GEOLOGIC EXPLORATION
AMERICAN TOWER SITE ID 306035
UNITY VILLAGE MO 2
LEE'S SUMMIT, MISSOURI

Prepared for:

FDH VELOCITEL
Raleigh, North Carolina

Prepared by:

GEOTECHNOLOGY, INC.
Overland Park, Kansas

Geotechnology Job No. J029737.02

May 19, 2017

GEOTECHNOLOGY INC
FROM THE GROUND UP

May 19, 2017 J029737.02

Mr. Steven Allen, P.E.
FDH Velocitel
6521 Meridien Drive
Raleigh, North Carolina 27616

GEOLOGIC EXPLORATION
AMERICAN TOWER SITE ID 306035
UNITY VILLAGE MO 2
LEE'S SUMMIT, MISSOURI

Dear Mr. Allen:

Presented in this report are the results of the geologic exploration performed for the referenced project. This exploration was performed in general accordance with our proposal P029737.02 dated April 10, 2017. This report includes our project understanding, observed site conditions, conclusions and/or recommendations, and support data as given in the Table of Contents.

It has been our pleasure to provide geologic exploration services for you. Please contact either of the undersigned if you need further information about this document.

Respectfully submitted,

GEOTECHNOLOGY, INC.

STATE OF MISSOURI
SHERYL D. GALLAGHER
NUMBER
E-2001027911
REGISTERED PROFESSIONAL ENGINEER
5/19/17

STATE OF MISSOURI
BENJAMIN PETERSEN
RG
2016031435
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SDG/BBP/MHM:sdg/ljd

Copies submitted: (1) pdf

J029737.02

GEOLOGIC EXPLORATION
AMERICAN TOWER SITE ID 306035
UNITY VILLAGE MO 2
LEE'S SUMMIT, MISSOURI

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GEOLOGIC EXPLORATION
AMERICAN TOWER SITE ID 306035
UNITY VILLAGE MO 2
LEE'S SUMMIT, MISSOURI

SECTION I - PROJECT DATA

AUTHORIZATION

Our services are provided in accordance with the scope of services described in Geotechnology's proposal P029737.02 dated April 10, 2017. The project was authorized by a representative of FDH Velocitel (FDH).

PURPOSE AND SCOPE OF SERVICES

The purpose of our services was to evaluate the geology at the site and provide a professional opinion of the impact of mining relative to the existing tower foundation as defined in the scope of services of the referenced proposal. Briefly, geologic services consisted of drilling and sampling and preparation of this report.

SITE LOCATION AND TOWER DESCRIPTION

Site Location. The facility is located at 2150 Northwest Lowenstein Drive in Lee's Summit, Missouri (Northwest ¼, Southeast ¼, Section 35, Township 48 North, Range 32 West). The site is bounded by I-470 on the north, and is approximately 1,500 feet west of the Pryor Road interchange. The facility is located within an overgrown pasture. The site location and general topography of the area as per the 2015 U.S.G.S. map of the vicinity are shown on Plate 1.

Tower Description. The plans from February 1992 indicate the tower is supported on a spread footing with overall dimensions of 31.5 feet by 31.5 feet; the footing bears 3 feet below grade.

SITE HISTORY

An abandoned underground limestone mine, formerly known as Union Quarries, is located adjacent to and south of the project site according to the City of Lee's Summit and available mapping. It is expected that the Missouri Department of Transportation's (MoDOT) right-of-way for I-470 is the northern limit of the mining activities. Mining occurred at this site between 1965 and 1981 for the Bethany Falls Limestone Member. In addition, two sets of tunnels were advanced under I-470 and the tunnels are located west of the site. The tunnel excavations were permitted in 1972.

In 2006 MoDOT personnel observed several "dome-outs" in the mine located on the north side of I-470. Dome-outs occur when the bedrock roof above a mine collapses. Progressive failure of the roof can occur resulting in subsidence features at the ground surface. Such subsidence was visible along the north side of I-470 west of the Pryor Road interchange. This area is currently being mined using surface methods to reclaim the remaining Bethany Falls limestone.

The room and pillar method of mining was performed at Union Quarries. The available mapping of the mine indicates a random pattern of pillars with variable spacing. The width of the in-place pillars is approximately 25 feet, with pillar spacing of approximately 35 feet. Room heights within the mine generally range from 10 to 12 feet.

SECTION II – FIELD EXPLORATION

The field exploration included drilling two borings, designated as Borings B-1 and -2, at approximately the locations shown on Plate 2. The borings were located in the field by a representative of Geotechnology. The boring elevations as noted on the logs were obtained from Google Earth. A licensed surveyor should be retained if precise horizontal and vertical locations are required.

The borings were drilled using an ATV-mounted Diedrich D-50 rotary drill rig equipped with 3 ¾-inch inside diameter hollow-stem augers. Standard penetration tests (SPTs) were performed using an automatic hammer. Split-spoon samples were obtained at the depths indicated on the boring logs presented in Appendix B. Explanations of the terms and symbols used on the boring logs are also included in Appendix B. The borings were extended into bedrock using double-tube NQ wireline methods. The rock cores were placed in cardboard boxes and transported to our laboratory. Photographs of the rock core are presented in Appendix C.

An engineer from Geotechnology provided direction during the field exploration. The drill crew recorded SPT N-values and prepared field logs of the material encountered. An engineer and geologist reviewed the field logs and the material encountered, and prepared boring logs.

Unless noted on the boring logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials could be gradual or could occur between recovered samples. The stratification given on the boring logs, or described herein, is for use by Geotechnology in its analyses and should not be used as the basis of design or construction cost estimates without realizing that there can be variation from that shown or described.

The boring logs and related information depict subsurface conditions only at the specific locations and time where sampling was performed. The passage of time can result in changes in conditions, interpreted to exist, at or between the locations where sampling was performed.

SECTION III - SUBSURFACE CONDITIONS

GENERAL REGIONAL GEOLOGY

The project site is within the uplands and the soils are residuum from shale and limestone per the Soil Survey of Jackson County, Missouri. Mapping by the Missouri Bureau of Geology and Mines (1917) indicates the near-surface geology of the general area of the site is the Drum Limestone and Cherryvale Shale of the Kansas City Group of the Pennsylvanian System (see Figures 1 and 2).

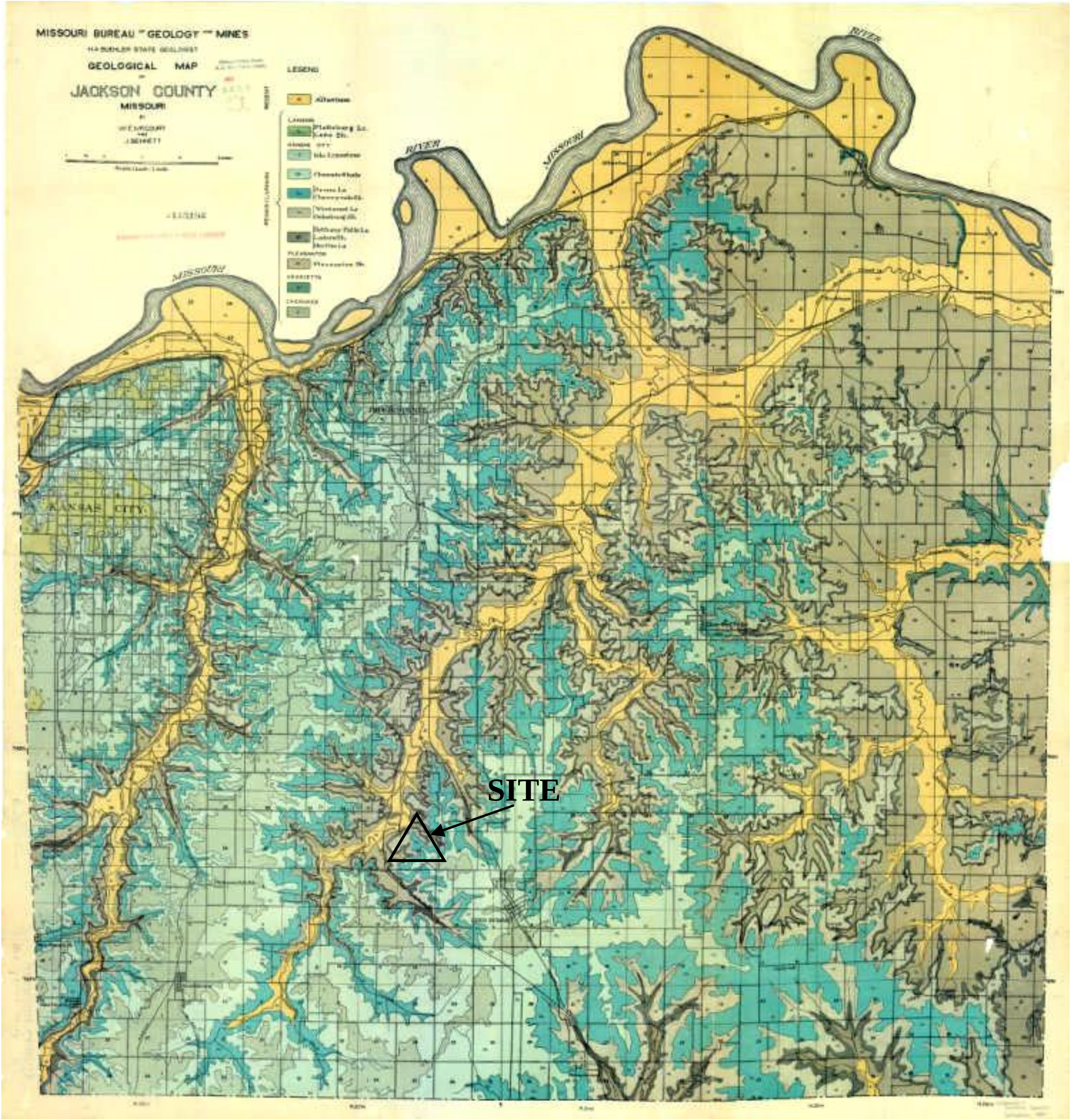


Figure 1: Geological map of Jackson County, Missouri (Missouri Bureau of Geology and Mines (1917))

Figure 2: Geological location of the site (courtesy Missouri Bureau of Geology and Mines (1917))

STRATIGRAPHY

The geology of the site generally consists of residual soils overlying Kansas City Group bedrock deposits. The residual soils generally consist of a high plasticity clay (CH). The clay extends to depths of approximately 6 and 8 feet at the two borings.

