive strength of the bedrock samples. Tests are performed by trimming the core to a height to width ratio of approximately 2, and applying an axial load to the sample. The load at which failure occurs is recorded and the compressive strength is calculated based on the failure load.

LABORATORY TEST RESULTS

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

Boring Location	Sample Depth (ft)	LL	PL	PI	% Passing #200 Sieve	Moisture Content (%)
B-01	0.5-2.0	46	18	28	---	21.0
B-02	2.5-4.0	46	18	28	---	19.6
B-03	0.5-2.0	29	18	11	---	16.9
B-05	2.5-4.0	56	18	38	86.9	23.5
B-07	5.0-6.5	55	18	37	92.5	27.4
B-09	2.5-4.0	51	18	33	---	20.5
B-10	0.5-2.0	42	19	23	---	26.7
B-12	2.5-4.0	53	19	34	87.5	21.7
CP-02	0.5-2.0	41	17	24	---	24.2
P-01	0.5-2.0	28	20	8	---	19.1
P-04	2.5-4.0	67	18	49	---	22.8
P-08	0.5-2.0	32	19	13	---	26.2

Table A-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.

Boring Location	Run No.	Sample Depth (ft)	Compressive Strength (psi)
B-01	2	16.5	7,290
B-03	1	12.5	4,640
B-09	2	18.5	6,450
B-10	1	14.0	5,780

Table A-2: Rock Core Test Results

PRELIMINARY BORING LOGS DRILLED AS PART OF 2015 EXPLORATION

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: CC-01 (#36)

Sheet 1 of 1

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/14/15
Weather Conditions: Partly Cloudy
Surface Elevation: 802.97
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0						0.5 TOPSOIL (~6") 802.5		
		⊠	1	2-3-3		LEAN CLAY (CL): firm, dark gray, dark brown, with fine roots and silt, very moist, low plasticity		Sample #1: 0.5-2.0 feet Atterberg Limits: LL=36, PL=19, PI=17 % Fines=93.2 % Organics=4.3
						2.5 800.5		
	800	⊠	2	3-3-4		FAT CLAY (CH): firm, gray with yellowish brown mottled, with black ferrous nodules, moist, high plasticity		
5		⊠	3	3-4-6		-stiff, yellowish brown, gray and orange brown mottled		
	795							Groundwater was encountered at a depth of about 9 feet during drilling and measured at 9.5 feet upon completion of drilling. Boring was dry 48 hours after drilling.
		⊠	4	3-3-2		-firm with dark brown, wet ▽		
10						10.5 (RESIDUAL) 792.5		Moderately hard drilling at 10 feet.
						AUGER REFUSAL at a depth of 10.5 feet. Boring backfilled on 01/16/2015.		
						Conceptual Final Grade = 806 feet; Anticipated Fill ~ 3 feet		
	790							
15								
	785							
20								

SAMPLE TYPE ⊠ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

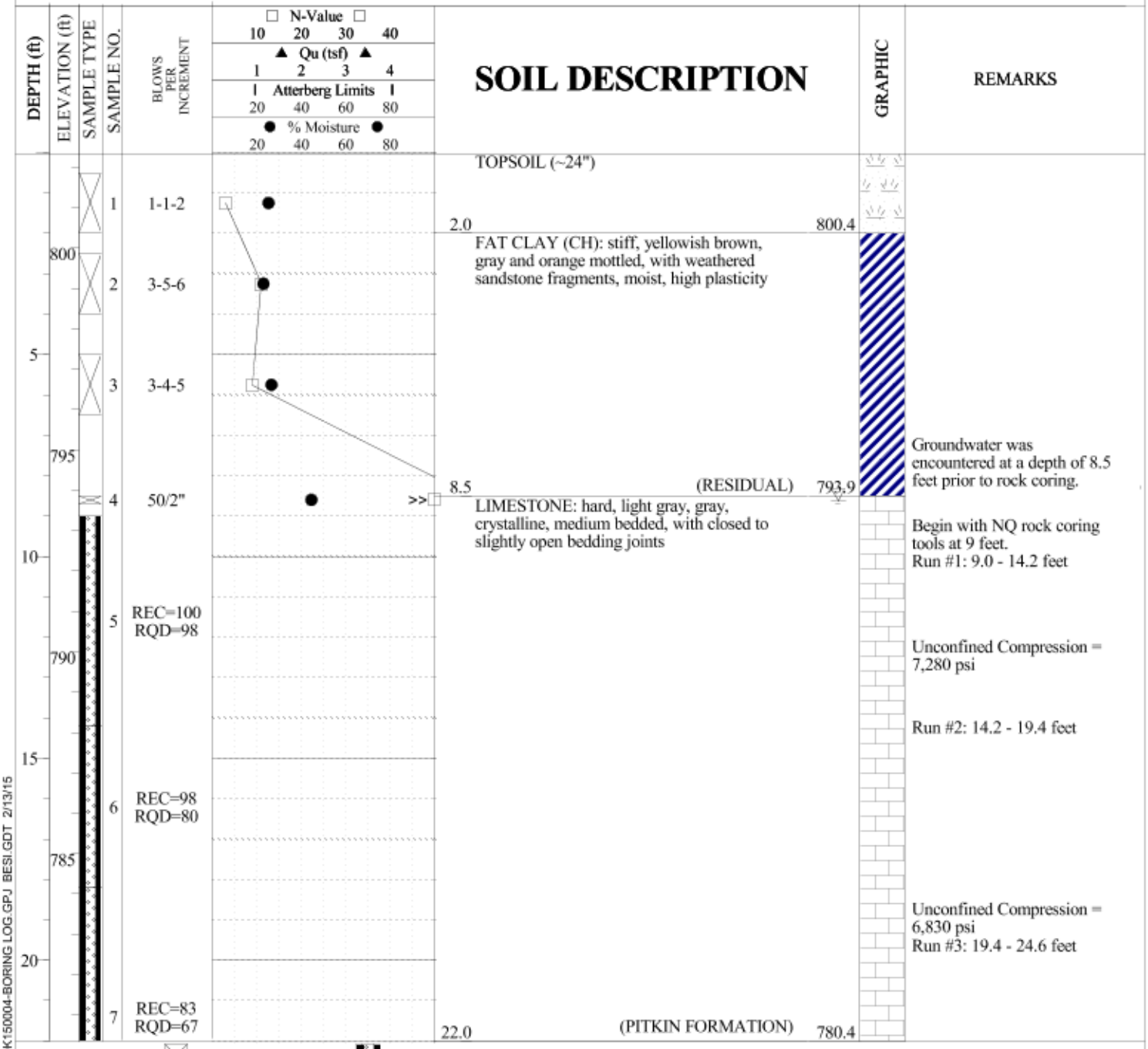
LOG OF BORING

Designation: CC-02 (#35)

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/17/15
Weather Conditions: Clear
Surface Elevation: 802.36
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson



SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: CC-02 (#35)

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/17/15
Weather Conditions: Clear
Surface Elevation: 802.36
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	780					CHERTY LIMESTONE: hard, light gray, gray, vuggy, thin to medium bedded, with slightly open bedding joints		Unconfined Compression = 9,230 psi
24.6	777.8					(KEOKUK FORMATION)		
25	775					Boring terminated at a depth of 24.6 feet. Boring backfilled on 01/17/2015.		
30	770					Conceptual Final Grade = 806 feet; Anticipated Fill ~ 3.5 feet		
35	765							
40	760							

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

LOG OF BORING

Designation: CC-03 (#34)

Sheet 1 of 1

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/16/15
Weather Conditions: Clear
Surface Elevation:
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
			1	WOH-1-1		TOPSOIL (`24")		WOH: Weight of Hammer
						2.0 FAT CLAY (CH): soft, dark gray, gray, moist, high plasticity		
			2	2-3-3		- firm at 2.5 feet		
5			3	2-3-5		-firm to stiff, gray, dark gray with fine sand, wet ▽		Groundwater was encountered during drilling at a depth of 6 feet blow the surface. Boring was dry prior to backfilling.
			4	3-3-4		-firm, with coarse sand		
10						10.5 (RESIDUAL) **AUGER REFUSAL** at a depth of 10.5 feet. Boring backfilled on 01/16/2015.		
15								
20								

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: CC-03 (#34A)

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/17/15
Weather Conditions: Clear
Surface Elevation: 798.95
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
			1	WOH-1-1		TOPSOIL (~24")		WOH: Weight of Hammer
						2.0 / 797.0 FAT CLAY (CH): firm, dark gray, gray, moist, high plasticity		
			2	2-3-3				
	795					- with limestone fragments		Groundwater was encountered during drilling at a depth of 4.5 feet below the surface.
5						5.0 (RESIDUAL) 794.0 LIMESTONE: hard, light gray, gray, crystalline, medium bedded, with slightly open bedding joints		Begin with NQ rock coring tools at 5 feet.
			3	REC=98 RQD=90		- closed joint at ~30 degree angle		Run #1: 5.0 - 9.0 feet Unconfined Compression = 7,730 psi
	790							Run #2: 9.0 - 14.0 feet
10			4	REC=100 RQD=96				
						- moderately hard, dark gray, shaly, between 13.0 to 19.0 feet		Unconfined Compression = 6,900 psi Run #3: 14.0 - 19.0 feet
	785							
15			5	REC=100 RQD=90				
	780					- hard, light gray, gray, pitted, medium bedded		Run #4: 19.0 - 24.0 feet
20			6	REC=100 RQD=92				

SAMPLE TYPE: Split Spoon; Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: CC-03 (#34A)

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/17/15
Weather Conditions: Clear
Surface Elevation: 798.95
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						LIMESTONE: hard, light gray, gray, crystalline, medium bedded, with slightly open bedding joints *(continued)*		
24.0	775.0					(PITKIN FORMATION)		
						Boring terminated at a depth of 24 feet. Boring backfilled on 01/17/2015.		
						Conceptual Final Grade = 802 feet; Anticipated Fill ~ 3 feet		

N-Value: 10 20 30 40
Qu (tsf): 1 2 3 4
Atterberg Limits: 20 40 60 80
% Moisture: 20 40 60 80

SAMPLE TYPE: Split Spoon; Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

LOG OF BORING

Designation: CC-04 (#33)

