ARDOT
ARKANSAS DEPARTMENT OF TRANSPORTATION

ARKANSAS DEPARTMENT OF TRANSPORTATION
ARDOT.gov | IDriveArkansas.com | Scott E. Bennett, P.E., Director
MATERIALS DIVISION
11301 West Baseline Road | P.O. Box 2261 | Little Rock, AR 72203-2261 | Phone: 501.569.2185 | Fax: 501.569.2368

June 19, 2019

TO: Mr. Trinity Smith, Engineer of Roadway Design

SUBJECT: Job No. 090555
West Fork Crooked Creek Strs. & Apprs. (S)
Route 7 Section 19
Boone County

Based on soil information from projects in the surrounding area, an estimated R-Value of 10 is appropriate for pavement design.

Listed below is the additional information requested for use in developing the plans:

Asphalt Concrete Hot Mix

Type	Asphalt Cement %	Mineral Aggregate %
Surface Course	5.5	94.5
Binder Course	4.4	95.6
Base Course	4.3	95.7

Michael Benson
Michael C. Benson
Materials Engineer

MCB:pt:bjj
Attachment
cc: State Constr. Eng. – Master File Copy
District 9 Engineer
System Information and Research Div.
G. C. File

Revised Geotechnical Engineering Report

Job No. 090555, West Fork Crooked Creek Structures & Approaches
Boone County, Arkansas

September 28, 2020
Terracon Project No. 3520P097.R1

Prepared for:
Arkansas Department of Transportation

Prepared by:
Terracon Consultants, Inc.
Little Rock, Arkansas

September 28, 2020

Terracon GeoReport

Arkansas Department of Transportation
11301 Baseline Road
Little Rock, Arkansas 72209

Attn: Mr. Paul Tinsley
P: (501) 569-2496
E: Paul.Tinsely@ardot.gov

Re: Revised Geotechnical Engineering Report
Job No. 090555, West Fork Crooked Creek Structures & Approaches
Highway 7
Boone County, Arkansas
Terracon Project No. 3520P097.R1

Dear Mr. Tinsley:

We have completed the Revised Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Task Order Number G004, dated May 14, 2020. This report presents the findings of the subsurface investigation and provides geotechnical recommendations concerning the proposed bridge replacement for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact [illegible]

Sincerely,
Terracon Consultants, Inc.
Certificate of Authorization #223 Expires 12/31/2021

No. 7052
MICHAEL H. HOMAN

Kimberly A Daggitt
Kimberly A. Daggitt, P.E.
Project Engineer

Michael H. Homan, [illegible]
Senior Principal/Office Manager
9/28/2020

REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Revised Geotechnical Engineering Report

Job No. 090555, West Fork Crooked Creek Structures & Approaches
Highway 7
Boone County, Arkansas

Terracon Project No. 3520P097.R1
September 28, 2020

INTRODUCTION

This report presents the results of our subsurface investigation and geotechnical engineering services performed for the proposed West Fork Crooked Creek Bridge Replacement along Highway 7 near Boone County, Arkansas. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Bridge foundation design and construction
- Embankment slope stability
- Embankment settlement
- Seismic site class per AASHTO

The geotechnical engineering Scope of Services for this project included the advancement of four bridge borings to depths ranging from approximately 24 to 40 feet below existing site grades and two embankment borings to depth ranging from approximately 15 to 20 feet below the existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field investigation are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field investigation and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	Structure number 02489 at log mile 4.66 on Section 19 of Highway 7 near Harrison in Boone County, Arkansas. See **Site Location**
Existing Improvements	Existing bridge over West Fork Crooked Creek