The Kansas City Group consists of the following units, in descending order: Wea Shale, Block Limestone, Fontana Shale, Winterset Limestone, Stark Shale, Canville Limestone, Galesburg Shale and the Bethany Falls Limestone (see Figure 3). This list of units is simplified. Described and adapted herein are details regarding the compositions of the Formations and Members within the Kansas City Group at the site.

Wea Shale (Cherryvale Formation). The Wea Shale is light gray to bluish gray that weathers to a light brown and green. This Member contains numerous scattered hard calcareous zones and interlayered limestone beds, and also contains scattered claystone seams. The thickness of this unit is approximately 24 feet in the borings.

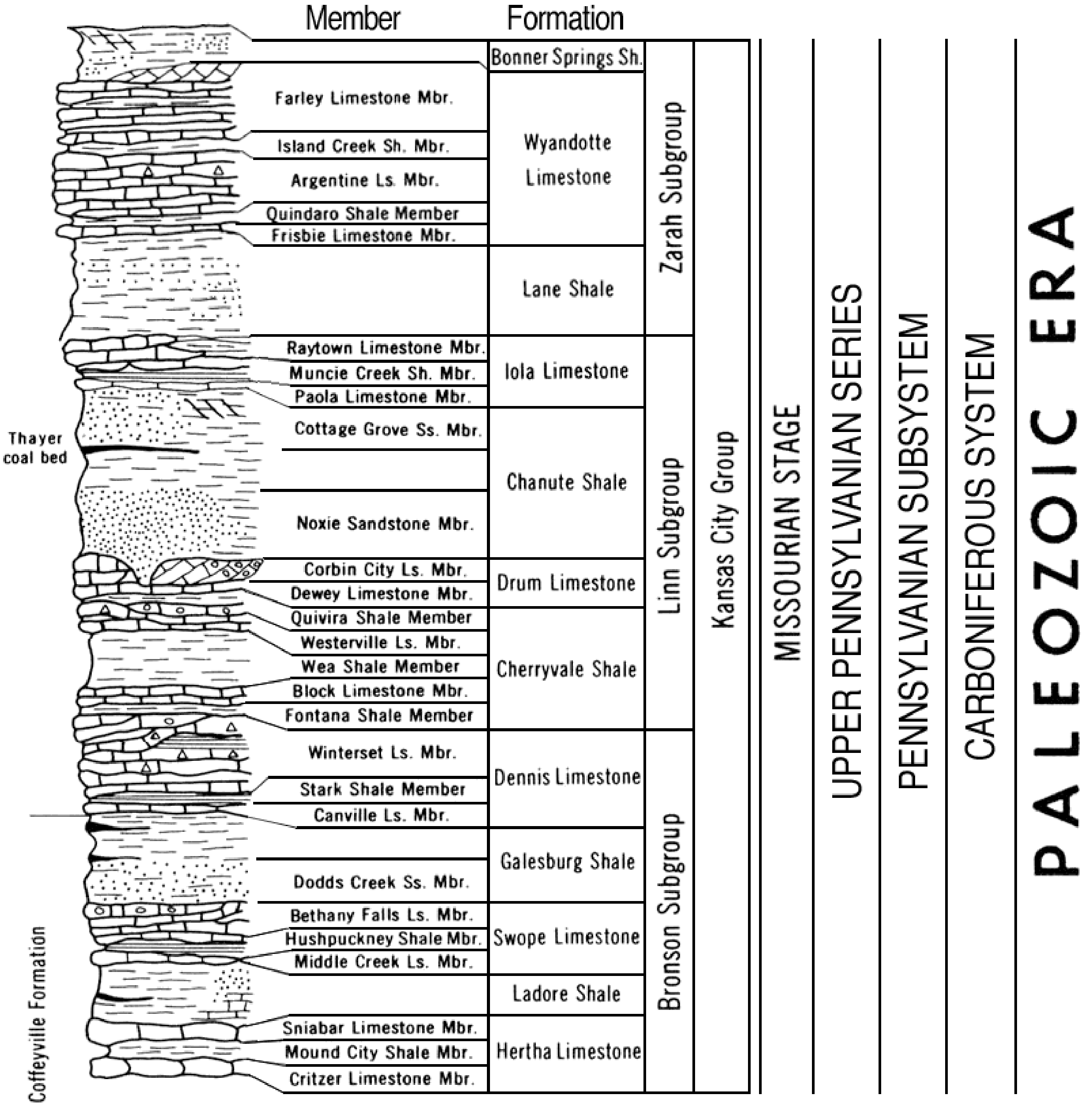


Figure 3: Kansas City Group Geological Column (courtesy of Kansas Geological Survey)

Block Limestone (Cherryvale Formation). The Block Limestone consists of 1 or 2 dark gray limestone beds separated by a calcareous shale bed. The upper limestone bed is about a foot thick; the lower limestone bed can vary from 1 to 2 feet thick. Occasionally the upper limestone bed will be absent. The total thickness of the Block Limestone is approximately 4 feet in the borings.

Fontana Shale (Cherryvale Formation). The Fontana Shale is a silty, gray micaceous shale and/or claystone. The Fontana ranges in thickness from 7 to 10 feet in the borings.

Winterset Limestone (Dennis Limestone). The Winterset is a limestone unit ranging in thickness from 31 to 33 feet in the borings. Areas that are relatively thick can be divided into an upper and lower unit by a shale seam. This seam can be up to 3 or more feet thick. Typically, the upper limestone portion is medium to thin bedded and less resistant to weathering. A distinctive black chert band might be present in the upper portion. At some locations the "Upper Winterset" will display a dark gray to bluish gray color indicative of a high clay mineral content. The upper portion is often referred to as an argillaceous limestone. The lower portion is thick-bedded with shale partings and sparse light-gray chert nodules and lenses. Overall, the Winterset can be described as a light to medium gray on freshly exposed surfaces and will weather to a light tan to drab gray after some exposure. It is generally medium to thick bedded and is known for its absorptive properties. The Winterset is probably the second most extensively quarried Pennsylvanian limestone in the Kansas City metropolitan area.

Stark Member (Dennis Limestone). The Stark Member is a dark gray to black pyretic shale that grades upward into medium gray shale. The Stark characteristically has a "slabby or slate-like" appearance. The thickness of this unit in the borings is approximately 2 to 3 feet.

Canville Member (Dennis Limestone). This unit is approximately 1 inch thick in the borings and is found only in a few counties in western Missouri. The Canville Member is a dark-gray, thin, lenticular or argillaceous limestone or calcareous shale that grades upward into medium-gray shale and is typically identified by the presence of the small mud-dwelling brachiopod Crurithyris.

Galesburg Shale. The Galesburg encountered in the borings is approximately 4 feet thick. This formation consists of a gray shale and claystone with irregularly shaped calcareous concretions that appear to be related to the underlying Bethany Falls Limestone.

Bethany Falls Limestone (Swope Formation). The Bethany Falls Member is typically exposed as a single massive ledge. A pronounced parting separates the wavy-bedded mottled lower part of the member from an upper, generally thinner, nodular portion. The variable uppermost layer is a prominent nodular zone (commonly referred to as Peanut Rock, Peanut Zone or Rubblized Zone). The thickness of this zone frequently varies from 18 to 36 inches thick. This nodular zone is contained within a carbonate enriched clayey shale matrix (sometimes referred to as a Marl). The Bethany Falls Member is typically chert-free in most areas and is generally 15 to 22 feet thick. Due to prominent vertical joints the Bethany Falls often outcrops in relatively large "slump blocks." This limestone unit is considered to be the most extensively quarried or mined Pennsylvanian limestone in the Kansas City metropolitan area.

The peanut zone thickness is approximately 5 feet in the borings. Both borings terminated in the Bethany Falls at depths of approximately 90 to 95 feet and within the anticipated mine level.

SECTION IV - FOUNDATION CONSIDERATIONS

The Union Quarries mine was not encountered in the borings. The tower foundation bears approximately 87 feet above the reported mined interval. The Winterset Limestone is at least 31 feet thick at the project site. It is Geotechnology's professional opinion that the long-term stability of the tower is favorable due to the thickness of the Winterset Limestone that overlies the mine. However, the slickensides noted in the core from the Galesburg Shale might be an indication of recent movement due to the lack of staining on the movement plane. If the tower is placed back into service, extensiometers or other instrumentation could be installed to monitor movement within the lower portion of the Winterset Limestone. Should movement be detected, remedial measures could be evaluated at that time. Remedial measures could include grouting the mined area under the tower, underpinning the tower foundations, or removing the tower.