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/16/15
Weather Conditions: Clear
Surface Elevation: 802.69
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0						TOPSOIL (~30")		WOH: Weight of Hammer
			1	WOH-1-2				
2.5	800.2							
	800		2	1-2-50/3"	>>	FAT CLAY (CH): soft, gray, yellowish brown mottled with weathered sandstone fragments, very moist, high plasticity (RESIDUAL)		
3.5	799.2							moderately hard drilling at 3.5 feet
5						LIMESTONE: hard, light gray, gray, medium bedding with calcite seams and few shaley partings, slightly open bedding joints		Groundwater was not encountered during drilling and boring dry prior to rock coring. Begin with NQ rock coring tools at 4.5 feet
			3	REC=70 RQD=61				Run #1: 4.5 to 9.5 feet
7.3	795.4							
	795					-apparent clay seam (core loss) between 7.3 to 8.5 feet.		
8.5	794.2							
10								Run #2: 9.5-14.5 feet
			4	REC=99 RQD=99				
	790							
15								Run #3: 14.5-19.5 feet
			5	REC=98 RQD=73				
17.5	785.2							
	785					-weathered shale seam from 17.5-18.5		
18.5	784.2							
						-gray to dark gray, highly fractured below 19 feet		
19.5	783.2					(PITKIN FORMATION)		
20						Boring terminated at a depth of 19.5 feet. Boring backfilled on 01/17/2015. Conceptual Final Grade = 800 feet; Anticipated Cut ~ 2.5 feet		

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

LOG OF BORING

Designation: CC-05 (#32)

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Casino/Hotel/Convention Ctr

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/14/15
Weather Conditions: Partly Cloudy
Surface Elevation: 801.13
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL (~22")		% Organics=4.7
	800	⊠	1	2-2-3		1.8 / 799.3		
		⊠	2	4-4-11		FAT CLAY (CH): firm, gray with yellowish brown mottled, moist, high plasticity -stiff to very stiff, gray with orange brown mottled, with trace small chert fragments		Sample #2: 2.5-4.0 feet Atterberg Limits: LL=55, PL=23, PI=32
						4.8 (RESIDUAL) 796.3		
5		⊠	3	50/0.5"	>>	5.0 LIMESTONE: hard, gray, cherty 796.1		Groundwater was not encountered during drilling and boring dry upon completion of drilling. Boring was dry prior to backfilling.
	795					**AUGER REFUSAL** at a depth of 5 feet. Boring backfilled on 01/16/2015.		
						Conceptual Final Grade = 800 feet; Anticipated Cut ~ 1 foot		
10	790							
15	785							
20	780							

SAMPLE TYPE ⊠ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: H-01 (#55)

Sheet 1 of 1

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Hotel #2

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/14/15
Weather Conditions: Partly Cloudy
Surface Elevation: 812.08
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	812.08					TOPSOIL (~30")		
	810		1	2-2-2				
2.5	809.6					LEAN TO FAT CLAY (CL-CH): stiff, reddish brown, with trace chert fragments, moist, moderate to high plasticity		Sample #2: 2.5-4.0 feet Atterberg Limits: LL=47, PL=21, PI=26
			2	4-6-6				
5			3	6-5-6		- yellowish brown, orange mottled, with black ferrous nodules		
	805							
8.0	804.1					(RESIDUAL)		
			4	50/1"	>>	**AUGER REFUSAL** on apparent BRECCIATED CHERT at a depth of 8 feet. Boring backfilled on 01/16/2015.		Groundwater was not encountered during drilling and boring dry upon completion of drilling, and 48 hours after drilling.
10						Conceptual Final Grade = 813 feet; Anticipated Fill ~ 1 foot		
	800							
15								
	795							
20								

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: H-02 (#54)

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Hotel #2

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/17/15
Weather Conditions: Clear
Surface Elevation: 807.68
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value / Qu (tsf) / Atterberg Limits / % Moisture	SOIL DESCRIPTION	GRAPHIC	REMARKS
						TOPSOIL (~18")		
			1	2-2-2		1.5 / 806.2		Sample #1: 0.5-2.0 feet Atterberg Limits: LL=33, PL=19, PI=14
	805		2	2-3-5		LEAN CLAY (CL: stiff, reddish brown, orange-brown, with small chert fragments, moist, moderate plasticity		
5			3	4-4-4		5.0 / 802.7 FAT CLAY (CH): stiff, orange-brown, yellowish brown, with chert and weathered limestone fragments, and ferrous nodules, moist, high plasticity		
	800		4	3-3-5		- with more abundant chert fragments and gravel, very moist		
10						▽		Groundwater was encountered at a depth of 11.5 feet prior to rock coring.
	795		5	50/0.5"	>>	13.5 (RESIDUAL) 794.2 CHERTY LIMESTONE: hard, light gray, gray, vuggy, thin to medium bedded, with slightly open bedding joints		Begin with NQ rock coring tools at 13.5 feet. Run #1: 13.5 - 15.0 feet
			6	REC=88 RQD=78				Run #2: 15.0 - 20.0 feet Unconfined Compression = 7,740 psi
15								
	790		7	REC=100 RQD=81				
20								Run #3: 20.0 - 23.5 feet

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: H-02 (#54)

Sheet 2 of 2

10828 East Newton Street, Suite 111
Tulsa, Oklahoma 74116
Office: (918) 439-9005
Fax: (918) 439-9255
www.BuildingAndEarth.com

Project Name: Proposed Cherokee Springs Plaza
Project Number: OK150004
Drilling Method: 3 1/4" HSA
Equipment Used: CME-550X
Hammer Type: Automatic
Boring Location: Hotel #2

Project Location: Tahlequah, Oklahoma
Date Drilled: 1/17/15
Weather Conditions: Clear
Surface Elevation: 807.68
Drill Crew: Mohawk Drilling, Inc.
Logged By: Terry Robinson

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	N-Value (10 20 30 40) / Qu (tsf) (1 2 3 4) / Atterberg Limits (20 40 60 80) / % Moisture (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
	785		8	REC=100 RQD=100		CHERTY LIMESTONE: hard, light gray, gray, vuggy, thin to medium bedded, with slightly open bedding joints *(continued)* (KEOKUK FORMATION)		Unconfined Compression = 10,190 psi
23.5	784.2					Boring terminated at a depth of 23.5 feet. Boring backfilled on 01/17/2015.		
25						Conceptual Final Grade = 813 feet; Anticipated Fill ~ 5 feet		
	780							
30								
	775							
35								
	770							
40								
	765							

SAMPLE TYPE ☒ Split Spoon ▮ Rock Core

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK150004-BORING LOG.GPJ BESI.GDT 2/13/15

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.

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

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:
   1. Footings.
   2. Foundation walls.
   3. Slabs-on-grade.
   4. Suspended slabs.
   5. Concrete toppings.
   6. Building frame members.
   7. Building walls.

1.03 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, Slag Cement, and silica fume; subject to compliance with requirements.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

1.05 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each of the following, signed by manufacturers:
   1. Cementitious materials.
   2. Admixtures.
   3. Form materials and form-release agents.
   4. Steel reinforcement and accessories.
   5. Fiber reinforcement.
   6. Waterstops.
   7. Curing compounds.
   8. Floor and slab treatments.
   9. Bonding agents.

10. Adhesives.
11. Vapor retarders.
12. Semirigid joint filler.
13. Joint-filler strips.
14. Repair materials.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

C. Testing Agency Qualifications: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
   2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

E. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
   1. ACI 301, "Specifications for Structural Concrete,"
   2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

F. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - PRODUCTS

2.01 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
   1. Plywood, metal, or other approved panel materials.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

F. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.

G. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

H. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
   1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

I. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
   1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.
   2. Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.
   3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.02 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

B. Deformed-Steel Welded Wire Reinforcement: ASTM A 1064/A 1064M, flat sheet.

2.03 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
   1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
   2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
   3. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.

2.04 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
   1. Portland Cement: ASTM C 150, Type I,. Supplement with the following:
      a. Fly Ash: ASTM C 618, Class F or C.
      b. Slag Cement: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 3M coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
   1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 1602/C 1602M and potable.

2.05 ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Calcium chloride or admixtures containing intentionally-added chlorides shall not be used in reinforced ad prestressed concretes.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
   7. Viscosity-Modifying Admixture: ASTM C 494/ C 494 M, Type S.

2.06 VAPOR RETARDERS

A. Sheet Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than 15 mils thick.

2.07 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, 18 to 25 percent solids, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. BASF Construction Chemicals - Building Systems; Kure-N-Seal W.
      b. ChemMasters; Safe-Cure Clear.
      c. Conspec by Dayton Superior; High Seal.

d. Dayton Superior Corporation; Safe Cure and Seal (J-19).
e. Edoco by Dayton Superior; Spartan Cote WB II 20 Percent.
f. Euclid Chemical Company (The), an RPM company; Diamond Clear VOX; Clearseal WB STD.
g. Kaufman Products, Inc.; SureCure Emulsion.
h. Lambert Corporation; Glazecote Sealer-20.
i. L&M Construction Chemicals, Inc.; Dress & Seal WB.
j. Meadows, W. R., Inc.; Vocomp-20.
k. Metalcrete Industries; Metcure 0800.
l. Nox-Crete Products Group; Cure & Seal 200E.
m. Symons by Dayton Superior; Cure & Seal 18 Percent E.
n. Vexcon Chemicals, Inc.; Starseal 0800.

2.08 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, aromatic polyurea with a Type A shore durometer hardness range of 90 to 95 per ASTM D 2240.

C. Dovetail Anchor Slots: Hot-dip galvanized-steel sheet, not less than 0.034 inch thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.09 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
   1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
   2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
   3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.
   4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.
   1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
   2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
   3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
   4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

2.10 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
   1. Fly Ash: 25 percent.
   2. Combined Fly Ash and Pozzolan: 25 percent.
   3. Slag Cement: 50 percent.
   4. Combined Fly Ash or Pozzolan and Slag Cement: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.
   5. Combined Fly Ash, Pozzolans, and Silica Fume: 35 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.
   6. Combined Fly Ash or Pozzolans, Slag Cement, and Silica Fume: 50 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

D. Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use high-range water-reducing admixture in concrete, as required, for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
   3. Use viscosity-modifying admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

2.11 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Concrete mixtures shall be as per indicated in the concrete notes on the plans.