Item	Description
Current Ground Cover	Existing bridge structure with asphalt pavement approaches and vegetated embankments
Existing Topography	From a provided grading plan, it appears that the planned bridge will be constructed near the same elevation as the existing bridge. If there are any changes in grading, Terracon should be notified to evaluate our recommendations as necessary.
Geology	From our experience near the project site, we expected soil and bedrock typical of the Boone formation to be encountered in the borings. Our expectations were confirmed during the subsurface investigation.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Project Description	ArDOT is proposing to replace the existing bridge with a bridge on an offset alignment to the west of the existing structure. This will necessitate the need to construct bridge approach embankments. Pavement design recommendations are not a part of the geotechnical scope of work for this project.
Bridge Construction	An email dated August 3, 2020 from Mr. Paul Tinsley with ARDOT discusses that the intermediate bridge bents will be supported on shallow foundations and the end bents will be supported on H-piles the are pre-bored into the limestone bedrock.
Maximum Loads	Maximum bridge loads were not provided at the time of the report. We must be notified if any uplift or lateral load resistance is required by design.
Approach Embankments	The new bridge will be constructed to the west of the existing bridge. Based on a provided grading plan, the planned bridge will be constructed near the same elevation as the existing bridge. This will necessitate construction of approach embankments up to 18 feet in height.
Pavements	Pavement sections or recommendations are not in the scope of work for this project.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface investigation, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each investigation point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Embankment and Creek Bed Soils**	Lean clay, silt and clayey sand soils containing varying amounts of sand and gravel.
2	**Bedrock**	Limestone bedrock with interbedded sandstone layers

The boreholes were observed for groundwater while drilling by dry auger. Groundwater was observed in Boring B-4 and Boring E-1 at a depth of 18.5 feet and 5 feet, respectively. Groundwater was not observed in the other borings while drilling with dry auger. Rock coring procedures were utilized to advance the borings to the termination depths. The rock coring procedure utilizes water as a drilling fluid; therefore, groundwater readings taken after the introduction of water into the borehole are not representative of the groundwater conditions. No groundwater measurements were taken after the start of rock coring. The groundwater levels observed in the boreholes can be found on the boring logs in **Exploration Results.**

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structures may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

The Arkansas Department of Transportation is proposing a bridge replacement along Highway 7 over the West Fork of Crooked Creek in Boone County, Arkansas. The native soils and rock encountered at the boring locations are associated with alluvial deposits and the Boone formation. Lean clay, silt, and clayey sand soils were observed in the borings overlying limestone bedrock at the project location. The results of our study indicate that the site can be developed for the proposed bridge replacement and approach embankment construction. During our study the following geotechnical concerns were identified:

- Deeper and lower-strength soils at the south end of the bridge
- Moisture-sensitive soils
- Shallow and hard limestone bedrock

The following discussion addresses these items and provides the basis for design recommendations present in the subsequent sections. Additional construction-related concepts are provided in the various **Construction Consideration** sections of this report.

Low-strength Soils

Lower-strength (soils with SPT N-values of 5 blows per foot or lower) lean clay soils was observed in Boring B-4 and Boring E-2 at varying depths below the existing ground surface. The overburden soils in these two borings extended to depths of 10.5 feet (E-2) and 19.4 feet (B-4). These two borings are at the south end of the proposed bridge. As a contrast, the overburden soils in the remaining borings extend to depths of 2.8 to 5.8 feet.

The lower-strength soils observed at Boring B-4 and Boring E-2 were observed at different depths in the two borings, but at a similar elevation of about 1092 feet. These lower-strength soils will be more compressible than the stiffer soils under new embankment fill loads. We recommend that settlement of new embankment fill be monitored through the installation of settlement plates.

Consideration of general embankment settlement is addressed in the **General Embankment Settlement** section of this report.

Moisture-Sensitive Soils

The lean clay, silt and clayey sand soils that were observed at or near the ground surface at the boring locations are moisture-sensitive and prone to further strength loss with increased moisture content. These soils could become unstable with typical earthwork and construction traffic, especially after precipitation events; therefore, effective site drainage should be developed early in the construction sequence and maintained during and after construction. If possible, the construction should be performed during warmer and drier times of the year. If construction is performed during the winter months, an increased risk for unstable subgrade conditions will occur.

Shallow and Hard Limestone Bedrock

Based on conversations with the client, we understand that shallow foundations are being considered for the support of the intermediate bridge bents and steel H-piles are being considered for the support of the end bents. Borings B-2 and B-3 were drilled near the proposed interior bridge bent locations. These borings encountered about 3.5 feet of overburden soils. Thus, shallow foundations are feasible.