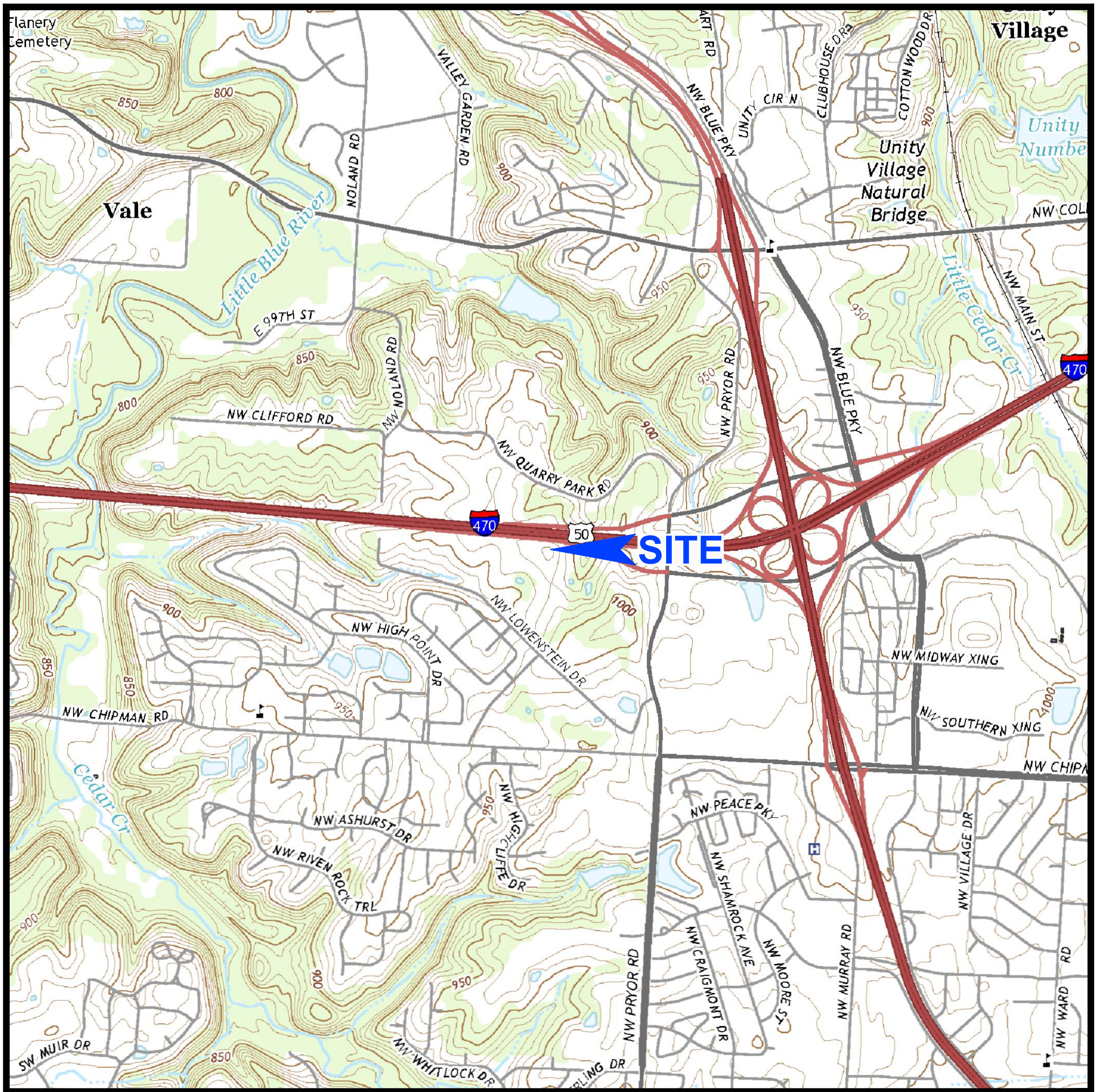
SECTION V - LIMITATIONS OF REPORT

This report has been prepared on behalf of, and for the exclusive use of, the client for specific application to the named project as described herein. If this report is provided to other parties it should be provided in its entirety with all supplementary information. In addition, the client should make it clear that the information is provided for factual data only, and not as a warranty of subsurface conditions presented in this report.

Geotechnology has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions. The recommendations and conclusions contained in this report are professional opinions.

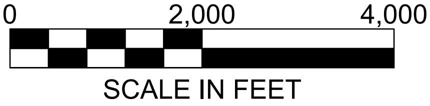
The analyses, conclusions, and recommendations contained in this report are based on the data obtained from the subsurface exploration. The field exploration methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Consequently, subsurface conditions may vary gradually, abruptly, and/or nonlinearly between sample locations and/or intervals.

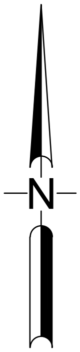
A copy of "Important Information about This Geotechnical-Engineering Report" that is published by the Geotechnical Business Council (GBC) of the Geoprofessional Business Association (GBA) is included in Appendix A for your review. The publication discusses some other limitations, as well as ways to manage risk associated with subsurface conditions.



NOTES

1. Plan adapted from a 7.5 minute U.S.G.S. map for Lee's Summit, Missouri quadrangle, last revised in 2015.





Drawn By: WAH	Ck'd By: SDG	App'vd By: MHM
Date: 5-16-17	Date: 5-17-17	Date: 5-18-17

GEOTECHNOLOGY INC
FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

SITE LOCATION
AND TOPOGRAPHY

Project Number
J029737.02

PLATE 1

NOTES

1. Plan adapted from a March 27, 2016 aerial photograph courtesy of Google Earth.
2. Borings were located in the field with reference to existing site features and are shown approximate only.

LEGEND

● Boring Location

0 60 120

SCALE IN FEET

N

Drawn By: WAH	Ck'd By: SDG	App'd By: MHM
Date: 5-16-17	Date: 5-17-17	Date: 5-18-17

GEOTECHNOLOGY INC
FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

AERIAL PHOTOGRAPH OF SITE AND BORING LOCATIONS

Project Number
J029737.02

PLATE 2

APPENDIX A

IMPORTANT INFORMATION ABOUT
THIS GEOTECHNICAL-ENGINEERING REPORT

Important Information about This

Geotechnical-Engineering Report

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

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

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

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

Read the Full Report

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

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

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

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

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

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

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

Subsurface Conditions Can Change

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

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are Not Final

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

A Geotechnical-Engineering Report Is Subject to Misinterpretation

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

Do Not Redraw the Engineer's Logs

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

Give Constructors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

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

Obtain Professional Assistance To Deal with Mold

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

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

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

GBC GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

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

APPENDIX B

LOGS OF BORINGS B-1 AND -2
BORING LOG: TERMS AND SYMBOLS
ROCK CORE: TERMS AND SYMBOLS

Surface Elevation 982

Datum NAVD 88

Completion Date: 5/11/17

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 ☐ - PP/2

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE (ASTM D 1586)

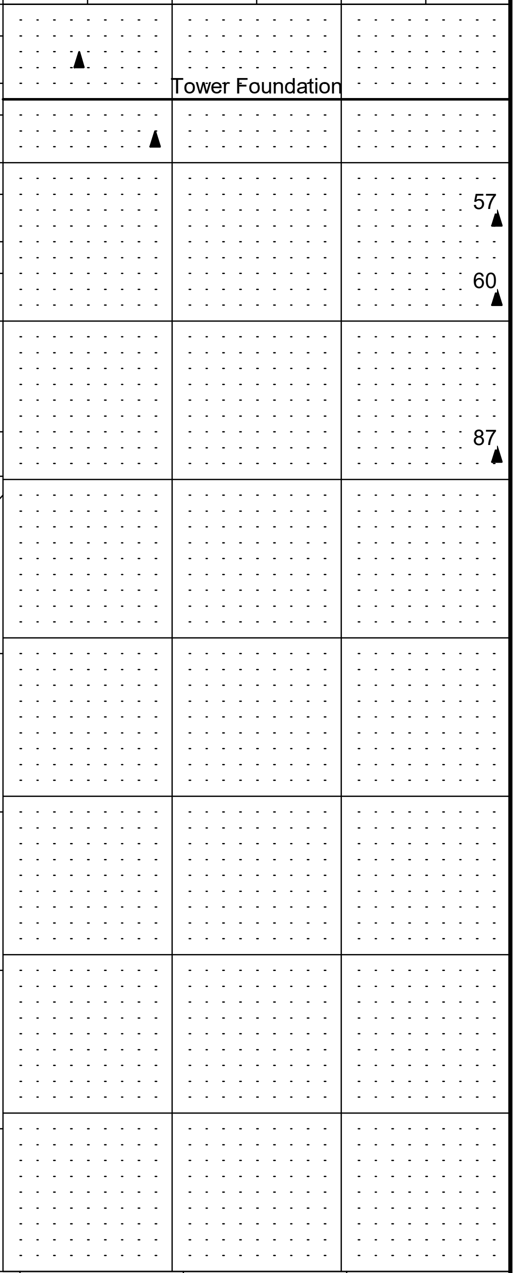
▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ├──●──┤ LL

10 20 30 40 50

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	CLAY - gray-brown, stiff to very stiff, fat, shaley - CH	▨	3-3-6	SS1
5		▨	5-8-10	SS2
	WEA SHALE - light brown to gray, rusted, micaceous, siderite partings, fissile, vertical fractures, very soft to soft, highly to slightly weathered	☰	11-21-36	SS3
10		☰	10-25-35	SS4
15		☰	15-37 -50/4.5"	SS5
		☰	100%/89%	NQ1
		☰	93% 93%	NQ2
20		☰	100% 80%	NQ3
25		☰	97% 81%	NQ4
30	BLOCK LIMESTONE - light gray, thin to medium beds, fossiliferous (crinoids and shells), stylolite and shale partings, moderately hard, fresh		100% 80%	NQ5
35	coal parting FONTANA SHALE - dark gray, platy, calcareous, a few 1/2" to 2" limestone beds, soft, fresh	☰	95% 90%	NQ6



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3.75" HOLLOW STEM

WASHBORING FROM __ FEET

RRM DRILLER BBP LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: BBP	Check by: SDG	App'vd by: MHM
Date: 5/9/17	Date: 5/17/17	Date: 5/18/17