2.12 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.13 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes. Alternatively, a hydration-controlling admixture, workability retaining admixture and other means as specified in ACI 305.1 may be used

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
   1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
   2. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
   3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.01 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:
   1. Class A, 1/8 inch for smooth-formed finished surfaces.
   2. Class B, 1/4 inch for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
   1. Install keyways, reglets, recesses, and the like, for easy removal.
   2. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.02 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."

2. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
3. Install dovetail anchor slots in concrete structures as indicated.

3.03 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations and curing and protection operations need to be maintained.
   1. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
   2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.04 VAPOR RETARDERS

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.
   1. Lap joints 6 inches and seal with manufacturer's recommended tape.

3.05 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
   1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
   1. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.06 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
   1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
   2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
   3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
   4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
   5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.

C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least 1/3 of concrete thickness as follows:
   1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
   1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
   2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants, specified in Section 07 9200 "Joint Sealants," are indicated.
   3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.07 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.

C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
   1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
   1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
   2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
   3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
   1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   2. Maintain reinforcement in position on chairs during concrete placement.
   3. Screed slab surfaces with a straightedge and strike off to correct elevations.
   4. Slope surfaces uniformly to drains where required.
   5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
   1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
   2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

G. Hot-Weather Placement: Comply with ACI 305.1 and as follows:
   1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.08 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
   1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:
   1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
   2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
   3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.09 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.
   1. Apply float finish to surfaces to receive trowel finish.

C. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
   1. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
   2. Finish and measure surface so gap at any point between concrete surface and an unleveled, freestanding, 10-ft.- long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/8 inch.

D. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.
   1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

3.10 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel finish concrete surfaces.

3.11 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305.1 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
   1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Continuous water-fog spray.
      c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
   2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
      a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
      b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
   a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.
4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.12 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.
   1. Defer joint filling until concrete has aged at least three months. Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.13 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
   1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension to solid concrete. Limit cut depth to 3/4 inch. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
   2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
   3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
   1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
   2. After concrete has cured at least 14 days, correct high areas by grinding.
   3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
   4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
   5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
   6. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
   7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.14 FIELD QUALITY CONTROL

A. Testing and Inspecting: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.

B. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
5. Density: ASTM C 138/ C 138M, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
6. Compression Test Specimens: ASTM C 31/C 31M.
    a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
    b. For tilt-up concrete and post-tensioning concrete, cast and field cure two sets of two standard cylinder specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two 6x12 or three 4x8 laboratory-cured specimens at 7 days and one set of two 6x12 or three 4x8 specimens at 28 days.
    a. Test one set of two 6x12 or three 4x8 field-cured specimens at 7 days and one set of two 6x12 or three 4x8 specimens at 28 days.
    b. A compressive-strength test shall be the average compressive strength from a set of two 6x12 or three 4x8 specimens obtained from same composite sample and tested at age indicated.
8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
9. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
10. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
11. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
12. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
14. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

C. Measure floor and slab flatness and levelness according to ASTM E 1155 within 48 hours of finishing.

END OF SECTION 03 30 00

SECTION 31 2000

EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Preparing subgrades for slabs-on-grade, walks, and pavements.
2. Excavating and backfilling for buildings and structures.
3. Preparing subgrade for walks and vehicular pavements.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Division 00 and Division 01 Sections, apply to this Section.

1.3 RELATED SECTIONS

1. Section 00 3100: Available Project Information.
2. Section 01 3216: Construction Progress Schedule.
3. Section 01 5000: Temporary Facilities and Controls.
4. Section 31 2319: Dewatering.
5. Section 31 2500: Erosion and Sedimentation Controls.
6. Section 31 5000: Excavation Support and Protection.

1.4 REFERENCED STANDARDS

A. Latest version or edition shall apply unless otherwise noted.

1. American Society of Testing and Materials (ASTM) International
    a. C33, Standard Specification for Concrete Aggregates.
    b. C94, Standard Specification for Ready-Mixed Concrete.
    c. C150, Standard Specification for Portland Cement.
    d. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
    e. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
    f. C869, Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete.
    g. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
    h. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
    i. D2922, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
    j. D3740, Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
    k. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
    l. D6913, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
    m. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

1.5 DEFINITIONS

A. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

B. CLSM: Controlled Low Strength Material

C. Drainage Aggregate: Aggregate material used in the construction of sub-drainage features

D. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by CO/COTR. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Owner. Unauthorized excavation, as well as remedial work directed by Owner, shall be without additional compensation.

E. Fill: Soil materials used to raise existing grades.

F. Geotechnical Report: *Report of Subsurface Exploration and Geotechnical Evaluation, Cherokee Springs Casino, Tahlequah, OK*, prepared by Building & Earth (Building & Earth Project No. OK170293), dated January 17, 2018.

G. Geotechnical Engineer: Building & Earth, 1403 South 70th East Avenue, Tulsa, Oklahoma 74112, Phone 918.439.9005, www.buildingandearth.com.

H. Geotechnical Testing Agency: to be appointed by Contractor**.** Geotechnical Testing Agency shall be qualified per requirements of ASTM E329 and ASTM D3740 for testing indicated. Documentation of said qualifications shall be submitted to Engineer for review and approval prior to performance of work.

I. SWPPP: Storm Water Pollution Prevention Plan.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below base course or topsoil materials.

L. Treated Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill which has been amended with hydrated lime or cement kiln dust per the recommendations of the Geotechnical Engineer.

M. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.6 INFORMATIONAL SUBMITTALS

A. Material Test Reports: Contractor shall coordinate and request the following reports from the Geotechnical Testing Agency for each type of soil encountered on-site and soil material proposed for fill and backfill:

1. Classification according to ASTM D2487.
2. Laboratory compaction curve according to ASTM D698.
3. Liquid Limit
4. Plasticity Index according to ASTM D4318.
5. Sieve Analyses according to ASTM D6913.

B. Field Quality Control Inspection and Test Reports.

1.7 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E329 and ASTM D3740 for testing indicated.

B. Pre-excavation Conference: To be addressed during project pre-work meetings scheduled by Architect and/or Owner. In instances where a pre-work meeting is not scheduled by the Architect or Owner, the Contractor shall arrange for an on-site meeting with the Engineer following completion of construction staking activities.

1.8 PROJECT CONDITIONS

A. Geotechnical Report: Read and review the Geotechnical Report for an analysis of existing soil conditions and engineering recommendations.

B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

C. Improvements on Adjoining Property: Do not proceed with work on adjoining property unless otherwise indicated on the Construction Drawings or directed by the Engineer or Owner.

D. Utility Locator Service: Notify Oklahoma One Call System (1-800-522-6543) before beginning earth moving operations.

E. Do not commence earth moving operations until temporary tree and plant protection measures, temporary erosion control measures, and temporary sedimentation control measures identified by the Erosion Control Plan and the SWPPP are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory and Unsatisfactory Soils: See Geotechnical Report for additional information.

C. Aggregate Base:

1. Materials Covered: These Specifications cover the aggregate for use in the construction of aggregate base courses, backfill and surfacing.

2. General Requirements: Aggregate material shall consist of an intimate mixture of graded aggregate, coarse and fine, and shall be practically free from vegetable or other deleterious substances. Coarse aggregate (material retained on a No. 10 sieve) shall consist of sound, tough, durable particles or fragments of gravel, stone, mine chats, disintegrated granite, or a combination thereof. Fine aggregate shall be sand, stone dust or other inert finely divided mineral matter.

3. At least 40 percent of that portion of the completed mixture retained on the No. 4 sieve shall be composed of uniformly graded crushed particles (pieces of aggregate with one or more fractured faces resulting from the artificial crushing).

4. Physical Properties: The coarse aggregate retained on the 3/8 inch sieve of the finished mixture shall have a percent of wear, Los Angeles Abrasion Test, of not more than 50. No source of material used in the blend shall have a percent of wear of more than 50.

5. Gradation: The graded aggregate when uniformly blended and sampled from trucks or windrows shall conform to the following requirements depending on the type being used. Materials which contain oversize particles of rock, gravel, lumps of clay or conglomerated material shall not be loaded into vehicles for delivery to the road. Such oversize particles of aggregate must be screened, crushed or otherwise processed to meet the Specifications before delivery to the road. The samples taken from trucks or windrows

after the graded aggregate has been uniformly blended, shall conform to the gradation limits for the type being constructed, as follows:.

a. Type A:
   1) Sieve size: 1-1/2-in, percent passing: 100%.
   2) Sieve size: 3/4-in, percent passing: 40-100%.
   3) Sieve size: 3/8-in, percent passing 30-75%.
   4) Sieve size: No. 4, percent passing 25-60%.
   5) Sieve size: No. 10, percent passing 20-43%.
   6) Sieve size: No. 40, percent passing 8-26%.
   7) Sieve size: No. 200, percent passing 4-12%.

b. Type B:
   1) Sieve size: 3-in, percent passing: 100%.
   2) Sieve size: 1-1/2-in, percent passing: 40-100%.
   3) Sieve size: 3/4-in, percent passing 30-75%.
   4) Sieve size: 3/8-in, percent passing 20-50%.
   5) Sieve size: No. 4, percent passing 25-60%.
   6) Sieve size: No. 10, percent passing 15-35%.
   7) Sieve size: No. 40, percent passing 7-22%.
   8) Sieve size: No. 200, percent passing 3-10%.

c. Type C:
   1) Sieve size: 2-in, percent passing: 100%.
   2) Sieve size: 1-1/2-in, percent passing: 90-100%.
   3) Sieve size: 1-in, percent passing: 80-100%.
   4) Sieve size: 1/2-in, percent passing 60-80%.
   5) Sieve size: No. 4, percent passing 40-60%.
   6) Sieve size: No. 10, percent passing 25-45%.
   7) Sieve size: No. 40, percent passing 15-30%.
   8) Sieve size: No. 200, percent passing 0-5%.

