GEOTECHNICAL ENGINEERING SERVICES REPORT

EAST CENTRAL UNIVERSITY (ECU) SLOPE FAILURE PROPOSED RETAINING WALL SOUTHWEST OF THE INTERSECTION OF S. STADIUM DRIVE AND E. 10TH STREET ADA, OKLAHOMA

Prepared For:
East Central University

Prepared By:
EST, Inc.

Approved by:

Bryce R. Hanlon, P.E.
Geotechnical Engineer

EST PROJECT NUMBER
6010092

May 19, 2020

Comprehensive Engineering Services

615 N. Hudson, Ste. 300
Oklahoma City, Oklahoma 73102
P (405) 815.3600
CA #: 3639, Ren. Date 06/30/2020

May 19, 2020

East Central University
200 S. Stadium Drive
Ada, Oklahoma 74820

Attn: Mr. Jerry Branscum

RE: Geotechnical Engineering Services Report
East Central University (ECU) Slope Failure – Proposed Retaining Wall
Southwest of the Intersection of S. Stadium Drive and E. 10th Street
Ada, Oklahoma
EST Project Number: 6010092

Dear Mr. Branscum:

EST has completed the geotechnical investigation for the proposed retaining wall to be constructed to repair the existing slope failure located southwest of the intersection of S. Stadium Drive and E. 10th Street within the ECU campus in Ada, Oklahoma.

Project Information and Existing Site Conditions

The project consists of constructing a new retaining wall to repair the existing slope failure that has occurred southwest of the intersection of S. Stadium Drive and E. 10th Street within the ECU campus in Ada, Oklahoma. The purpose of this subsurface exploration was to investigate the groundwater, soil, and bedrock conditions at the site within the existing slope failure, and provide soil design parameters and recommendations to be used for the design of the proposed retaining wall. The following photographs show the condition of the project slop failure prior to our fieldwork:

Photograph #1: ECU Slope Failure

Photograph #2: ECU Slope Failure

Photograph #3: ECU Slope Failure

We understand the proposed retaining wall is expected to be constructed approximately 12 feet from the existing sidewalk, and will be used to step down and flatten the slope leading to the roadway (S. Stadium Drive), the drainage system behind the wall will be used to redirect the persistent groundwater around the slope failure area.

Subsurface Conditions

Exploration of the subsurface materials at the project site consisted of three (3) borings advanced within the existing slope failure area to depths ranging from approximately 30 to 35 feet below the existing ground surface elevation. In order for us to access these hole locations, ECU constructed level pads for us to drill on. Samples obtained from these borings were brought to our laboratory for further processing and/or testing. The presence of groundwater was observed in borings (B-2 and B-3) during drilling operations at depths ranging from 9.5 to 11.5 feet below the existing ground surface. Groundwater was not encountered in boring B-1 during or 24 hours after drilling the boring. The groundwater in boring B-2 rose from 11.5 feet to 2.5 feet in the boring after 24 hours, showing the flowing groundwater is entering the slope at the center of the failure. The final boring logs along with a diagram showing the approximate locations of the borings are included as attachments to this letter.

Visual classification indicates the subsurface materials generally consist of very soft to soft silty clay (fill material), over stiff lean clay, over very stiff to very hard shaley lean clay, over gray weathered shale bedrock. Bedrock was encountered in all of the borings at the depths and elevations shown in Table I:

TABLE I – BEDROCK INFORMATION

Boring Location	Surface Elevation (feet)	Depth to Bedrock (feet)	Bedrock Elevation (feet)	Bedrock Type
B-1	1015.9	24.0	991.9	Gray, Weathered Shale
B-2	1016.5	24.5	992.0	Gray, Weathered Shale
B-3	1015.2	29.0	986.2	Gray, Weathered Shale

Groundwater

Groundwater was encountered in two of the borings during drilling operations, B-2 and B-3, depths ranging from 9.5 to 11.5 feet below the existing ground surface. Borings B-1 and B-2 were left open to collect 24 hour (stabilized) water level readings. The results of the groundwater elevation readings are provided in Table II:

TABLE II – GROUNDWATER INFORMATION

Boring Location	Initial Water Level (04/21/20) (Feet)	24 Hour Water Level (04/22/2020) (Feet)
B-1	None - Dry	None - Dry
B-2	11.5	2.5
B-3	9.5	N/A

Based on the observed water level readings, boring location B-1 (north side of failure) does not have any groundwater. At boring location B-2, the groundwater level in the boring rose from 11.5 feet to 2.5 feet below the existing ground surface. This indicates that groundwater is flowing into this area, which is evident by the persistent failure of the slope.