GEOTECHNOLOGY INC
FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

LOG OF BORING: B-1

Project No. J029737.02

Surface Elevation 982

Datum NAVD 88

Completion Date: 5/11/17

SHEAR STRENGTH, tsf

∆ - UU/2 ○ - QU/2 ☐ - PP/2

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

(ASTM D 1586)

▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ⊢──●──⊣ LL

10 20 30 40 50

DEPTH IN FEET	DESCRIPTION OF MATERIAL	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	FONTANA SHALE - dark gray, platy, calcareous, a few 1/2" to 2" limestone beds, soft, fresh *(continued)*		
	WINTERSET LIMESTONE - gray, dark gray shale partings and thin beds with limestone nodules, wavy bedding, fossiliferous, stylolites, soft and moderately hard, fresh	100% 100%	NQ7
45	dark gray shale, calcareous, platy, soft, fresh		
	light gray limestone, oolitic and fossiliferous, stylolites and lensing, calcite crystals, wavy bedding, dark gray shale partings and thin beds	100% 95%	NQ8
50		100% 100%	NQ9
55		100% 100%	NQ10
60	dark gray and gray, calcareous, shale with thin limestone beds		
	high-angle slickenside		
	intermixed nodular limestone and claystone seam, 3 inches	100% 93%	NQ11
65	siliceous limestone, light gray, fossiliferous, hard		
		100% 96%	NQ12
70	light gray limestone, oolitic and fossiliferous (crinoids), stylolites and lensing, calcite crystals, wavy bedding, gray shale partings and thin beds		
		100% 100%	NQ13
75	STARK SHALE - dark gray to black, fissile, calcium-phosphate partings and nodules		
	CANVILLE MEMBER - dark and light gray limestone, argillaceous, fossiliferous, moderately hard, fresh	100% 88%	NQ14

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3.75" HOLLOW STEM

WASHBORING FROM __ FEET

RRM DRILLER BBP LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: BBP	Check by: SDG	App'vd by: MHM
Date: 5/9/17	Date: 5/17/17	Date: 5/18/17

GEOTECHNOLOGY INC
FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

CONTINUATION OF LOG OF BORING: B-1

Project No. J029737.02

Surface Elevation 982

Datum NAVD 88

Completion Date: 5/11/17

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	change to gray claystone, soft GALESBURG SHALE - dark gray to gray, calcareous, soft, fresh *(continued)* numerous slickensides to 82.2 feet			
85	BETHANY FALLS LIMESTONE - light gray and gray, nodular limestone intermixed with claystone, soft and moderately hard		100% 88%	NQ15
90	change to light gray limestone with wavy shale partings, decreasing shale with depth, thin to medium bedded, hard, fresh		100% 94%	NQ16
	Boring terminated at 90.5 feet.			
95				
100				
105				
110				
115				

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 ☐ - PP/2

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

(ASTM D 1586)

▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ● **LL**

10 20 30 40 50

Expected Mine Roof

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3.75" HOLLOW STEM

WASHBORING FROM __ FEET

RRM DRILLER BBP LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: BBP	Check by: SDG	App'vd by: MHM
Date: 5/9/17	Date: 5/17/17	Date: 5/18/17

GEOTECHNOLOGY INC

FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

CONTINUATION OF LOG OF BORING: B-1

Project No. J029737.02

Surface Elevation 982

Datum NAVD 88

Completion Date: 5/15/17

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	CLAY - brown, medium stiff to stiff, fat - CH	▨	3-3-5	SS1
			2-4-5	SS2
5			2-4-8	SS3
10	WEA SHALE - light brown to gray, rusted, micaceous, siderite partings, fissile, soft, highly to slightly weathered	☰	7-19-33	SS4
			11-30-50	SS5
15			100%/0%	NQ1
			100% 80%	NQ2
20			100% 55%	NQ3
25			100% 93%	NQ4
30			100% 68%	NQ5
35	BLOCK LIMESTONE - light gray, thin to medium beds, fossiliferous (crinoids and shells), stylolite and shale partings, moderately hard, fresh			
	FONTANA SHALE - dark gray, platy, calcareous, soft, fresh		93% 85%	NQ6

SHEAR STRENGTH, tsf

∆ - UU/2 ○ - QU/2 ☐ - PP/2

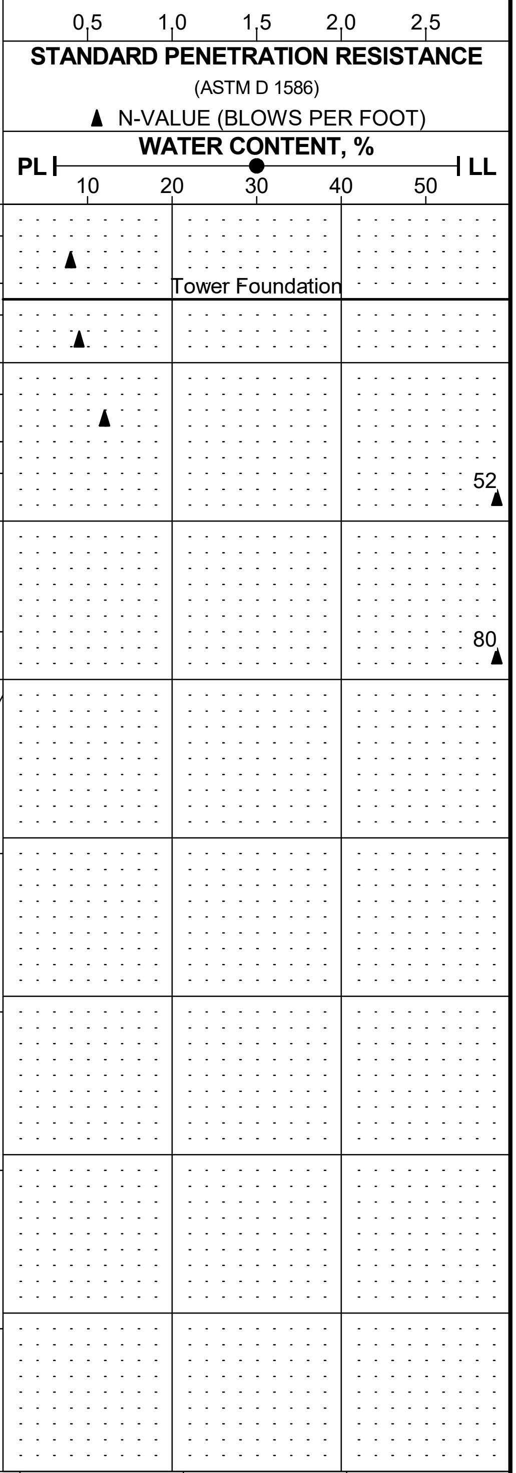
STANDARD PENETRATION RESISTANCE

(ASTM D 1586)

▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ├──●──┤ LL



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3.75" HOLLOW STEM

WASHBORING FROM __ FEET

RRM DRILLER SDG LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: SDG	Check by: MHM	App'vd by: BBP
Date: 5/17/17	Date: 5/18/17	Date: 5/18/17

GEOTECHNOLOGY INC
FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

LOG OF BORING: B-2

Project No. J029737.02

Surface Elevation **982**

Datum **NAVD 88**

Completion Date: **5/15/17**

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 ☐ - PP/2

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

(ASTM D 1586)

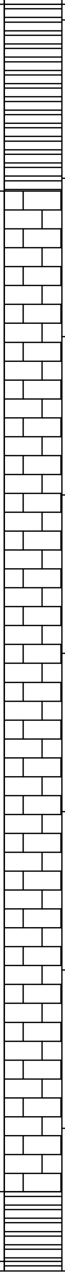
▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ├──●──┤ **LL**

10 20 30 40 50

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	FONTANA SHALE - dark gray, platy, calcareous, soft, fresh *(continued)*		100% 100%	NQ7
45	with limestone partings and bands			
	WINTERSET LIMESTONE - gray, dark gray shale partings and thin beds with limestone nodules, wavy bedding, fossiliferous, stylolites, soft and moderately hard, fresh		100% 86%	NQ8
50			100% 100%	NQ9
55	5-inch intermixed nodular limestone and claystone seam		97% 97%	NQ10
60	siliceous limestone, light gray, fossiliferous, hard		100% 97%	NQ11
65			100% 92%	NQ12
70			98% 98%	NQ13
75	STARK SHALE - dark gray to black, fissile, calcium-phosphate partings and nodules		100% 88%	NQ14



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GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3.75" HOLLOW STEM

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RRM DRILLER SDG LOGGER

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REMARKS:

Drawn by: SDG	Check by: MHM	App'vd by: BBP
Date: 5/17/17	Date: 5/18/17	Date: 5/18/17

GEOTECHNOLOGY INC

FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

CONTINUATION OF LOG OF BORING: B-2

Project No. J029737.02

Surface Elevation 982

Datum NAVD 88

Completion Date: 5/15/17

SHEAR STRENGTH, tsf

∆ - UU/2 ○ - QU/2 ▯ - PP/2

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

(ASTM D 1586)