6. Material passing the No. 200 sieve shall not be greater than 2/3 of the amount of material passing the No. 40 sieve

7. Characteristics of material passing the No. 40 sieve:
   a. Plasticity Index: less than 6.
   b. Liquid Limit: less than 25
   c. The blending of separate aggregates will be permitted to produce an aggregate mixture meeting this requirement providing no individual aggregate has a plasticity index in excess of 8.

D. Sand: fine aggregate per ASTM C33. Gradation shall be as follows:
   1. Sieve size: 3/8-in, percent passing: 100%.
   2. Sieve size: No. 4, percent passing 95-100%.
   3. Sieve size: No. 8, percent passing 80-100%.
   4. Sieve size: No. 16, percent passing 50-85%.
   5. Sieve size: No. 30, percent passing 25-60%.
   6. Sieve size: No. 50, percent passing 5-30%.

7. Sieve size: No. 100, percent passing 0-10%.

E. Drainage Aggregate: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel. Gradation of material subject to associated drainage conduit perforation schedule.

2.2 ACCESSORIES

A. CLSM: Self-compacting, flowable concrete material produced from the following:

1. Portland Cement: ASTM C150, Type I.
2. Fly Ash: ASTM C618, Class C or F.
3. Normal-Weight Aggregate: ASTM C33, 3/8-inch nominal maximum aggregate size.
4. Foaming Agent: ASTM C869.
5. Water: ASTM C94/C 94M.
6. Air-Entraining Admixture: ASTM C260.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
    a. 24 inches outside of concrete forms other than at footings.
    b. 12 inches outside of concrete forms at footings.
    c. 6 inches outside of minimum required dimensions of concrete cast against grade.
    d. 6 inches beneath bottom of concrete slabs-on-grade.

3.4 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. The Geotechnical Engineer has specified 3-feet of properly compacted low-plasticity structural fill beneath the floor slab. Contractor shall over-excavate beneath limits of proposed slab as required. See Geotechnical Report for additional guidance regarding the limits of this over-excavation.

3.5 SUBGRADE INSPECTION

A. Notify Geotechnical Testing Agency when excavations have reached required subgrade.

B. In the presence of the Geotechnical Testing Agency, proof-roll subgrade below the building slabs and pavements with a tandem-axle dump truck, or other similar rubber-tired vehicle weighing 25-tons or more to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Soils which are observed to rut or deflect greater than 1-in under the moving load shall be undercut and replaced with properly compacted satisfactory soil material. Imported soil material should be moisture conditioned during placement.

C. If Geotechnical Testing Agency determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed. Work shall be completed at no cost to the Owner.

D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.6 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. CLSM, with 28-day compressive strength of 2500 psi, may be used when approved by Geotechnical Engineer.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by the Geotechnical Engineer.

3.7 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover or water to prevent windblown dust. Contractor responsible for installation of necessary temporary erosion control devices as required to ensure compliance with the SWPPP.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
2. Stockpile locations shall be subject to review and approval of Engineer. Contractor shall confirm stockpile location prior to placement.

3.8 BACKFILL

A. Place and compact backfill in excavations promptly per the requirements of the Geotechnical Report, but not before completing the following:

1. Surveying locations of underground utilities for Record Documents.
2. Testing and inspecting underground utilities.
3. Removing concrete formwork.
4. Removing trash and debris.
5. Removing temporary shoring and bracing, and sheeting.
6. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.9 FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers per requirements of the Geotechnical Report.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.10 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction per requirements of Geotechnical Report.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that does not meet the requirements of the Geotechnical Report and is too wet to compact to specified dry unit weight.

B. Maintain moisture up until the placement of concrete in structural areas.

3.11 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers per requirements of Geotechnical Report.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials per requirements of Geotechnical Report.

3.12 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.

2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.

2. Walks: Plus or minus 1/2 inch.

3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.13 FIELD QUALITY CONTROL

A. Special Inspections: Contractor shall engage Geotechnical Testing Agency to perform all Special Inspections related to soils inspections, excavation, and compaction required by Geotechnical Engineer.

B. Allow Geotechnical Testing Agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Geotechnical Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D2922, or other methods approved by the Geotechnical Engineer. Tests will be performed at the location and frequencies identified by the Geotechnical Engineer.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.14 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Geotechnical Engineer; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.15 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 2000

SECTION 31 2319
DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes construction dewatering.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 00 Specification Sections, apply to this Section.

1.3 RELATED SECTIONS

1. Section 01 3100: Available Project Information.
2. Section 01 3300: Submittal Procedures.
3. Section 31 2000: Earthwork.
4. Section 31 2514: Erosion and Sedimentation Controls.

1.4 DEFINITIONS

A. Geotechnical Report: *Report of Subsurface Exploration and Geotechnical Evaluation, Cherokee Springs Casino, Tahlequah, OK*, prepared by Building & Earth (Building & Earth Project No. OK170293), dated January 17, 2018.

B. Geotechnical Engineer: Building & Earth, 1403 South 70th East Avenue, Tulsa, Oklahoma 74112, Phone 918.439.9005, www.buildingandearth.com.

1.5 ALLOWANCES

A. Dewatering observation wells are part of dewatering allowance.

1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Review condition of site to be dewatered including coordination with temporary erosion-control measures and temporary controls and protections.
3. Review geotechnical report.
4. Review proposed site clearing and excavations.
5. Review existing utilities and subsurface conditions.
6. Review observation and monitoring of dewatering system.

1.7 ACTION SUBMITTALS

A. General: Comply with requirements of Section 01 3300.

B. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

1.10 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. IHS is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.

B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.

2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.

3. Prevent surface water from entering excavations by grading, dikes, or other means.

4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.

5. Remove dewatering system when no longer required for construction.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with ODEQ and OWRB water-disposal regulations and EPA debris-disposal regulations.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.

2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 31 2500 "Erosion and Sedimentation Control," during dewatering operations.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.

2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.

3. Maintain piezometric water level a minimum of 60 inches below bottom of excavation.

C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.

2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend

construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.

3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify IHS if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

D. Prepare reports of observations.

3.5 PROTECTION

A. Protect and maintain dewatering system during dewatering operations.

B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION 31 2319

SECTION 31 2500

EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Prevention of erosion due to construction activities.
2. Prevention of sedimentation of waterways, open drainage ways, and storm and sanitary sewers due to construction activities.
3. Restoration of areas eroded due to insufficient preventive measures.
4. Performance bond.
5. Temporary Construction Fence.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 00 Specification Sections, apply to this Section.

1.3 RELATED SECTIONS

A. Section 01 3300: Submittal Procedures.

B. Section 31 2000: Earthwork.

1.4 REFERENCED STANDARDS

A. Latest version or edition shall apply unless otherwise noted.

1. American Society of Testing and Materials (ASTM) International
   a. D 4355, *Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus*.
   b. D 4491, *Standard Test Methods for Water Permeability of Geotextiles by Permittivity*.
   c. D 4533, *Standard Test Method for Trapezoid Tearing Strength of Geotextiles*.
   d. D 4632, *Standard Test Method for Grab Breaking Load and Elongation of Geotextiles*.
   e. D 4751, *Standard Test Method for Determining Apparent Opening Size of a Geotextile*.
   f. D 4873, *Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples*.
2. Environmental Protection Agency (EPA)
   a. *National Pollutant Discharge Elimination System (NPDES).*
   b. *Construction General Permit*.

1.5 PERFORMANCE REQUIREMENTS

A. Comply with all requirements of U.S. Environmental Protection Agency for erosion and sedimentation control, as specified for the National Pollutant Discharge Elimination System (NPDES), Phases I and II, under requirements for the Construction General Permit (CGP).

B. Comply with all requirements of governing authorities for erosion and sedimentation control.

C. Develop and follow an Erosion and Sedimentation Prevention Plan and submit periodic inspection reports.

D. Do not begin clearing, grading, or other work involving disturbance of ground surface cover until

applicable permits have been obtained; furnish all documentation required to obtain applicable permits.

1. Obtain and pay for permits and provide security required by authority having jurisdiction.

E. Timing: Put preventive measures in place as soon as possible after disturbance of surface cover and before precipitation occurs.

F. Storm Water Runoff: Control increased storm water runoff due to disturbance of surface cover due to construction activities for this project.

1. Prevent runoff into storm and sanitary sewer systems, including open drainage channels, in excess of actual capacity or amount allowed by authorities having jurisdiction, whichever is less.

G. Erosion On Site: Minimize wind, water, and vehicular erosion of soil on project site due to construction activities for this project.

1. Control movement of sediment and soil from temporary stockpiles of soil.
2. Prevent development of ruts due to equipment and vehicular traffic.
3. If erosion occurs due to non-compliance with these requirements, restore eroded areas at no cost to Owner.

H. Erosion Off Site: Prevent erosion of soil and deposition of sediment on other properties caused by water leaving the project site due to construction activities for this project.

1. Prevent windblown soil from leaving the project site.
2. Prevent tracking of mud onto public roads outside site.
3. Prevent mud and sediment from flowing onto sidewalks and pavements.
4. If erosion occurs due to non-compliance with these requirements, restore eroded areas at no cost to Owner.

I. Sedimentation of Waterways On Site: Prevent sedimentation of waterways on the project site, including rivers, streams, lakes, ponds, open drainage ways, storm sewers, and sanitary sewers.

1. If sedimentation occurs, install or correct preventive measures immediately at no cost to the Owner; remove deposited sediments; comply with requirements of authorities having jurisdiction.
2. If sediment basins are used as temporary preventive measures, pump dry and remove deposited sediment after each storm.

J. Sedimentation of Waterways Off Site: Prevent sedimentation of waterways off the project site, including rivers, streams, lakes, ponds, open drainage ways, storm sewers, and sanitary sewers.

1. If sedimentation occurs, install or correct preventive measures immediately at no cost to the Owner; remove deposited sediments; comply with requirements of authorities having jurisdiction.