It should be noted that groundwater level fluctuations may occur due to seasonal variations in the amount of rainfall and other factors such as drainage and soil characteristics.

Proposed Retaining Wall Design Recommendations and Parameters

The lateral forces on retaining walls depend upon the walls ability to rotate, the type and density of backfill material behind the walls, the inclination of the backfill behind the wall, and the influence of surface loads imposed behind the walls. We recommend using a free draining granular material behind the proposed wall. For the design process, assume a soil friction angle of 30 degrees and a unit weight of 120 pcf for the granular backfill. To account for the groundwater fluctuations and the fact that hydrostatic forces could potentially develop, we recommend all walls be designed to resist the at-rest forces generated from saturated materials. Assuming the wall is constructed with horizontal and granular backfill we recommend using an equivalent fluid pressure of 60 psf/foot of depth to represent the at-rest pressure conditions and 40 psf/foot of depth for the active condition of granular structured materials. The equivalent fluid pressures/ lateral earth pressures provided have no safety factors.

At the time of this report the design bearing elevation for the proposed retaining wall had not yet been provided. For the design of the foundation for the proposed retaining wall, we recommend using the provided design parameters in Table III based on the varying potential bearing elevations. It is recommended that proposed retaining wall foundation system bear at a minimum of 5 feet below the existing roadway elevation. This puts the minimum bearing depth at an approximate elevation of 1,000 feet. This would put the foundation system bearing within the hard, gray, shaley lean clay layer. The preferred foundation system was not provided to us, however we believe both a shallow footing foundation and drilled pier foundations would both be potentially adequate for design.

TABLE III – SOIL PARAMETERS FOR FOUNDATION DESIGN

Bearing Elevation Range (feet)	Bearing Material	Unit Weight (pcf)	Net Allowable Bearing Capacity (psf)	Ultimate Passive Earth Pressure (psf/foot)	Coefficient of Sliding Friction
1000 - 992	Hard, Gray, Shaley Lean Clay	130.0	5,000	3,000	0.4
992 - 980	Moderately Hard, Gray, Weathered Shale (Bedrock)	135.0	9,500	6,000	0.5

This bearing pressure is the pressure that can be applied to the soil at the bottom of the foundation system in excess of the minimum surrounding overburden pressure.

Because of the existing problem with groundwater infiltration, to help prevent hydrostatic loading on the walls, a perforated, rigid plastic or metal drain line should be installed at the base of the walls. The drain line should be sloped to provide positive gravity drainage to a suitable collection point. To prevent the intrusion of fines into the drain system, the drain line should be surrounded by at least 6 inches of clean, well-graded crushed aggregate encapsulated with a suitable filter fabric. A class 2 non-woven geotextile with a maximum apparent opening size (AOS) of 0.25 should be used. Free draining granular fill should be used to backfill above the drains and should extend behind the walls a minimum width of 24 inches. The upper 2 feet of backfill placed adjacent to the walls should consist of an approved, compacted, low volume change cohesive soil to reduce surface water infiltration. A procedure should be used to discharge water from the outlet point, which would not allow reverse flow into the drain system.

General

This report was prepared for East Central University in reference to the proposed retaining wall to be constructed to repair the existing slope failure located southwest of the intersection of S. Stadium Drive and E. 10th Street within the ECU campus in Ada, Oklahoma.. This report provides geotechnical recommendations based on the subsurface conditions encountered in the borings. Subsurface conditions may vary between borings. However, EST warrants that the findings contained herein have been made with generally accepted professional geotechnical practices in the local area. No other warranties are implied or expressed.

Mr. Branscum, we appreciate the opportunity to work with you on this project. If you have any questions regarding the information contained in this report or if we can be of further assistance, please call us at (405) 815-3600.