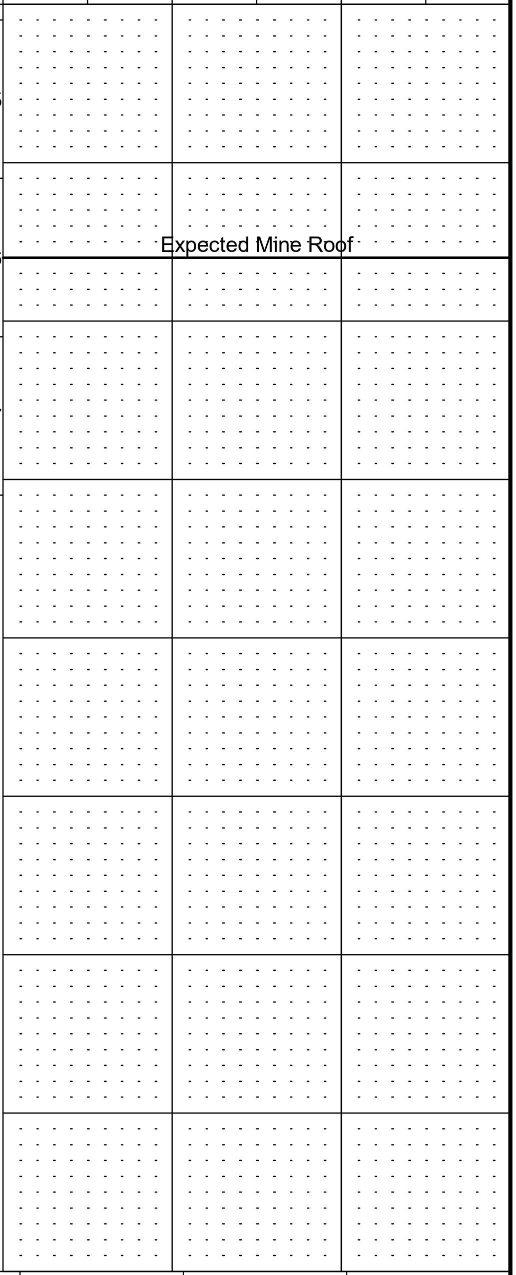
▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ├──●──┤ **LL**

10 20 30 40 50

DEPTH IN FEET	**DESCRIPTION OF MATERIAL**	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	CANVILLE MEMBER - dark and light gray limestone, argillaceous, fossiliferous, moderately hard, fresh *(continued)*			
	GALESBURG SHALE - dark gray to gray, calcareous, soft, fresh		100% 90%	NQ15
	change to gray claystone, soft			
85	slickenside 45 degree angle			
	slickenside 45 degree angle			
	slickenside 45 degree angle			
	slickenside 45 degree angle		100% 98%	NQ16
	BETHANY FALLS LIMESTONE - light gray and gray, nodular limestone intermixed with claystone, soft and moderately hard			
90				
	change to light gray limestone with wavy shale partings, decreasing shale with depth, thin to medium bedded, hard, fresh		98% 98%	NQ17
95				
	Boring terminated at 95.5 feet.			
100				
105				
110				
115				



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3.75" HOLLOW STEM

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RRM DRILLER SDG LOGGER

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HAMMER TYPE Auto

REMARKS:

Drawn by: SDG	Check by: MHM	App'vd by: BBP
Date: 5/17/17	Date: 5/18/17	Date: 5/18/17

GEOTECHNOLOGY INC
FROM THE GROUND UP

American Tower Site ID 306035
Unity Village MO 2
Lee's Summit, Missouri

CONTINUATION OF LOG OF BORING: B-2

Project No. J029737.02

BORING LOG: TERMS AND SYMBOLS

GENERAL NOTES

1. *Information on each boring log is a compilation of subsurface conditions based on soil or rock classifications obtained from the field as well as from laboratory testing of samples. The strata lines on the logs may be approximate or the transition between the strata may be gradual rather than distinct. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.*
2. *Relative composition and Unified Soil Classification designations are based on visual estimates and are approximate only. If laboratory tests were performed to classify the soil, the unified designation is show in parenthesis.*
3. *Value given in Unit Dry Weight/SPT Column is either a unit dry weight in pounds per cubic foot, if adjacent to a ST sample designation, or blows per 6-inch increment if adjacent to a SS sample designation.*

ABBREVIATIONS

UU/2	*Shear Strength from Unconsolidated – Undrained Triaxial Test (ASTM D2850)*
QU/2	*Shear Strength from Unconfined Compression Test (ASTM D2166)*
SV	*Shear Strength from Field Vane (ASTM D2573)*
PL	*Plastic Limit (ASTM D4318)*
LL	*Liquid Limit (ASTM D4318)*

LEGEND

CS	Continuous Sampler
GB	Grab Sample Taken From Auger Cuttings or Wash Water Return
NX 100 42	NX Rock Core with Percent Recovery/R.Q.D. Given In Adjacent Column
PST	Three Inch Diameter Piston Tube Sample
SS	Split Spoon Sample (Standard Penetration Test)
ST	Three Inch Diameter Shelby Tube Sample
*	Sample Not Recovered
SV	Field Vane Test

SPLIT – BARREL SAMPLER DRIVING RECORD

Blow per Foot (N-Value)	*Description*
25	*25 blows drove sampler 12 inches after initial 6 inches of seating.*
75/10”	*75 blows drove sampler 10 inches after initial 6 inches of seating.*
50/S3”	*50 blows drove sampler 3 inches during initial 6 inch seating interval.*

NOTES:
1. *To avoid damage to sampling tools, driving is limited to 50 blows during any six inch interval.*
2. *N-Value (Blow Count) is the standard penetration resistance based on the total number of blows, using a 140-lb hammer with 30-inch free fall, required to drive a split spoon the last two of three, 6-inch drive increments. (Example: 4/7/9, N = 7 + 9 = 16). Values are shown as a summation on grid plot and may be shown as 4/7/9 in Unit Dry Weight – SPT column.*

RELATIVE COMPOSITION

Trace…………………....0-10 %
With/Some…………....11-35 %
Soil modifier such…..... > 35 %
As silty, clayey, sandy, etc.

DENSITY OF GRANULAR SOILS

Descriptive Term:	***N—Value***
Very Loose	*0 - 4*
Loose	*5 - 10*
Medium Dense	*11 - 30*
Dense	*31 - 50*
Very Dense	*> 50*

STRENGTH OF COHESIVE SOILS

Consistency	***Undrained Shear Strength Tons Per Sq. Ft.***	***Field Test***	***Approximate N-Value Range***
Very Soft	*less than 0.12*	*Thumb will penetrate soil more than 1”*	*0 - 1*
Soft	*0.13 to 0.25*	*Thumb will penetrate soil about 1”*	*2 - 4*
Medium Stiff	*0.26 to 0.50*	*Thumb will penetrate soil about ¼”*	*5 – 8*
Stiff	*0.51 to 1.00*	*Thumb hardly indents soil*	*9 – 15*
Very Stiff	*1.01 to 2.00*	*Thumb will not indent soil, but readily indented with thumbnail*	*16 – 30*
Hard	*greater than 2.00*	*Thumbnail will not indent soil*	*> 30*

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

12” 3” ¾“ 4 10 40 200

BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

300 76.2 19.1 4.76 2.00 0.42 0.074 0.002

SOIL GRAIN SIZE IN MILLIMETERS

SOIL STRUCTURE

Calcareous *– Having appreciable quantities of carbonate.*

Fissured *– Containing shrinkage or relief cracks, often filled with sand or silt; usually more or less vertical.*

Slickensided *– Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the ease of breaking along those planes.*

Layer *-- Inclusion greater than 3 inches thick.*

Seam *– Inclusion 1/8 inch to 3 inches thick extending through the sample*

Parting *– Inclusion less than 1/8 inch thick.*

Pocket *– Inclusion of material of different texture that is smaller than the diameter of the sample.*

Interlayered *– Soil samples composed of alternating layers of different soil types.*

Intermixed *– Soil samples composed of pockets of different soil types and a layered or laminated structure is not evident.*

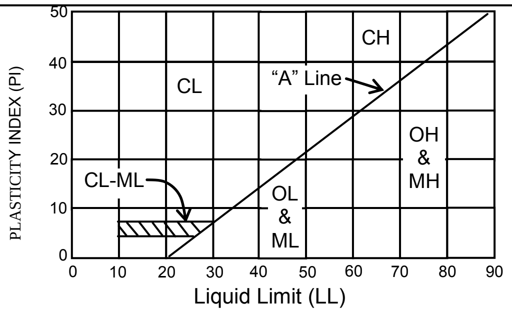
Laminated *– Soil sample composed of alternating partings or seams of different soil type.*

GEOTECHNOLOGY INC
FROM THE GROUND UP

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOL	DESCRIPTION
Coarse-Grained Soils (More than 50% Larger than No 200 Sieve Size)	Gravel and Gravelly Soils	Clean Gravels Little or no Fines	GW	Well-Graded Gravel, Gravel-Sand Mixture
			GP	Poorly –Graded Gravel, Gravel-Sand Mixture
		Gravels with Appreciable Fines	GM	Silty Gravel, Gravel-Sand-Silt Mixture
			GC	Clayey-Gravel, Gravel-Sand-Clay Mixture
	Sand and Sandy Soils	Clean Sands Little or no Fines	SW	Well-Graded Sand, Gravelly Sand
			SP	Poorly Graded Sand, Gravelly Sand
		Sands with Appreciable Fines	SM	Silty Sand, Sand-Silt Mixture
			SC	Clayey Sand, Sand-Clay Mixture
Fine-Grained Soils (More than 50% Smaller than No 200 Sieve Size)	Silts and Clays	Liquid Limit Less Than 50	ML	Silt, Clayey Silt, Silty or Clayey Very Fine Sand, Slight Plasticity
			CL	Clay, Sandy Clay, Silty Clay, Low to Medium Plasticity
			OL	Organic Silts, or Silty Clays of Low Plasticity
	Silts and Clays	Liquid Limit More Than 50	MH	Silt, Fine Sandy or Silt Soil with High Plasticity
			CH	Clay, High Plasticity
			OH	Organic Clay of Medium to High Plasticity
	Highly Organic Soils		PT	Peat, Humus, Swamp Soil

PLASTICITY CHART



RELATIVE PLASTICITY

Nonplastic	Cannot Roll Into Ball
Trace Plasticity	Barely Roll Into Ball
Medium Plastic	Can be Rolled Into Ball
Highly Plastic	No Rupture by Kneading