K. Open Water: Prevent standing water that could become stagnant.

L. Maintenance: Maintain temporary preventive measures until permanent measures have been established.

1.6 SUBMITTALS

A. General: Comply with requirements of Section 01 3300.

B. Certificate: Mill certificate for silt fence fabric attesting that fabric and factory seams comply with specified requirements signed by legally authorized official of manufacturer; indicate actual minimum average roll values; identify fabric by roll identification numbers.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Silt Fence Fabric: Polypropylene geotextile resistant to common soil chemicals, mildew, and insects; non-biodegradable; in longest lengths possible; fabric including seams with the following minimum average roll lengths:

1. Average Opening Size: 30 U.S. Std. Sieve, maximum, when tested in accordance with ASTM D 4751.
2. Permittivity: 0.05 sec^{-1}, minimum, when tested in accordance with ASTM D 4491.
3. Ultraviolet Resistance: Retaining at least 70 percent of tensile strength, when tested in accordance with ASTM D 4355 after 500 hours exposure.
4. Tensile Strength: 100 lb-f, minimum, in cross-machine direction; 124 lb-f, minimum, in machine direction; when tested in accordance with ASTM D 4632.
5. Elongation: 15 to 30 percent, when tested in accordance with ASTM D 4632.
6. Tear Strength: 55 lb-f, minimum, when tested in accordance with ASTM D 4533.
7. Color: Manufacturer's standard, with embedment and fastener lines preprinted.
8. Manufacturers:
    a. BP Amoco, Amoco Fabrics and Fibers: www.geotextile.com.
    b. TenCate: www.tencate.com.
    c. Propex Geosynthetics: www.geotextile.com

B. Silt Fence Posts: Minimum 5 feet long:

1. Steel U- or T-section, with minimum mass of 1.33 lb per linear foot.

C. Temporary Construction Fence: Where indicated on the Drawings, provide plastic mesh fencing supported by steel posts driven into ground.

1. Height: 36 inch minimum.
2. Color: Safety orange.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine site and identify existing features that contribute to erosion resistance; maintain such existing features to greatest extent possible.

3.2 PREPARATION

A. Schedule work so that soil surfaces are left exposed for the minimum amount of time.

3.3 SCOPE OF PREVENTIVE MEASURES

A. In all cases, if permanent erosion resistant measures have been installed temporary preventive measures are not required.

B. Construction Entrances: 8 inch course of Type B Aggregate Base or Crushed Rock Foundation per Section 31 2000 “Earth Moving”.

1. Width: As required; 20 feet, minimum.
2. Length: 50 feet, minimum.
3. Provide at each construction entrance from public right-of-way.
4. Where necessary to prevent tracking of mud onto right-of-way, provide wheel washing area out of direct traffic lane, with drain into sediment trap or basin.

C. Linear Sediment Barriers: Made of silt fences.

1. Provide linear sediment barriers:
    a. Along downhill perimeter edge of disturbed areas, including soil stockpiles.
    b. Along the top of the slope or top bank of drainage channels and swales that traverse disturbed areas.
    c. Along the toe of cut slopes and fill slopes.
    d. Perpendicular to flow across the bottom of existing and new drainage channels and swales that traverse disturbed areas or carry runoff from disturbed areas; space at maximum of 200 feet apart.
    e. Across the entrances to culverts that receive runoff from disturbed areas.
2. Space sediment barriers with the following maximum slope length upslope from barrier:
    a. Slope of Less Than 2 Percent: 100 feet.
    b. Slope between 2 and 5 Percent: 75 feet.
    c. Slope between 5 and 10 Percent: 50 feet.
    d. Slope between 10 and 20 Percent: 25 feet.
    e. Slope over 20 Percent: 15 feet.

D. Soil Stockpiles: Protect using one of the following measures:
1. Cover with polyethylene film, secured by placing soil on outer edges.
2. Cover with mulch at least 4 inches thickness of pine needles, sawdust, bark, wood chips, or shredded leaves, or 6 inches of straw or hay.

E. Temporary Seeding: Use where temporary vegetated cover is required.

3.4 INSTALLATION

A. Traffic-Bearing Aggregate Surface:
1. Excavate minimum of 6 inches.
2. Place geotextile fabric full width and length, with minimum 12 inch overlap at joints.
3. Place and compact at least 6 inches of 1.5 to 3.5 inch diameter stone.

B. Temporary Construction Fences:
1. Space steel support posts to insure mesh remains vertical and at proper height. Securely tie to posts.

C. Silt Fences:
1. Store and handle fabric in accordance with ASTM D 4873.
2. Where slope gradient is less than 3:1 or barriers will be in place less than 6 months, use nominal 16 inch high barriers with minimum 36 inch long posts spaced at 6 feet maximum, with fabric embedded at least 4 inches in ground.
3. Where slope gradient is steeper than 3:1 or barriers will be in place over 6 months, use nominal 28 inch high barriers, minimum 48 inch long posts spaced at 6 feet maximum, with fabric embedded at least 6 inches in ground.
4. Where slope gradient is steeper than 3:1 and vertical height of slope between barriers is more than 20 feet, use nominal 32 inch high barriers with woven wire reinforcement and steel posts spaced at 4 feet maximum, with fabric embedded at least 6 inches in ground.
5. Install with top of fabric at nominal height and embedment as specified.
6. Do not splice fabric width; minimize splices in fabric length; splice at post only, overlapping at least 18 inches, with extra post.
7. Fasten fabric to steel posts using wire, nylon cord, or integral pockets.

8. Wherever runoff will flow around end of barrier or over the top, provide temporary splash pad or other outlet protection; at such outlets in the run of the barrier, make barrier not more than 12 inches high with post spacing not more than 4 feet.

D. Temporary Seeding:

1. When hydraulic seeder is used, seedbed preparation is not required.
2. When surface soil has been sealed by rainfall or consists of smooth undisturbed cut slopes, and conventional or manual seeding is to be used, prepare seedbed by scarifying sufficiently to allow seed to lodge and germinate.
3. If temporary mulching was used on planting area but not removed, apply nitrogen fertilizer at 1 pound per 1000 sq ft.
4. On soils of very low fertility, apply 10-10-10 fertilizer at rate of 12 to 16 pounds per 1000 sq ft.
5. Incorporate fertilizer into soil before seeding.
6. Apply seed uniformly; if using drill or cultipacker seeders place seed 1/2 to 1 inch deep.
7. Irrigate as required to thoroughly wet soil to depth that will ensure germination, without causing runoff or erosion.
8. Repeat irrigation as required until grass is established.

3.5 MAINTENANCE

A. Inspect preventive measures weekly, within 24 hours after the end of any storm that produces 0.5 inches or more rainfall at the project site, and daily during prolonged rainfall.

B. Repair deficiencies immediately.

C. Silt Fences:

1. Promptly replace fabric that deteriorates unless need for fence has passed.
2. Remove silt deposits that exceed one-third of the height of the fence.
3. Repair fences that are undercut by runoff or otherwise damaged, whether by runoff or other causes.

D. Clean out temporary sediment control structures weekly and relocate soil on site.

E. Place sediment in appropriate locations on site; do not remove from site.

3.6 CLEAN UP

A. Remove temporary measures after permanent measures have been installed..

B. Clean out temporary sediment control structures that are to remain as permanent measures.

C. Where removal of temporary measures would leave exposed soil, shape surface to an acceptable grade and finish to match adjacent ground surfaces.

END OF SECTION 31 2500

SECTION 31 5000
EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes temporary excavation support and protection systems.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 00 Specification Sections, apply to this Section.

1.3 RELATED SECTIONS

1. Section 00 3100: Available Project Information.
2. Section 31 2000: Earth Moving.
3. Section 31 2319: Dewatering

1.4 REFERENCED STANDARDS

A. Latest version or edition shall apply unless otherwise noted.

1. American Concrete Institute (ACI)
   a. 301, Specification for Structural Concrete.
2. American Society of Testing and Materials (ASTM) International
   a. A 36, Standard Specification for Carbon Structural Steel.
   b. A 615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. A 328, Standard Specification for Steel Sheet Piling.
   d. A 416, Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
   e. A 572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   f. A 690, Standard Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments.
   g. A 722, Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete.
   h. A 992, Standard Specification for Structural Steel Shapes.

1.5 DEFINITIONS

A. Geotechnical Report: *Report of Subsurface Exploration and Geotechnical Evaluation, Cherokee Springs Casino, Tahlequah, OK*, prepared by Building & Earth (Building & Earth Project No. OK170293), dated January 17, 2018.

B. Geotechnical Engineer: Building & Earth, 1403 South 70th East Avenue, Tulsa, Oklahoma 74112, Phone 918.439.9005, www.buildingandearth.com.

1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review Geotechnical Report.
2. Review existing utilities and subsurface conditions.
3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
4. Review proposed excavations.

5. Review proposed equipment.
6. Review monitoring of excavation support and protection system.
7. Review coordination with waterproofing.
8. Review abandonment or removal of excavation support and protection system.

1.7 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, performance properties, and dimensions of individual components and profiles, and calculations for excavation support and protection system.

1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer.

B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.9 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Owner's written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from the data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection according to the performance requirements.
2. The Geotechnical Report is included in Section 00 3100 “Available Project Information”.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide, design, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.

1. Contractor Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
4. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

2.2 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36, ASTM A 690, or ASTM A 992.

C. Steel Sheet Piling: ASTM A 328, ASTM A 572, or ASTM A 690; with continuous interlocks.

1. Corners: Roll-formed corner shape with continuous interlock.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.

E. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

F. Reinforcing Bars: ASTM A 615, Grade 60, deformed.

G. Tiebacks: Steel bars, ASTM A 722.

H. Tiebacks: Steel strand, ASTM A 416.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that construction and finishing of other work is not impeded.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by IHS.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify IHS if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.7 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified in Section 31 2000 "Earth Moving."
3. Repair or replace, as approved by Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

END OF SECTION 31 5000

SECTION 31 6329

DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Dry-installed drilled piers.
   2. Slurry displacement-installed drilled piers.
   3. Dry-installed or slurry displacement-installed drilled piers at Contractor's choice.

B. Related Sections:
   1. Section 31 1000 "Site Clearing" for preparation of subgrade for drilled-pier operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface.