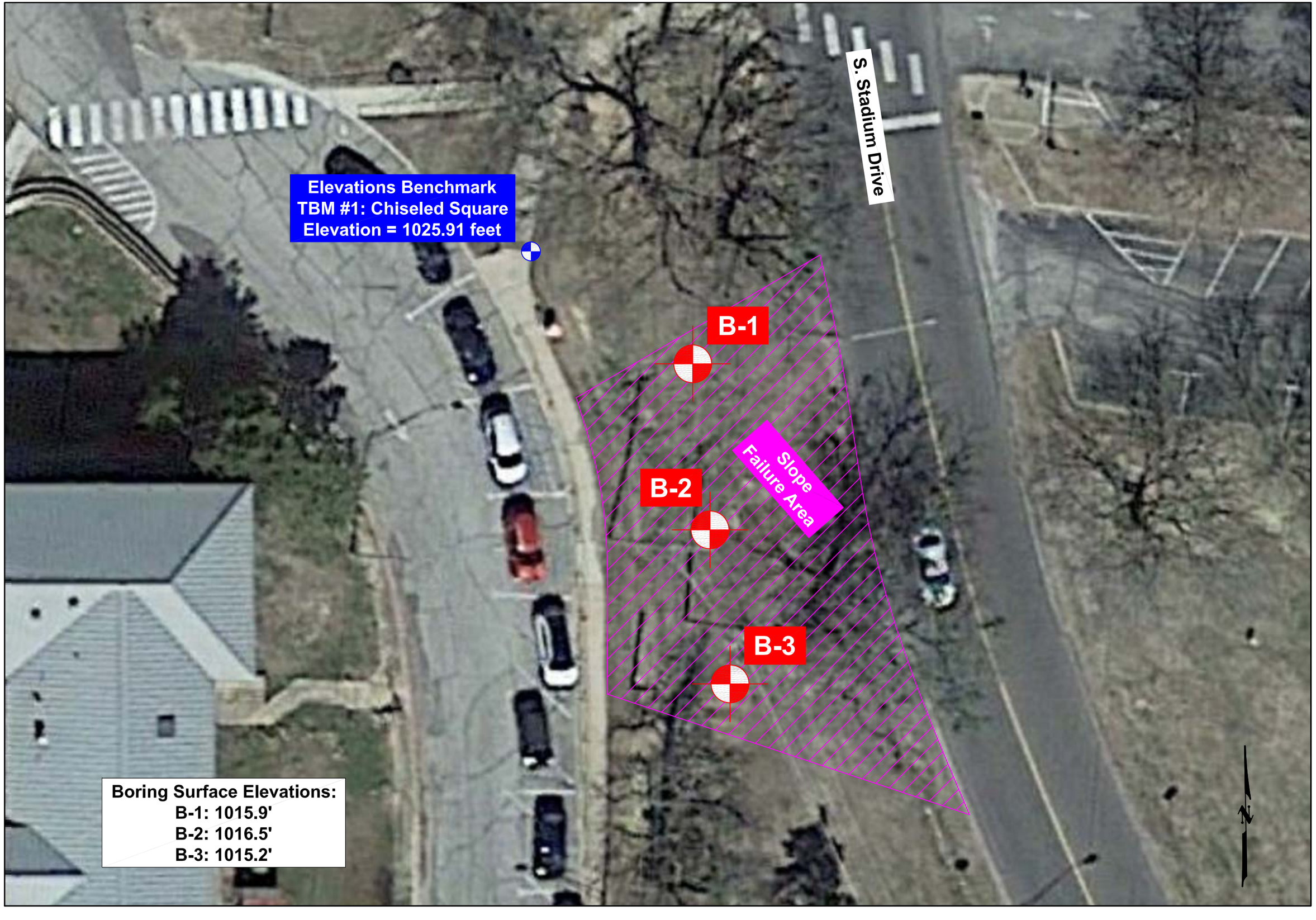
Respectfully,
EST, Inc.

Bryce R. Hanlon, P.E.
Geotechnical Engineer

Attachments: 1. Approximate Boring Location Diagram
2. Boring Logs (3)
3. General Notes, Boring Log Acronym Library, General Notes for Rock Classification

Attachment 1

Approximate Boring Location Diagram



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EXP. DATE 06/30/2020

EAST CENTRAL UNIVERSITY (ECU) SLOPE FAILURE
S. STADIUM DRIVE AND E. 10TH STREET
ADA, OKLAHOMA
APPROXIMATE BORING LOCATION DIAGRAM

DATE
05/19/2020
SCALE
NOT TO SCALE
PROJECT NUMBER
6010092

Attachment 2

Boring Logs

BORING LOG

BORING NO. B-1

CLIENT: East Central University

ENGINEER: EST, Inc.