VISUAL DESCRIPTION CRITERIA*

TABLE 1: CRITERIA FOR DESCRIBING ANGULARITY OF COARSE-GRAINED PARTICLES

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

TABLE 2: CRITERIA FOR DESCRIBING PARTICLE SHAPE

Description	Criteria
Flat	*Particles with width/thickness X3*
Elongated	*Particles with length/width X3*
Flat and Elongated	*Particles meet criteria for both flat and elongated*

TABLE 3: CRITERIA FOR DESCRIBING MOISTURE CONDITION

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

TABLE 4: CRITERIA FOR DESCRIBING REACTION WITH HCL

Description	Criteria
None	*No visible reaction*
Weak	*Some reaction, with bubbles forming slowly*
Strong	*Violent reaction, with bubbles forming rapidly*

TABLE 6: CRITERIA FOR DESCRIBING CEMENTATION

Description	Criteria
Weak	*Crumbles or breaks with handling or little finger pressure*
Moderate	*Crumbles or breaks with considerable finger pressure*
Strong	*Will not crumble or break with finger pressure*

TABLE 8: CRITERIA FOR DESCRIBING DRY STRENGTH

Description	Criteria
None	*The dry specimen crumbles into powder with mere pressure of handling*
Low	*The dry specimen crumbles into powder with some finger pressure*
Medium	*The dry specimen breaks into pieces or crumbles with considerable finger pressure*
High	*The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.*
Very High	*The dry specimen cannot be broken between the thumb and a hard surface*

TABLE 9: CRITERIA FOR DESCRIBING DILATANCY

Description	Criteria
None	*No visible change in the specimen*
Slow	*Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.*
Rapid	*Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.*

TABLE 10: CRITERIA FOR DESCRIBING TOUGHNESS

Description	Criteria
Low	*Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.*
Medium	*Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness*
High	*Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness*

TABLE 12: IDENTIFICATION OF INORGANIC FINE-GRAINED SOILS FROM MANUAL TESTS

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	*None to low*	*Slow to rapid*	*Low or thread cannot be formed*
CL	*Medium to high*	*None to slow*	*Medium*
MH	*Low to medium*	*None to slow*	*Low to medium*
CH	*High to very high*	*none*	*High*

**NOTES: 1. Tables adapted from ASTM D2488 "Description and identification of Soils" (Visual-Manual Procedure)*
2. Tables 5, 7 and 11 incorporated into other information on this plate.

ROCK CORE: TERMS AND SYMBOLS

GENERAL NOTES

A field description should be very specific and cover all aspects of the rock mass. Field logs should include coring times, notes on water losses and color, rod drops, and notes as to the locations and thickness of voids and/or seams. As a minimum, a field description should include the following, preferably in sequential order:

TERM	REFERENCE
Hardness	Table 1
Color	(1)
Crystallinity	Table 2
Bedding	Table 3
Weathering	Table 4
Fabric (if applicable)	Table 5
Jointing (including filling)	Table 6
Voids	Table 7
RQD	Table 8
Sorting Criteria	Figure 1
Angularity Criteria	Figure 2

(1) Color should be as descriptive as possible, so as to distinguish the stratum from that which surrounds it. Common colors are gray, brown, black and white and may be modified by adjectives such as light and dark. Exotic colors such as aqua, cobalt, amber and magenta may be used when necessary. If one or more colors are present it should be noted.

TABLE 1: ROCK HARDNESS

DESCRIPTION	CRITERIA
Very Soft	- Easily indented with the thumb
Soft	- Able to be scratched with a fingernail
Moderately Hard	- Easily scratched with a knife; Cannot be scratched with the fingernail
Hard	- Difficult to scratch with a knife
Very Hard	- Cannot be scratched with a knife

TABLE 2: ROCK CRYSTALLINITY

DESCRIPTION	CRITERIA
Aphanitic (Micritic)	- Crystals cannot be distinguished with the naked eye
Very Finely Crystalline	- Crystals are barely discernable with the naked eye
Finely Crystalline	- Crystals are easily discernable with the naked eye
Medium Crystalline	- Crystals are medium size; up to 1/8" in diameter
Coarsely Crystalline	- Crystals are 1/8" to 1/4" in Diameter
Very Coarsely Crystalline	- Crystals are larger than 1/4" In diameter

TABLE3: ROCK MASS BEDDING

DESCRIPTION	CRITERIA
Parting	- Less than 0.02 foot (<0.60 cm)
Band	- 0.02 to 0.2 foot (0.60 to 6.1 cm)
Thin Bed	- 0.2 to 0.5 foot (6.1 to 15.2 cm)
Medium Bed	- 0.5 to 1.0 foot (15.2 to 30.5 cm)
Thick Bed	- 1.0 to 2.0 feet (30.5 to 61.0 cm)
Massive	- Greater than 2.0 feet (>61.0 cm)

TABLE 4: ROCK WEATHERING

DESCRIPTION	CRITERIA
Fresh	- No visible signs of decomposition or discoloration
Slightly Weathered	- Slight discoloration inward from open fractures
Moderately Weathered	- Discoloration throughout, slight loss of strength, texture intact
Highly Weathered	- Specimens can be broken by hand, texture indistinct, fabric intact
Completely Weathered	- Specimens easily crumbled, minerals decomposed to soil
Residual Soil	- Advanced state of decomposition resulting in plastic soil

TABLE 5: ROCK FABRIC

DESCRIPTION	CRITERIA
Equigranular	- Grains essentially of equal size
Porphyritic	- Mixed coarse and fine grains
Amorphous	- No definite crystal form (Glass)
Platy	- Schistose or foliated, planar

TABLE 6: ROCK JOINTING

DESCRIPTION	CRITERIA	
Very Wide	>3.25 ft.	(>3 m)
Wide	1.1 – 3.25 ft.	(1-3 m)
Moderately Wide	0.3 – 1.1 ft.	(0.3 – 1 m)
Close	0.05 – 0.3 ft.	(0.05 – 0.3 m)
Very Close	<0.05 ft.	(<0.05 m)

TABLE 7: ROCK VOIDS

DESCRIPTION	CRITERIA
Dense	- Usually not discernable with the naked eye
Pit (Pitted)	- Discernable to 1/4"
Vug (Vuggy)	- 1/4" to diameter of the core
Cavity	- Larger than 6" in diameter

ROCK 8: ROCK QUALITY

PERCENT RQD	QUALITY
90 to 100	Excellent
75 to 90	Good
50 to 75	Fair
25 to 50	Poor
0 to 25	Very Poor

FIGURE 1: Sorting Criteria

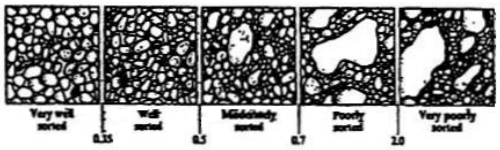
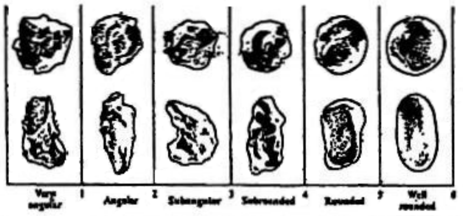


FIGURE 2: Angularity Criteria



TYPE SPECIFIC CHARACTERISTICS

CHARACTERISTICS OF DETRITAL SEDIMENTARY ROCKS

ROCK TYPE	CHARACTERISTICS
	COARSE-GRAINED
Conglomerates	- Rounded fragments of any type rock; cementing agent chiefly silica, but iron, clay, and calcareous material also common/
Breccia	- Angular fragments of any type rock; resulting from glaciation, rock falls, cave collapse, and/or fault movements.
	MEDIUM-GRAINED
Sandstones	- Predominantly quartz grains cemented by silica, iron,clay or carbonate material. Color depends on cementing agent; porous and pervious; hard and generally thickly bedded.
Arkose	- Similar to sandstone but at least 25% feldspar.
Graywacke	- Angular particles of a variety of minerals in a clay matrix; indurated, impure sandstone.
	FINE-GRAINED
Siltston	- Composition similar to sandstone but at least 50% of grains 0.002 – 0.02mm in size. Rarely forms thick beds, but often hard.
Shale	- Predominant particles, <0.002mm; a wall defined fissile fabric. Commonly interbedded with sandstone and relatively soft.
Argillites	- Hard, indurated shales devoid of fissility.
Clay Shale	- Moderately indurated shales.
Claystone	- Clay-size particles compacted into rock without a fissle structure (stiff to hard consistency).

CHARACTERISTICS OF NON-DETRITAL SEDIMENTARY ROCKS

ROCK TYPE	CHARACTERISTICS
	CALCAREOUS PRECIPITATES
Limestone	- Contains more than 50% calcium carbonate. The calcite can be precipitated chemically, organically, or it may be detrital in origin. Reacts violently with dilute HCL.
Coquina	- Weak porous rock consisting of lightly cemented shells and shell fragments.
Chalk	- Soft, porous, and fine-textured; composed of shells of microscopic organisms; usually white.
Dolomite	- Harder and heavier than limeston. Forms by alteration of limestone or by direct precipitation from sea water. Reacts with dilute HCL only when powered; hardness >5.
Gypsum	- An evaporate, commonly massive, white and soft.
Anhydrite	- An evaporate, harder than gypsum; normally white with a pearly luster and splintery fracture.
Halite	- An evaporate; a crystalline aggregate of salt.
	ORGANIC ORIGIN
Coal	- Composed of highly altered plant remains and varying amounts of clay, generally black.
	BIOGENIC AND CHEMICAL ORIGIN
Chert	- Formed by silica deposted from solution in water. May occur as nodules or relatively thick beds; hardness of 7.
Diatomite	- Soft, white, very light, porous rock.