1.03 UNIT PRICES

A. Unit prices are included in Section 01 2200 "Unit Prices."

B. Drilled Piers: Actual net volume of drilled piers in place and approved. Actual length, shaft diameter, and bell diameter if applicable, may vary, to coincide with elevations where satisfactory bearing strata are encountered. These dimensions may also vary with actual bearing value of bearing strata determined by an independent testing and inspecting agency. Adjustments will be made on net variation of total quantities, based on design dimensions for shafts and bells.
   1. Base bids on indicated number of drilled piers and, for each pier, the design length from top elevation to bottom of shaft, extended through the bell, if applicable, and the diameter of shaft and bell.
   2. Unit prices include labor, materials, tools, equipment, and incidentals required for excavation, trimming, shoring, casings, dewatering, reinforcement, concrete fill, testing and inspecting, and other items for complete drilled-pier installation.

C. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed outside dimensions of drilled piers cast against rock. Unit prices for rock excavation include replacement with approved materials.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
   1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Shop Drawings: For concrete reinforcement detailing fabricating, bending, supporting, and placing.

D. Qualification Data: For qualified Installer and testing agency.

E. Welding certificates.

F. Material Certificates: For the following, from manufacturer:
   1. Cementitious materials.
   2. Admixtures.
   3. Steel reinforcement and accessories.

G. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
   1. Aggregates..

H. Field quality-control reports.

I. Other Informational Submittals:
   1. Record drawings.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in drilled-pier work.

B. Testing Agency Qualifications: Qualified according to ASTM C 1077, ASTM D 3740, and ASTM E 329 for testing indicated.

C. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.4, "Structural Welding Code - Reinforcing Steel."

D. Drilled-Pier Standard: Comply with ACI 336.1 unless modified in this Section.

1.06 PROJECT CONDITIONS

A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.
   1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.

B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
   1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of utility.
   2. Do not proceed with interruption of utility without Construction Manager's written permission.

C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.
   1. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
   2. The geotechnical report is included elsewhere in the Project Manual.

D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
   1. Record and maintain information pertinent to each drilled pier and cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.01 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

C. Plain-Steel Wire: ASTM A 82, as drawn.

D. Deformed-Steel Wire: ASTM A 496.

E. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain. Cut bars true to length with ends square and free of burrs.

2.02 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
   1. Portland Cement: ASTM C 150, Type I/II. Supplement with the following:
      a. Fly Ash: ASTM C 618, Class F or C.
      b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregate: ASTM C 33, graded, 3/4-inch- nominal maximum coarse-aggregate size. Provide aggregate from a single source with documented

service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 94/C 94M and potable.

D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
3. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
4. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

E. Sand-Cement Grout: Portland cement, ASTM C 150, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi, of consistency required for application.

2.03 STEEL CASINGS

A. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.

B. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.

C. Liners: Comply with ACI 336.1.

2.04 SLURRY

A. Slurry: Pulverized bentonite or polymers mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

2.05 CONCRETE MIXTURES

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

D. Proportion normal-weight concrete mixture as follows:
1. Compressive Strength (28 Days): 4000 psi.
2. Maximum Water-Cementitious Materials Ratio: 0.50.
3. Minimum Slump: Capable of maintaining the following slump until completion of placement:

a. 4 inches for dry, uncased, or permanent-cased drilling method.
b. 6 inches for temporary-casing drilling method.
c. 7 inches for slurry displacement method.

4. Air Content: Do not air entrain concrete.

2.06 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.07 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

3.02 EXCAVATION

A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
   1. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time will be authorized for removal of obstructions.
   2. Obstructions: Unclassified excavated materials may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. Payment for removing obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.

B. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:
   1. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
   2. Special excavation includes excavation that requires special equipment or procedures above or below indicated depth of drilled piers where drilled-pier

excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.

a. Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
b. Earth seams, rock fragments, and voids included in rock excavation area will be considered rock for full volume of shaft from initial contact with rock.

3. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.

C. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.

D. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
2. Remove water from excavated shafts before concreting.
3. Excavate rock sockets of dimensions indicated.
4. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.

E. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.
1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
2. Payment for additional authorized excavation will be according to Contract provisions for changes in the Work.

F. End-Bearing Drilled Piers: Probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.
1. Test first three drilled piers and one of every six drilled piers thereafter.
2. Fill augur-probe holes with grout.

G. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.

H. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.
1. Excavate and complete concreting of drilled pier on same day if possible, or redrill, clean, and test slurry in excavation before concreting.
2. Clean bottom of each shaft before concreting.

I. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
   1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete, or leave temporary casings in place.

J. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.
   1. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.

K. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.
   1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit design and construction proposals to Architect for review before proceeding.

3.03 PERMANENT STEEL CASINGS

A. Install steel casings of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.
   1. Install casings as excavation proceeds, to maintain sidewall stability.
   2. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.
   3. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
   4. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
   5. Fill annular void between casing and shaft wall with grout.

B. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.
   1. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.

3.04 STEEL REINFORCEMENT

A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.

C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.

D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.

E. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.

F. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

3.05 CONCRETE PLACEMENT

A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by Owner's independent testing and inspecting agency.
   1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete and insert joint dowel bars. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.

B. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
   1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
   2. Vibrate top 60 inches of concrete.

C. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no fewer than 60 inches into concrete and that flow of concrete is continuous from bottom to top of drilled pier.

D. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch head of concrete above bottom of casing.
   1. Vibrate top 60 inches of concrete after withdrawal of temporary casing.

E. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.

F. Protect concrete work, according to ACI 301, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.
   1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
   2. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.

G. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 to maintain delivered temperature of concrete at no more than 90 deg F.
   1. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.06 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Drilled piers.
   2. Excavation.
   3. Concrete.
   4. Steel reinforcement welding.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.
   1. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities will be determined by testing and inspecting agency. Final evaluations and approval of data will be determined by Architect.

D. Concrete Tests and Inspections: ASTM C 172 except modified for slump to comply with ASTM C 94/C 94M.
   1. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
   2. Concrete Temperature: ASTM C 1064**/**C 1064M; 1 test hourly when air temperature is 40 deg F and below and 80 deg F and above, and 1 test for each set of compressive-strength specimens.
   3. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
   4. Compressive-Strength Tests: ASTM C 39; one set for each drilled pier but not more than one set for each truck load. One specimen will be tested at 7 days, 2 specimens will be tested at 28 days, and 1 specimen will be retained in reserve for later testing if required.
   5. If frequency of testing will provide fewer than five strength tests for a given class of concrete, testing will be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   6. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
   7. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
   8. Report test results in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.

9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
10. Additional Tests: Testing and inspecting agency will make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.
    a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.
11. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

E. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports for each drilled pier as follows:
1. Actual top and bottom elevations.
2. Actual drilled-pier diameter at top, bottom, and bell.
3. Top of rock elevation.
4. Description of soil materials.
5. Description, location, and dimensions of obstructions.
6. Final top centerline location and deviations from requirements.
7. Variation of shaft from plumb.
8. Shaft excavating method.
9. Design and tested bearing capacity of bottom.
10. Depth of rock socket.
11. Levelness of bottom and adequacy of cleanout.
12. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
13. Ground-water conditions and water-infiltration rate, depth, and pumping.
14. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
15. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
16. Bell dimensions and variations from original design.
17. Date and time of starting and completing excavation.
18. Inspection report.
19. Condition of reinforcing steel and splices.
20. Position of reinforcing steel.
21. Concrete placing method, including elevation of consolidation and delays.
22. Elevation of concrete during removal of casings.
23. Locations of construction joints.
24. Concrete volume.
25. Concrete testing results.
26. Remarks, unusual conditions encountered, and deviations from requirements.

3.07 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION

SECTION 32 9200
TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Seeding.
2. Hydroseeding.
3. Sodding.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 REFERENCED STANDARDS

A. Latest version or edition shall apply unless otherwise noted.

1. Turfgrass Producers International (TPI)
   a. Guideline Specifications to Turfgrass Sodding.
2. Association of Official Seed Analysts, Inc. (AOSA)
   a. Rules for Testing Seeds.

1.4 DEFINITIONS

A. EPA: Environmental Protection Agency.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

E. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2-inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials. When not available on-site, Contractor shall be responsible for importing same from off-site locations. Contractor shall be responsible for amending soil with fertilizer and other amendments as required to produce a soil mixture best for plant growth.

F. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before Topsoil is placed.

1.5 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

B. Product Certificates: For fertilizers, from manufacturer.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Three (3) years' experience in turf installation.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Pesticide Applicator: Certified Applicator per the Oklahoma Agriculture Department, Food and Forestry.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Accompany each delivery of bulk materials with appropriate certificates.

1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:

1. Quality: State-certified seed of grass species as listed below for solar exposure.
2. Full Sun: Bermudagrass (*Cynodon dactylon*).
3. Sun and Partial Shade: Proportioned by weight as follows:
    a. 50 percent Kentucky bluegrass (*Poa pratensis*).
    b. 30 percent chewings red fescue (*Festuca rubra* variety).
    c. 10 percent perennial ryegrass (*Lolium perenne*).
    d. 10 percent redtop (*Agrostis alba*).
4. Shade: Proportioned by weight as follows:
    a. 50 percent chewings red fescue (*Festuca rubra* variety).

b. 35 percent rough bluegrass (*Poa trivialis*).

c. 15 percent redtop (*Agrostis alba*).

2.2 TURFGRASS SOD

A. Turfgrass Sod: Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Turfgrass Species: Bermudagrass (*Cynodon dactylon*).

2.3 FERTILIZERS

A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.4 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray if included in the scope of the project.
2. Protect grade stakes set by others until directed to remove them.

3.3 TURF AREA PREPARATION

A. General: Prepare planting area for Topsoil placement.

B. Placing Topsoil: Place Topsoil over exposed subgrade to a total depth of not less than 6-inches..

1. Reduce subgrade elevation in areas where sod has been specified in order to allow for soil thickness of sod in areas where sod has been specified.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Engineer's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5-mph.

1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

2. Do not use wet seed or seed that is moldy or otherwise damaged.

3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed according to the following rate schedule:

1. Bermudagrass (*Cynodon dactylon*): 2-lb/1000-sq.ft.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas from hot, dry weather or drying winds by applying Topsoil within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.5 HYDROSEEDING

A. Hydroseeding: Mix specified seed, slow-release fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Spray-apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.6 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across all disturbed areas as documented on the Construction Drawings.