LOCATION: S. Stadium Drive and E. 10th Street, Ada, Oklahoma

PROJECT: East Central University (ECU) Slope Failure

GRAPHICS LOG	LAYER / MATERIAL DESCRIPTION	DEPTH, FT.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, IN.	SAMPLES SPT- N BLOWS / FT.	TESTS MOISTURE, %	TESTS DRY DENSITY, PCF	TESTS UNCONFINED STRENGTH, PSF	TESTS LIMITS (LL) (PL) INDEXES (PI) #200 SIEVE
	Surface Elev. = 1015.9 feet Vegetation Thickness : N/A										
	Very Soft to Soft, Red-Brown, Silty Clay				HS						
		5		1	SS	18	2				
	El. = 1008.9				HS						
	Stiff, Gray, Lean Clay			2	SS	18	17				
		10			HS						
	El. = 1002.9			3	SS	18	34				
	Hard, Gray, Lean Clay (Shaley)	15			HS						
				4	SS	18	34				
		20			HS						
	El. = 991.9			5	SS	12	23/6.0"				
	Moderately Hard, Gray, Weathered Shale (Bedrock)	25		1	TCP		50/6.0" 50/4.0" 50/3.5"				
					RB						
	El. = 986	30		2	TCP		50/2.5" 50/2.3"				
	Bottom of Boring at 29.9 feet										
		35									
		40									

REMARKS: SOIL AND ROCK CLASSIFICATIONS ARE FROM DISTURBED SAMPLES. CORE SAMPLES AND FURTHER LABORATORY TESTING MAY REVEAL OTHER ROCK AND/OR SOIL TYPES. THE STRATIFICATION SHOWN IN THE SOIL AND ROCK ABOVE IS AN ESTIMATION OF IN-SITU CONDITIONS. THEREFORE, THE NATURAL TRANSITION BETWEEN SOIL AND ROCK TYPES MAY BE GRADUAL.

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WATER LEVEL OBSERVATIONS			BORING STARTED	4/21/20	
WL	▽ None-WD	▼	BORING COMPLETED	4/21/20	
WL	▼ None-24 Hrs. AB		RIG CME-55	FOREMAN A.K.	
WL			APPROVED B.R.H.	JOB# 6010092	

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BORING LOG

BORING NO. B-2

CLIENT: East Central University

ENGINEER: EST, Inc.

LOCATION: S. Stadium Drive and E. 10th Street, Ada, Oklahoma

PROJECT: East Central University (ECU) Slope Failure

GRAPHICS LOG	LAYER / MATERIAL DESCRIPTION	DEPTH, FT.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, IN.	SAMPLES SPT- N BLOWS / FT.	TESTS MOISTURE, %	TESTS DRY DENSITY, PCF	TESTS UNCONFINED STRENGTH, PSF	TESTS LIMITS (LL) (PL) INDEXES (PI) #200 SIEVE
	Surface Elev. = 1016.5 feet Vegetation Thickness : N/A										
	Very Soft to Soft, Red-Brown, Silty Clay				HS						
				1	SS	18	2				
		5			HS						
	El. = 1009.5										
	Stiff, Gray, Lean Clay			2	SS	18	11				
		10			HS						
	El. = 1005										
	Very Stiff to Hard, Gray, Lean Clay (Shaley)			3	SS	18	24				
		15			HS						
				4	SS	18	35				
		20			HS						
	El. = 992										
				5	SS	18	10/6.0" 6/6.0"				
	Moderately Hard, Gray, Weathered Shale (Bedrock)	25		1	TCP		50/6.0"				
					RB		50/5.3" 50/3.5"				
	El. = 985.87	30		2	TCP		50/4.5" 50/3.0"				
	Bottom of Boring at 30.6 feet										
		35									
		40									

REMARKS: SOIL AND ROCK CLASSIFICATIONS ARE FROM DISTURBED SAMPLES. CORE SAMPLES AND FURTHER LABORATORY TESTING MAY REVEAL OTHER ROCK AND/OR SOIL TYPES. THE STRATIFICATION SHOWN IN THE SOIL AND ROCK ABOVE IS AN ESTIMATION OF IN-SITU CONDITIONS. THEREFORE, THE NATURAL TRANSITION BETWEEN SOIL AND ROCK TYPES MAY BE GRADUAL.

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WATER LEVEL OBSERVATIONS			BORING STARTED	4/21/20	
WL	▽ 11.5 Ft.-WD	▼	BORING COMPLETED	4/21/20	
WL	▼ 2.5 Ft.-24 Hrs AB		RIG CME-55	FOREMAN A.K.	
WL			APPROVED B.R.H.	JOB# 6010092	

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BORING LOG

BORING NO. B-3

CLIENT: East Central University

ENGINEER: EST, Inc.