CHARACTERISTICS OF IGNEOUS ROCKS

ROCK TYPE	CHARACTERISTICS
	COARSE TO MEDIUM GRAINED
Pegmatite	- Chiefly quartz and feldspar, occuring separately as large grains; abundant as dikes in granite.
Granite	- Most common igneous rock; normally equigranular and light in color; chiefly quartz and feldspar.
Syenite	- Light colored rock similar to granite but contains no quartz; almost entirely feldspar.
Diorite	- Equlgranular and gray to dark gray; composed of plagioclase feldspar and at least one ferromagnesian mineral.
Gabbro	- Dark colored rock composed of ferromagnesian minerals and plagiociase feldspar.
Peridotite	- Dark colored rock composed almost entirely of ferromagnesian minerals, readily altertered.
Dunite	- Very dark green; major constituent is olivine. Readily alters to serpentine.
Dolerite	- Dark colored rock, intermediate in grain size.
	FINE-GRAINED
Andesite	- Generally dark gray, green or red, fine-grained rock; occasionally porphyritic.
Basalt	- Most abundant extrusive rock; variable colors; fine-grained with a dense structure.
Rhyolite	- Microcrystalline equivalent of granite; usually white, gray or pink with a few phenocrysts.
Felsite	- A finely-crystalline variety of quartz-porphyry.
	GLASSY ROCKS
Obsidian	- Solid natural glass devoid of all crystal form.
Pumice	- Extremely vesicular glass; sponge structure.
Scoria	- Rock which has equal void space and solid mass.

CHARACTERISTICS OF METAMORPHIC ROCKS

ROCK TYPE	CHARACTERISTICS
	FOLIATED FABRIC
Gneiss	- Coarse-grained rock with imperfect follation resulting in slabbing. Chief minerals are quartz and feldspar.
Schist	- Fine-grained rock with a well-developed foliation. Mainly consists of platy minerals and commonly garnet.
Amphibolite	- Consists largely of amphibole with a schist-like foliation. Commonly hard and very dense.
Phyllite	- Soft, with a satin luster and extremely fine schistosity; very unstable cut slopes.
Slate	- Extremely fine-grained (micritic) with a very well-defined cleavage; generally hard.
	MASSIVE FABRIC
Meta-conglomerate	- Similar to conglomerate in appearance but has been fused and deformed by heat and pressure.
Quartzite	- Extensively altered sandstone; individual sand grains have been fused together.
Serpentine	- A green, soft, compact rock with a waxy luster and splintery fracture.
Soapstone	- Derived from talc; generally green in color and easily cut with a sharp knife; resists the action of heat and acids.
Hornfels	- Rocks baked by contact metamorphism into a hard aphanitic material, with concoldal fracture and generally dark gray to black in color.
Migmatite	- A complex intermixture of metamorphic and granular igneous rocks formed by injection of granite magma into foliated rocks.
Mylonites	- Produced by intense metamorphism; variable fabric due to deformation of original minerals. Common along the base of overthrust sheets.

GEOLOGIC DEFINITIONS

ARENACEOUS – A term applied to rocks that have been derived from sand or contain abundant, >30% , sand in composition.

ARGILLACEOUS – A term applied to all rock or substances composed of clay minerals or having a notable portion, >30%, clay in composition.

BRECCIATED – A rock texture with is composed of angular fragments which corresponds in size to gravel and/or pebbles.

CONGLOMERITIC – A rock texture which is composed of rounded fragments which correspond in size to gravel and/or pebbles.

FABRIC – That factor of the texture of a crystalline rock which depends on the relative sizes, shapes, and arrangements of the component crystals.

FISSILITY – A property of splitting along closely spaced parallel planes.

OOLITIC – A spherical or ellipsoidal texture, 0.25 – 2.0mm in diameter, with a concentric or radial structure.

PHANERITIC – A textural term applied to those igneous rocks in which all the grains are essentially the same size.

PORPHYRITIC- A textural term applied to those igneous rocks which have larger crystals set in a fine matrix.

SLICKENSIDE – A polished or striated surface on or within a rock or compact soil.

STYLOLITE – A term applied to parts of certain limestones which have a columnlike development that is grooved, sutured, or striated and irregular

Note: Tables, Figures and data adapted from: *"Geotechnical Engineering Investigation Manual"*, Roy E. Hunt, McGraw-Hill Book Co., New york, NY, 1984., *"Petrology Igneous, Sedimentary, and Metamorphic"*, Harvey Blatt & Ernest G. Ehlers, W. H. Freman & co., San Francisco, CA, 1982., and the U.S. Army Corps of Engineers.

APPENDIX C

ROCK CORE PHOTOGRAPHS

Boring B-1

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Run No.	Depth (ft)	Recovery (%)	RQD (%)
1	14.9 – 15.5	100	89
2	15.5 – 20.5	93	93

Boring B-1

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Run No.	Depth (ft)	Recovery (%)	RQD (%)
3	20.5 – 25.5	100	80
4	25.5 – 30.5	97	81

Boring B-1

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Run No.	Depth (ft)	Recovery (%)	RQD (%)
5	30.5 – 35.5	100	80
6	35.5 – 40.5	95	90

Boring B-1

American Tower Site ID 306035 Unity Village MO 2

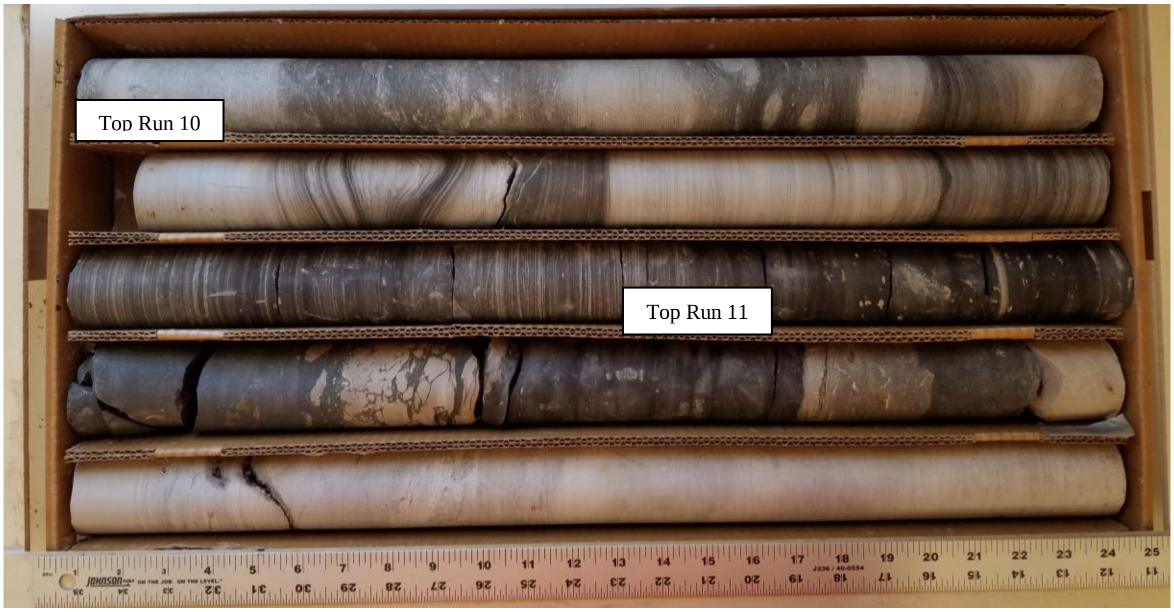
J029737.02

Run No.	Depth (ft)	Recovery (%)	RQD (%)
7	40.5 – 45.5	100	100

Boring B-1 **American Tower Site ID 306035 Unity Village MO 2** J029737.02

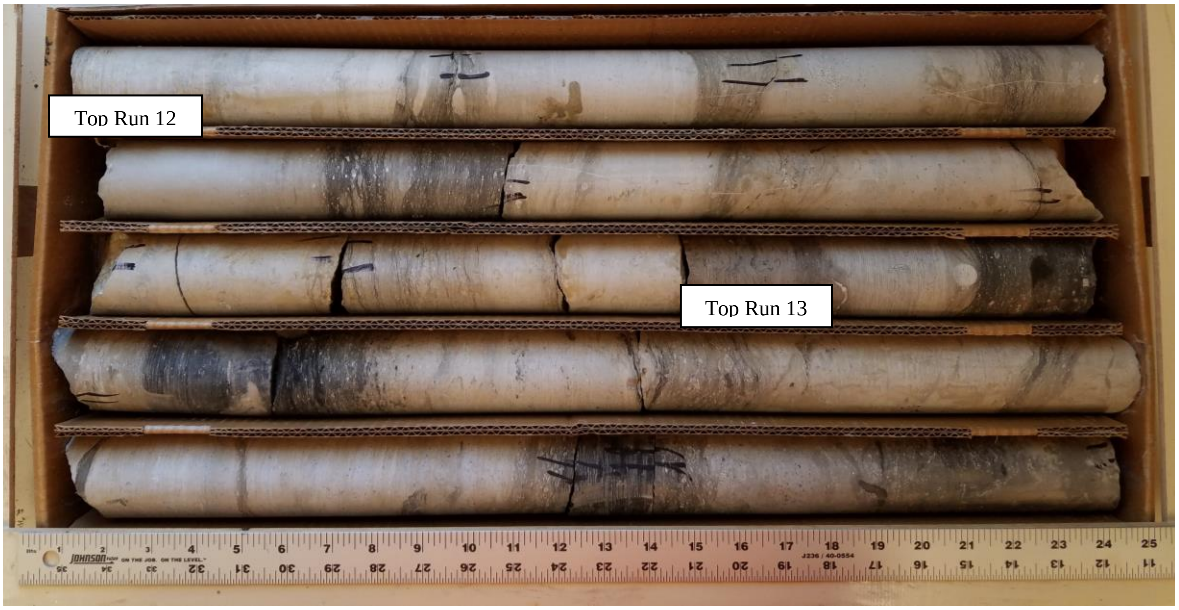
Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
8	**45.5 – 50.5**	**100**	**95**
9	**50.5 – 55.5**	**100**	**100**