2. Anchor sod on slopes exceeding 4:1 with steel staples spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.7 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll,

regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Where existing permanent irrigation is not available, or new permanent irrigation is not operational, install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4-inches. In the event that irrigation is not available from existing or new permanent irrigation systems, the cost of irrigation during establishment period shall be the responsibility of the Contractor.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water turf with fine spray at a minimum rate of 1-inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow Bermudagrass to a height of 1/2 to 1-inch.

D. Turf post-fertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that provides actual nitrogen of at least 1-lb/1000-sq.ft. to turf area.

3.8 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by the Engineer:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10-sq.ft. and bare spots not exceeding 5-in x 5-in.
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.9 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.10 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

3.11 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. Seeded Turf: 120-days from date of Substantial Completion.
2. Sodded Turf: 90-days from date of Substantial Completion.
3. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

END OF SECTION 32 9200

SECTION 33 4100
PRIVATE STORM SEWER

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes storm sewer piping and related components outside the building which are to be retained by the Owner as private improvements at the completion of the project.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Division 00 and Division 01 Sections, apply to this Section.

1.3 REFERENCED STANDARDS

A. Latest version or edition shall apply unless otherwise noted.

1. American Association of State Highway and Transportation Officials (AASHTO)
    a. M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.
    b. M294, Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter.
2. American Concrete Institute (ACI)
    a. 318, Building Code Requirements for Structural Concrete and Commentary.
3. American Concrete Pipe Association (ACPA)
    a. Concrete Pipe Installation Manual.
4. American Society of Testing and Materials (ASTM)
    a. A 48, Standard Specifications for Gray Iron Castings.
    b. C 76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
    c. C 443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gasket.
    d. C 890, Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
    e. C 891, Standard Practice for Installation of Underground Precast Concrete Utility Structures.
    f. C 913, Standard Specification for Precast Concrete Water and Wastewater Structures.
    g. C 923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Lateral.
    h. C 924,Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method.
    i. C 990, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
    j. C 1173, Standard Specification for Flexible Transition Couplings for Underground Piping System.
    k. C 1460, Standard Specification for Shielded Transition Couplings for Use With Dissimilar DWV Pipe and Fittings Above Ground.
    l. C 1479, Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations.
5. PVC Pipe Association

a. UNI-B-06, Recommended Low-Pressure Air Testing of Installed Sewer Pipe.

1.4 DEFINITIONS

A. ACI: American Concrete Institute.

B. AHJ: Authority Having Jurisdiction

C. ACPA: American Concrete Pipe Association.

D. Box Inlet: Square concrete structure with openings for collection of storm water at the top of one or more sidewalls. Inlet is typically provided with a concrete lid containing a standard manhole frame and lid.

E. CGMA: Corrugated Metal Pipe Arch

F. CGMP: Corrugated Metal Pipe

G. Combination Inlet: Storm water inlets which include both grates and curb hoods.

H. Crushed Rock Foundation: Aggregate layer placed beneath proposed storm sewer structures.

I. Grated Area Inlet: Storm water inlets which include grates only. When installed in paved areas, frame is typically cast into adjacent paving. When installed in non-paved areas, concrete apron is usually documented around perimeter of grate.

J. HDPP: High Density Polypropylene.

K. IPC: International Plumbing Code, version as adopted by AHJ.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product used in completion of the scope of work.

B. Shop Drawings: for all pre-cast concrete or PVC structures used in the completion of the scope of work.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle pre-cast storm sewer structures according to manufacturer's written rigging instructions.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner's written permission.
3. Do not proceed with interruption of service without Utility Owner’s written permission.

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: for concrete reinforcement and dowel bars used in the work.

1. Billet Steel: Grade 40 per AASHTO M 31.

2. Axle Steel: Grade 40 per AASHTO M 53.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

C. Zinc Repair Material: ASTM A 780.

2.3 CONCRETE MATERIALS

A. Portland cement: Shall conform to the requirements of AASHTO M 85 or AASHTO M 240. Type I, Type I (SM), Type I (PM), and Type IP shall be used in concrete for general concrete construction. Type II shall be used in concrete exposed to moderate sulphate action or moderate heat of hydration. Type III may be used when high early strength concrete is required. Unless otherwise approved by the Engineer, the product of only one mill of any one brand and type of portland cement shall be used on any structure or adjacent structures. Provide suitable means of storing and protecting the cement against dampness.

1. Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used. All methods of sampling and testing shall be in accordance with the requirements of AASHTO M 85 or AASHTO M 240.

B. Water: All water used in mixing or curing Portland cement concrete or cement treated base shall be clean and practically free from oil, salt, acid, alkali, organic matter, or other substances injurious to the finished product. Water from city water supply may be accepted without being tested. Water from doubtful sources shall not be used until tested and approved. When required by the Engineer, the quality of the mixing water shall be determined in accordance with AASHTO T 26. When tests are made comparing the water with water of known satisfactory quality, any indication of unsoundness, marked change in time of set, or reduction in mortar strength shall be sufficient cause for rejection of the water under test

C. Fine Aggregate: This specifications cover the quality and size of fine aggregates for Portland cement concrete pavements or bases, and incidental structures. Mortar sand shall meet the requirements of AASHTO M 45.

1. General Requirements. Fine aggregate shall consist of natural sand, or, subject to approval, combinations of manufactured sand and natural sand, having hard, strong, durable particles, and it shall conform to these Specifications. Mix and store fine aggregate from different sources in separate stockpiles; in addition, do not use them alternately in the same class of construction or mix without permission from the Engineer or as provided herein for manufactured sand. When manufactured sand is approved for use in combination with natural sand, at least 50 percent of the total fine aggregate by mass shall be natural sand. Store and batch the two materials separately. Each of the materials shall conform to the requirements of these Specifications, except that the mortar strength test shall be made on the blend of materials proposed for use.

2. Deleterious Substances. The amount of deleterious substances shall not exceed the following limits: Clay lumps and friable particles 3%, Coal and Lignite 0.25%

3. Organic Impurities. All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test as specified below. Should the aggregate show a darker color than that of samples originally approved for the work, its use shall be withheld until tests satisfactory

to the Engineer have been made to determine whether the increased color is indicative of an injurious amount of deleterious substances. NOTE: A fine aggregate failing in the test may be used provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 and 28 days calculated in accordance with Section 10 of AASHTO T 71 is not less than 95 percent.

4. Gradation. Fine aggregate shall be well graded from coarse to fine, and when tested by means of laboratory sieves. Gradation shall meet the following requirements:
    a. Sieve size: 3/8-in, percent passing: 100%.
    b. Sieve size: No. 4, percent passing 95-100%.
    c. Sieve size: No. 8, percent passing 80-100%.
    d. Sieve size: No. 16, percent passing 50-85%.
    e. Sieve size: No. 30, percent passing 25-60%.
    f. Sieve size: No. 50, percent passing 5-30%.
    g. Sieve size: No. 100, percent passing 0-10%.
5. The gradation requirements given above represent the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity, determine a fineness modulus (See Note). Determination shall be made from a representative sample obtained by the Engineer from the Contractor' s proposed source.
    a. Fine aggregates will be rejected from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample.
    b. NOTE: The fineness modulus of an aggregate is determined by adding the total percentages of material in the sample that are coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100; No. 100 (150 µm), No. 50 (300 µm), No. 30 (600 µm), No. 16(1.18 mm), No. 8 (2.36 mm), No. 4 (4.75 mm), 3/8 inch (9.5 mm), 3/4 inch (19.0 mm), 1 1/2 inch (37.5mm), and larger increasing at the ratio of 2 to 1.
6. Methods of Sampling and Testing. Sampling and testing of fine aggregate shall be in accordance with the following AASHTO Methods:
    a. Sampling T 2
    b. Friable particles T 112
    c. Coal and lignite T 113
    d. Amount of passing a No. 200 sieve T 11
    e. Organic impurities T 21
    f. Mortar-making properties T 71
    a. Sieve analysis T 27

D. Coarse Aggregate: This specification covers the quality and size of coarse aggregate for use in portland cement concrete pavements or bases and incidental structures.

1. General Requirements. Coarse aggregate shall be a gravel or crushed stone which shall conform to the requirements of AASHTO M 80, Class A, except as modified by these Specifications. Coarse aggregate shall produce Class A concrete with a durability factor of 50 or more. The durability factor will be determined after 350 cycles of alternate freezing and thawing in accordance with AASHTO T 161, Procedure A. The Los Angeles Abrasion percent wear shall be limited to a maximum of 40 percent after 500 revolutions when tested in accordance with AASHTO T 96. The sodium sulfate soundness requirement shall not apply. Use only coarse aggregate shall consisting of clean, tough, durable

particles, practically free from clay, shale, coatings of any character, disintegrated or soft pieces, conglomerates, mud balls, sticks, salt, alkali, or vegetable matter. Crushed stone or crushed gravel from different sources may be combined in the mix when stored and batched separately in recommended proportions, upon written permission of the Engineer. At least 70 percent of all aggregate retained on the No. 4 (4.75 mm) sieve in the combined mix shall be crushed stone or mechanically crushed gravel having two or more fractured faces and shall contain not more than 15 percent of flat and elongated pieces. (A flat and elongated piece is one in which the length is greater than five times the average thickness).