LOCATION: S. Stadium Drive and E. 10th Street, Ada, Oklahoma

PROJECT: East Central University (ECU) Slope Failure

GRAPHICS LOG	LAYER / MATERIAL DESCRIPTION	DEPTH, FT.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, IN.	SAMPLES SPT- N BLOWS / FT.	TESTS MOISTURE, %	TESTS DRY DENSITY, PCF	TESTS UNCONFINED STRENGTH, PSF	TESTS LIMITS (LL) (PL) INDEXES (PI) #200 SIEVE
	Surface Elev. = 1015.2 feet Vegetation Thickness : N/A										
	Very Soft to Soft, Red-Brown, Silty Clay				HS						
		5		1	SS	18	7				
	El. = 1008.2				HS						
	▽ Stiff, Gray, Lean Clay			2	SS	18	17				
	El. = 1003.7	10			HS						
				3	SS	18	31				
	Hard to Very Hard, Gray, Lean Clay (Shaley)	15			HS						
				4	SS	18	38				
		20			HS						
				5	SS	18	65				
		25			HS						
	El. = 986.2			6	SS	12	30/6.0"				
		30		1	TCP		50/6.0"				
	Moderately Hard, Gray, Weathered Shale (Bedrock)				RB		50/4.5" 50/3.8"				
	El. = 980.16	35		2	TCP		50/3.5" 50/3.0"				
	Bottom of Boring at 35.0 feet										
		40									

REMARKS: SOIL AND ROCK CLASSIFICATIONS ARE FROM DISTURBED SAMPLES. CORE SAMPLES AND FURTHER LABORATORY TESTING MAY REVEAL OTHER ROCK AND/OR SOIL TYPES. THE STRATIFICATION SHOWN IN THE SOIL AND ROCK ABOVE IS AN ESTIMATION OF IN-SITU CONDITIONS. THEREFORE, THE NATURAL TRANSITION BETWEEN SOIL AND ROCK TYPES MAY BE GRADUAL.

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WATER LEVEL OBSERVATIONS			BORING STARTED	4/21/20	
WL	▽ 9.5 Ft.-WD	▼	BORING COMPLETED	4/21/20	
WL	▼		RIG CME-55	FOREMAN A.K.	
WL			APPROVED B.R.H.	JOB# 6010092	

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Attachment 3

General Notes
Boring Log Acronym Library
General Notes for Rock Classification

GENERAL NOTES

Water levels measured in low permeability soils (clays & unfractured rock) may require long term observations and therefore, the depths shown may not be accurate.

Sample Classification and Descriptions

- Soil Classification: The soil description and classification is based on the Unified Soil Classification System (USCS) unless noted otherwise
- Description Modifier: Trace - material slightly present in sample, less than 15%
- Rock: Rock samples are described according to the "General Notes for Rock Classification"

Consistency of Fine-Grained Soils:

Qu, Unconfined Compressive Strength (psf)	SPT	Consistency
< 500	0-2	Very Soft
500 - 1,000	2-5	Soft
1,001 - 2,000	5-10	Medium
2,001 - 4,000	10-20	Stiff
4,001 - 8,000	20-30	Very Stiff
8,001 - 16,000	30-60	Hard
> 16,000	> 60	Very Hard

Relative Density of Coarse-Grained Soils:

N-Blows/ft.	Relative Density
0-4	Very Loose
5-10	Loose
11-24	Medium Dense
25-50	Dense
51-80	Very Dense
80+	Extremely Dense

Grain Size Terminology:

Major Component of Sample	Size Range
Boulders	Over 12 in. (305mm)
Cobbles	12 in. to 3 in. (300mm to 76mm)
Gravel	3 in. to #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 sieve (0.075mm)

BORING LOG ACRONYM LIBRARY

Boring Log Symbol Library

- SPT-N: Blow or strike count for the Standard Penetration Test or the Texas Cone Penetrometer Test. In general, the Standard Penetration Test "N" is the numbers of strikes required to advance a standard 2-inch outside diameter split-spoon a distance of 1-foot, or portion thereof, with a 140 pound hammer falling 30 inches. In general, the Texas Cone Penetrometer Test "N" is the numbers of strikes with penetration depths required to advance a solid steel three-inch diameter cone of standard dimensions with a170-pound weight falling 24-inches. Two 50 strike intervals or two 6-inch penetration intervals is recorded.
- WOH: Weight of Hammer
- WOR: Weight of Drilling Rod
- USCS Symbol: The Unified Soil Classification System Identification Symbol
- ATV: All-Terrain Vehicle Mounted Drill Rig
- EL: Elevation
- Lt: Left
- Rt: Right
- LL, PL, PI: Atterberg Limits (Liquid Limit, Plastic Limit, Plasticity Index)
- -#200: Percent Passing Standard No. 200 Sieve
- NP – Non Plastic