Boring B-1 **American Tower Site ID 306035 Unity Village MO 2** J029737.02



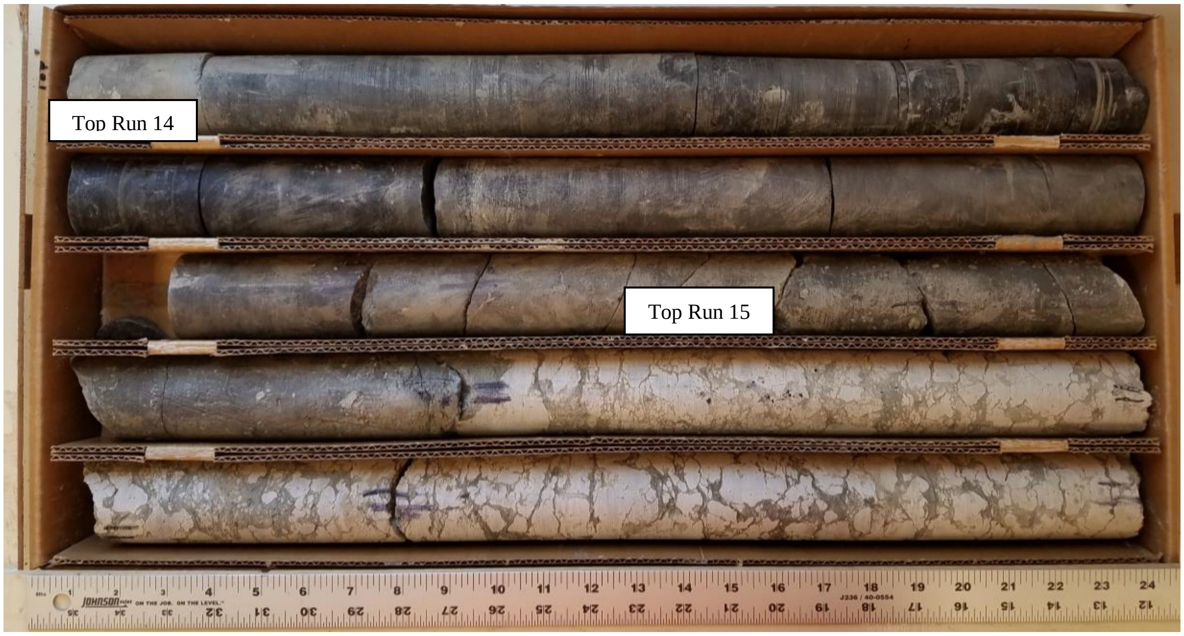
Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
10	**55.5 – 60.5**	**100**	**100**
11	**60.5 – 65.5**	**100**	**93**

Boring B-1 **American Tower Site ID 306035 Unity Village MO 2** J029737.02



Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
12	**65.5 – 70.5**	**100**	**96**
13	**70.5 – 75.5**	**100**	**100**

Boring B-1 **American Tower Site ID 306035 Unity Village MO 2** J029737.02



Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
14	**75.5 – 80.5**	**100**	**88**
15	**80.5 – 85.5**	**100**	**88**

Boring B-1

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Run No.	Depth (ft)	Recovery (%)	RQD (%)
16	85.5 – 90.5	100	94

Boring B-2

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
1	**15.0 – 15.5**	**100**	**0**
2	**15.5 – 20.5**	**100**	**80**

Boring B-2

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
3	**20.5 – 25.5**	**100**	**55**
4	**25.5 – 30.5**	**100**	**93**

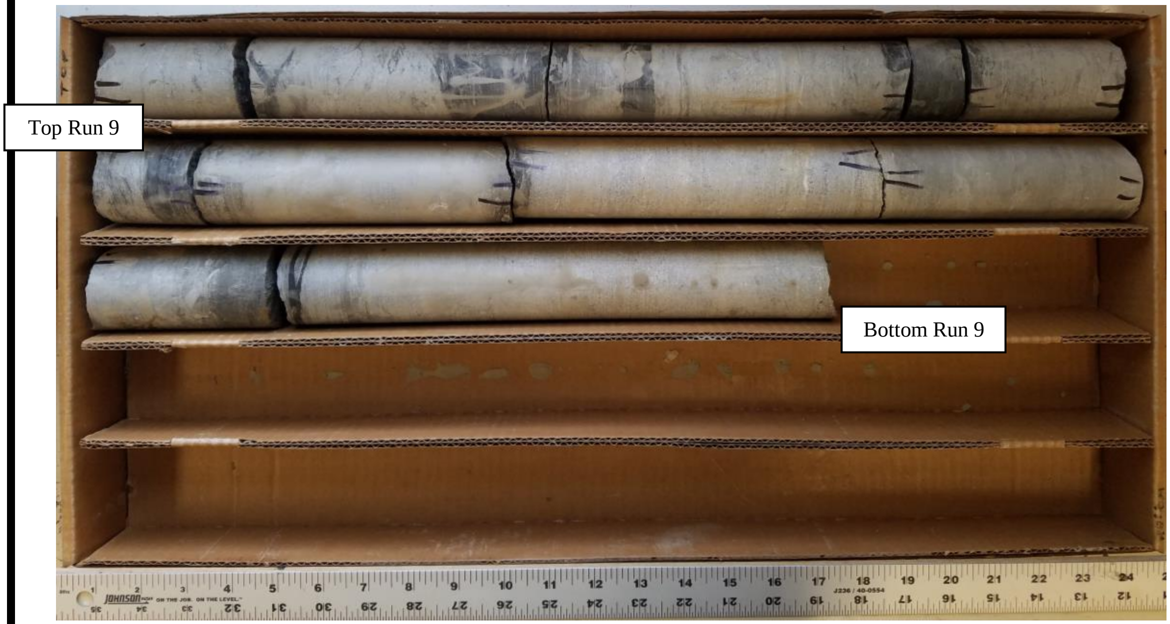
Boring B-2 **American Tower Site ID 306035 Unity Village MO 2** J029737.02

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
5	**30.5 – 35.5**	**100**	**68**
6	**35.5 – 40.5**	**93**	**85**

Boring B-2 **American Tower Site ID 306035 Unity Village MO 2** J029737.02

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
7	**40.5 – 45.5**	**100**	**100**
8	**45.5 – 50.5**	**100**	**86**

Boring B-2 **American Tower Site ID 306035 Unity Village MO 2** J029737.02



Top Run 9

Bottom Run 9

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
9	**50.5 – 55.5**	**100**	**100**

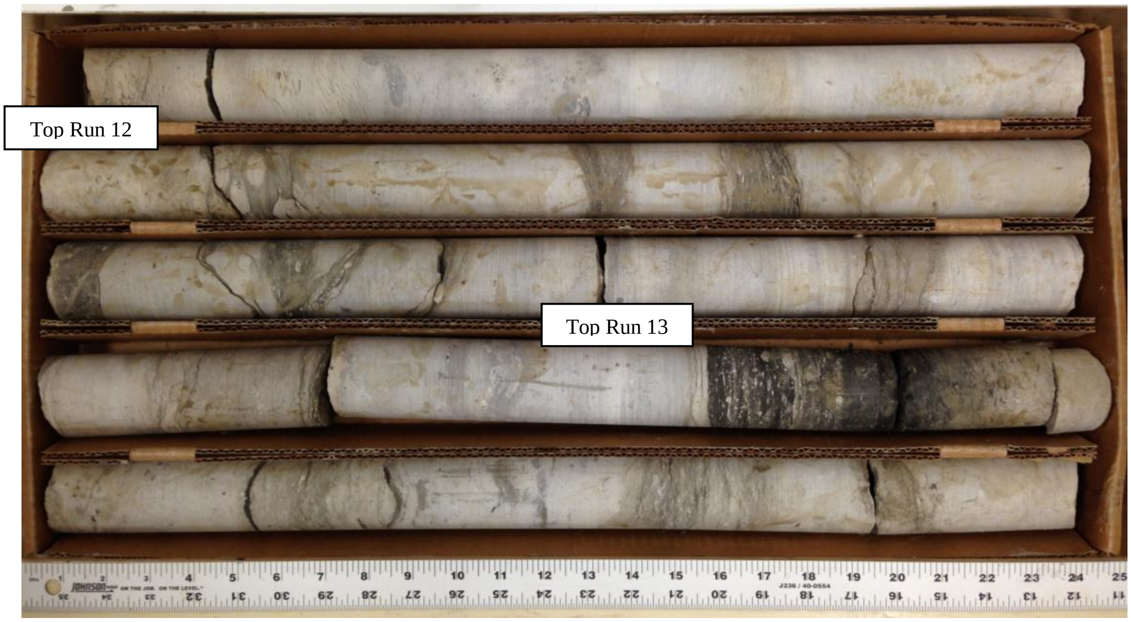
Boring B-2 **American Tower Site ID 306035 Unity Village MO 2** J029737.02

Top Run 10

Top Run 11

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
10	**55.5 – 60.5**	**97**	**97**
11	**60.5 – 65.5**	**100**	**97**

Boring B-2 **American Tower Site ID 306035 Unity Village MO 2** J029737.02



Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
12	**65.5 – 70.5**	**100**	**92**
13	**70.5 – 75.5**	**98**	**98**

Boring B-2 **American Tower Site ID 306035 Unity Village MO 2** J029737.02

Run No.	**Depth (ft)**	**Recovery (%)**	**RQD (%)**
14	**75.5 – 80.5**	**100**	**88**
15	**80.5 – 85.5**	**100**	**90**

Boring B-2

American Tower Site ID 306035 Unity Village MO 2

J029737.02

Top Run 16

Top Run 17

Bottom Run 17

Run No.	Depth (ft)	Recovery (%)	RQD (%)
16	85.5 – 90.5	100	98
17	90.5 – 95.5	98	98