2. Gradation. The coarse aggregate shall be well graded as follows:
   a. No. 357:
      1) Sieve size 2-1/2-in., percent passing 100%.
      2) Sieve size 2-in., percent passing 95-100%.
      3) Sieve size 1-in., percent passing 35-70%.
      4) Sieve size 1/2-in., percent passing 10-30%.
      5) Sieve size No. 4, percent passing 0-5%.
      6) Sieve size No. 200, percent passing 0-1.5%.
   b. No. 57
      1) Sieve size 1-1/2-in., percent passing 100%.
      2) Sieve size 1-in., percent passing 95-100%.
      3) Sieve size 1/2-in., percent passing 25-60%.
      4) Sieve size No. 4, percent passing 0-10%.
      5) Sieve size No. 8, percent passing 0-5%.
      6) Sieve size No. 200, percent passing 0-2%.
   c. No. 67
      1) Sieve size 1-in., percent passing 100%.
      2) Sieve size 3/4-in., percent passing 90-100%.
      3) Sieve size 3/8-in., percent passing 20-55%.
      4) Sieve size No. 4, percent passing 0-10%.
      5) Sieve size No. 8, percent passing 0-5%.
      6) Sieve size No. 200, percent passing 0-2%.
   d. No. 7
      1) Sieve size 3/4-in., percent passing 100%.
      2) Sieve size 1/2-in., percent passing 90-100%.
      3) Sieve size 3/8-in., percent passing 40-70%.
      4) Sieve size No. 4, percent passing 0-15%.
      5) Sieve size No. 8, percent passing 0-5%.
      6) Sieve size No. 200, percent passing 0-2%.
   e. No. 8
      1) Sieve size 1/2-in., percent passing 100%.
      2) Sieve size 3/8-in., percent passing 85-100%.
      3) Sieve size No. 4, percent passing 10-30%.
      4) Sieve size No. 8, percent passing 0-10%.

5) Sieve size No. 16, percent passing 0-5%.

6) Sieve size No. 200, percent passing 0-2%.

3. Furnish coarse aggregate for Class A concrete in the No. 57 size only except as noted below

4. Furnish coarse aggregate for massive Class A concrete in the No. 357 size.

5. Furnish coarse aggregate for thin section concrete in the No. 7 size.

2.4 CONCRETE MIXTURES

A. Prepare design mixtures, for each class of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Class A

a. Compressive Strength (28 Days):

1) 3,500-psi for rigid vehicular pavements.

2) 3,000-psi for all other civil improvements.

b. Maximum Cement Content: 564-lb/yd^3

c. Minimum 28-day Air Content: 6% $\pm$ 1.5%

d. Water-Cement Ratio at Point of Placement: 0.48.

e. Slump Limit: 2 inches, plus or minus 1 inch.

C. Cementitious Materials: Use fly ash, ground granulated blast-furnace slag, as needed to reduce the total amount of portland cement which would otherwise be used. Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. November through March: Fly ash meeting the requirements of this section may be substituted for up to 15% of the required cement. Ground granulated blast furnace slag meeting the requirements of AASHTO M 302 Grade 100 or Grade 120 may be substituted for up to 25% of the required cement. A combination of up to 25% ground granulated blast furnace slag and up to 15% fly ash may be substituted for up to 40% of the required cement.

2. April through October: A combination of up to 25% ground granulated blast furnace slag and up to 20% fly ash may be substituted for up to 45% of the required cement.

3. Substitution shall be by weight: 1.0 pound (1 kg) for each 1.0 pound (1 kg) of cement. The concrete mix design shall be appropriately adjusted. These substitutions will not be allowed for high early strength concrete, Class P concrete or concrete containing Type IP, Type I (PM), or Type I (SM) cement. If the specified minimum cement content is satisfied, additional fly ash or ground granulated blast furnace slag, or silica fume complying with ASTM C 1240, may be added to the mix when approved as part of the mix design.

D. Water Cement Ratio. Using the weight in pounds of each material, calculate the water-cement ratio (W/C) by the following equation: W/C = Water/ (Cement + Fly Ash + Blast Furnace Slag + Silica Fume) The water actually used is determined by the water measured into the batch plus the free water on wet aggregate minus the water absorbed by dry aggregate plus water in any admixture solutions and shall not exceed the limit specified.

E. Slump. The slump shall be as shown, or as specified in the contract documents, or as approved by the Engineer, and the consistency required shall be that which will provide satisfactory workability for the type work being done. Slump tests will be made during the progress of the

work as a measure of uniformity of the consistency of the concrete. If using a high-range water reducing admixture, limit the slump to a maximum of 9 inches (230 mm).

F. Compressive Strength. Compressive strength is based on the average of three test cylinders. When the class of concrete is not expressly indicated on the Plans, the following requirements shall govern:

1. Class AA. Use Class AA concrete in superstructure items, such as bridge floors, approach slabs, reinforced concrete piles, drilled shaft foundations, parapet walls, concrete rail and handrails.
2. Class A. Use Class A concrete for pavements and in substructures items, such as pier caps, columns, abutments, retaining walls, box culverts, and all reinforced concrete not requiring Class AA concrete.
3. Class AP. Use Class AP concrete in shoulders, merge areas and gore areas for PCC pavements, unless otherwise directed by plan notes.
4. Class C. Use Class C concrete for soil erosion control structures.

2.5 CONCRETE MIXING

A. Base the mix design on absolute volume for the class of concrete specified and the consistency suitable for satisfactory placement of the concrete. Design and produce concrete mixtures that conform to the Class of Concrete in this section and base the mix design on absolute volume. Proportion the coarse and fine aggregate in accordance with ACI 211.1. Use the least amount of sand and mixing water which will ensure concrete of the required workability for placement conditions. Meet the minimum strength within 72 hours of placement for high early strength concrete. Submit the mix design at least 14 days before production to the Engineer. Include at least the following information with each mix design:

1. Project identification
2. Name and address of contractor and producer
3. Mix design designation
4. Intended use of the mix design
5. Expected travel time from batch to placement
6. If the concrete will be pumped or not
7. Aggregate sources, gradation, moisture content, saturated surface dry batch mass, LA abrasion (AASHTO T 96), and freeze thaw durability (AASHTO T 103).
8. Fineness modulus of fine aggregate.
9. Cement type and source
10. Type of cement replacement, if used, and source
11. Type of admixtures and sources
12. Material proportions
13. Air content
14. Slump
15. Water / cement ratio
16. Strengths at 7 and 28 days
17. Strengths at 72 hours for high early strength concrete.

B. Do not place any concrete until the mix design is approved. Submit new mix designs if the mix design is rejected by the Engineer, the source of any material changes, or the mix design produces unacceptable workability or production test results.

2.6 STEEL REINFORCEMENT

A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

2.7 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subgrade or aggregate base surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement dowels and joint devices.

G. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.

2. Do not use frozen materials or materials containing ice or snow.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents

H. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete.

4. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

2.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing

operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture-retaining-cover curing as follows:

1. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.

2.9 SOIL MATERIALS

A. Crushed Rock Foundation: Uniformly graded crusher run material without rounded faces. Gradation shall be as follows:

1. Sieve size: 2-in, percent passing: 100%.
2. Sieve size: ½-in, percent passing less than 30%.

2.10 PRIVATE STORM SEWER AND FITTINGS

A. Dual Wall HDPP: Advanced Drainage Systems (ADS) High Performance Storm approved equal. Pipe shall meet the requirements of ASTM F2881.

1. JOINT PERFORMANCE Pipe shall be joined with a gasketed integral bell & spigot joint meeting the requirements of ASTM F2881. 12 through 60-in shall be watertight according to the requirements of ASTM D3212. Spigots shall have gaskets meeting the requirements of ASTM F477. Gasket shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during joint assembly. Pipe shall have an exterior bell wrap installed by the manufacturer.
2. Fittings: Conform to ASTM F2881 and AASHTO M330. Bell and spigot connections shall utilize a spun–on, welded or integral bell and spigots with gaskets meeting ASTM F477. Bell & spigot fittings joint shall meet the watertight joint performance requirements of ASTM D3212. Corrugated couplings shall be split collar, engaging at least 2 full corrugations.

2.11 PRIVATE STORM SEWER STRUCTURES

A. Meeting Construction Drawing requirements in regards to location, dimensions, depth, invert elevation(s), weir elevation(s), grate elevation, rim elevation, and/or top of curb elevation. Material of construction shall be as indicated on the Construction Drawings and shall generally be pre-cast concrete or cast-in-place concrete.

B. Material Substitutions: subject to review and approval of the Engineer and the following schedule:

1. Permitted substitutions:
   a. Pre-cast concrete for cast-in-place concrete
2. Prohibited substitutions:
   a. PVC for masonry, pre-cast concrete, or cast-in-place concrete
   b. Masonry for pre-cast concrete or cast-in-place concrete.

C. Cast-in-place concrete structures:

1. Concrete: Class A.
2. Reinforcement: of the size, length, and configuration indicated on the Construction Drawings. Reinforcing steel shall be billet or axle steel.

D. Pre-cast structures: Pre-cast manhole structures shall meet the requirements of ASTM C478. All other pre-cast concrete structures shall meet the requirements of ASTM C913. All pre-cast

structures shall be designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading.

1. Joint Sealants: ASTM C 990, bitumen or butyl rubber.
2. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

E. Frames, Covers, and Grates: ASTM A 48, Class B, Grade U-60-60, designed for A-16 (AASHTO HS20-44) structural loading. Manufacturers and models shall be per the following schedule, substitutions subject to review and approval of the engineer:

1. Manhole Frame and Cover: Deeter Foundry, Product No. 1159.

PART 3 - EXECUTION

3.1 EARTHWORK

A. All excavation, trenching, and backfilling shall be completed as indicated on the Construction Drawings. Contractor is responsible for protecting items to remain for the duration of the project as well as adjacent, off-site features. The following additional standards shall also apply:

1. Private Dual Wall HDPE Installations: per requirements of ASTM D2321 and pipe manufacturer requirements.

3.2 PRIVATE STORM SEWER PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use trenchless methods as indicated on the Construction Drawings.

3.3 PRIVATE STORM STRUCTURE INSTALLATION

A. Cast-in-Place Concrete Structures: Complete construction per requirements of ACI 318.

B. Pre-Cast Structures: Install structure per requirements of ASTM C891.

3.4 IDENTIFICATION

A. Materials and their installation are specified in Section 31 2000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.5 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:
    a. Alignment: Less than full diameter of inside of pipe is visible between structures.

b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.

c. Damage: Crushed, broken, cracked, or otherwise damaged piping.

d. Infiltration: Water leakage into piping.

e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.

4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.

2. Test completed piping systems according to requirements of Service Provider.

3. Schedule tests and inspections by Service Provider with at least 24 hours' advance notice.

4. Submit separate report for each test.

5. Gravity-Flow Storm Drainage Piping: Test according to requirements of Service Provider, UNI-B-6, and the following:

a. Test concrete piping according to ASTM C 924.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.6 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION **33 4100**