Drilling & Sampling Symbol Library

AS: Auger Sample
BS: Bucket Sample
DB: Diamond Drilling Bit (Truck Rotary Drilling using air or water to remove cuttings)
DCD: Diamond Core Barrel Drilling
HA: Hand Auger
HS: Hollow Stem Auger (Truck Rotary Drilling)
PA: Power Auger (Truck Rotary Drilling)
PM: Pressure Meter
RB: Rock Bit (Truck Rotary Drilling using air or water to remove cuttings)
RQD: Rock Quality Designation
SS: Standard Penetration Test (Split-Spoon): a $1^{3/8}$ inch I.D. and 2" O.D. tube, unless noted
ST: Thin-Wall Tube Sample (Shelby Tube): a 3" O.D. tube, unless noted otherwise
TCP: Texas Cone Penetrometer Test
WS: Wash Sample
WB: Wash Bore

Water Level Symbol Library

AB: After Boring Complete
DCI: Dry Cave In
WCI: Wet Cave In
WD: While Drilling
WL: Water Level Depth From Boring Surface Elevation
WS: While Sampling

GENERAL NOTES FOR ROCK CLASSIFICATION

Igneous Rock

Igneous rock is formed from the cooling process of molten material (magna) beneath the earth's surface (plutonic or intrusive rock) or from the rapid cooling at or near the earth's surface (volcanic or extrusive rock). The rate of cooling, mineral composition, and mode of deposition control the type, texture, and shape of Igneous rocks. However, the most common Igneous rocks are:

- Granite: Intrusive rock; very hard; generally coarse-grained; usually light colored (pink, red or gray); typically lighter weight than most rocks (specific gravity = 2.6); and for the most part composed of Quartz, Feldspar, and some dark minerals, usually Mica, crystalline texture; usually even-grained or grains are equal in size.
- Basalt: Extrusive rock; very hard; generally fine-grained; usually dark colored (green, gray, or black); typically heavier weight than most rocks (specific gravity = 2.9); and has a glassy texture.

Sedimentary Rock

Sedimentary rock is formed from the deposition of material (previous rock fragments, soil and minerals) by erosion or precipitation. The loose deposited material slowly hardens and develops into rock from the processes of compaction, cementation, and/or recrystallization. Sedimentary rocks are composted of cemented boulders, cobbles, gravels, sands, silts and clay size particles. The most common minerals composing Sedimentary rock are quartz, kaolinite, feldspar, mica, and iron oxides, together with those precipitated from solution such as carbonates (dolomite, calcite, and siderite) and the sulfates gypsum and anhydrite. The most common Sedimentary rocks are:

- Limestone: White to light gray or bluish-gray in color; crystalline to fine-grained texture; varies in hardness from soft to very hard; chiefly composed of calcium carbonate which will effervesce upon contact with dilute hydrochloric acid.
- Dolomite: Very similar to limestone. Usually harder than limestone and usually does not effervesce upon contact with dilute hydrochloric acid. However, will effervesce upon contact with dilute hydrochloric acid if in powered state.
- Shale: Light to dark colored; very fine-grained texture; composed of consolidated clay or silt; bedded in thin layers.
- Siltstone: Very similar to shale, but unlaminated. Usually more cemented and less cohesive to non-cohesive.
- Sandstone: Commonly light colored; coarse to fine-grained texture; composed of cemented sand size particles.
- Conglomerate: Varies in color; composed of boulder size material to silt, generally sand to cobble size; cemented together with various cementing agents.
- Chert: Light to dark colored; very fined-grained texture; common constituent of conglomerates; breaks conchoidally or into angular fragments; will scratch glass.

Degree of Weathering

- Slight: Noted predominantly by color change with no disintegrated zones. May have slight decomposition of parent material at joints.
- Moderate: Noted by color change throughout and some decomposition.
- High: Noted by complete color change throughout, highly decomposed, may be extremely broken, general appearance approaching soil.