Excavations into the limestone may encounter significant construction difficulties. Given the high unconfined strengths in the limestone, some cost increases above normal excavation costs should be anticipated. Some of the limestone is broken, while other parts are massive. Both will be very difficult to excavate or grade, with conventional excavation equipment and will require other special excavation techniques. Contractors should also be made aware of the relative strength of the limestone, which exhibits intact unconfined strengths more than 18,000 psi, which will cause significant wear and damage to conventional excavation equipment. In our opinion and our experience on past projects, the variability of the overall stratum and the hardness of the limestone will incur significantly higher excavation and foundation construction costs compared to normal construction. The **Shallow Foundations** section addresses the support of the interior bridge bents on shallow foundations.

Borings B-1 and B-4 were drilled near the proposed bridge abutments. Boring B-1 encountered 2.8 feet of overburden and 3.5 feet of fractured limestone with a possible filled void. Boring B-4 encountered 19.4 feet of overburden soils and about 3 feet of weathered fractured limestone. We understand that driven piles will be used to support the bridge abutments. Predrilling will be required at the north end of the bridge, near Boring B-1. The **Deep Foundations** section addresses the support of the bridge abutments on driven piles. The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork should be performed as required in the most recent ArDOT Standard Specification for Highway Construction. The following recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project are considered general recommendations for earthwork on-site. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, and other geotechnical conditions during construction of the project.

Site Preparation

We understand that both shallow and deep foundations are being utilized for the support of the bridge. Because of this, we anticipate that preparation of the subgrade may not be necessary in the bridge foundation areas. Where site preparation and grading are necessary for the roadway and approach aprons to the bridge, surface vegetation, topsoil, pavements and any other surface and subsurface structures should be removed from the construction areas. Unstable subgrade conditions will likely develop during site clearing operations, particularly near the creek and if the soils are wet and/or subjected to repetitive construction traffic. Using low ground pressure (tracked or balloon tired) construction equipment would aid in reducing subgrade disturbance. Even with using low ground pressure equipment, difficult conditions should be expected if the ground surface is disturbed and wetted.

After stripping, completing grading operations, and prior to placing fill, the subgrade should be proof-rolled to aid in locating loose of soft areas. Proof-rolling can be performed with a loaded tandem axle dump truck. Where unstable soils are identified by proof-rolling, stabilization could include scarification, moisture-conditioning and compaction; or removal of unstable materials and replacement with aggregate. The appropriate method of improvement, if required, would depend on factors such as schedule, weather, the size of the area to be treated, and the nature of the instability. More detailed recommendations can be provided during construction. Construction during warm, dry periods would help reduce the amount of subgrade stabilization required.

Fill Material Types

Fill materials should be free of organic matter and debris. Based on the limited lab testing performed, the existing fill material and native soils sampled appear to be suitable for use as engineered fill. Though on-site soils appear suitable, we recommend thorough testing prior to reuse. Materials with plasticity indices greater than 20 should not be used within the upper 2 feet of the finished pavement subgrade.

While ArDOT has no specific requirement for borrow materials, they do require that the material be capable of forming and maintaining stable embankment when compacted. Therefore, we recommend specifically avoiding elastic silts (MH) and organic soils (OL, OH and PT) when considering materials for use as borrow.

We suggest that approved imported borrow soils meet the following material property requirements:

Sieve Size	Percent Finer by Weight (ASTM C136)
3 inches	100
No. 4	50-100
No. 200	15-50

- Plasticity Index……………………………………………………..20(max)

Fill Placement

Where fill is placed on existing slopes steeper than 4H:1V, benches should be cut into the existing slopes prior to fill placement. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface. We recommend that fill slopes be filled beyond the planned final slope face and then cut back to develop an adequately compacted slope face.

Earthwork Construction Considerations

Unstable subgrade conditions are likely to develop during general construction operations, particularly where the soils are wetted and/or subjected to repetitive construction traffic. Unstable soils, where encountered, should be improved in-place prior to placing new engineered fill. If the in-place soils cannot be sufficiently improved, it may be necessary to strip and/or undercut the rutted and wet surface soils prior to performing subgrade improvement. Subgrade improvement techniques are discussed in detail in the following paragraphs.

The near-surface lean clay, silt and clayey sand soils observed at this site are moisture-sensitive and susceptible to disturbance from construction activity, particularly when the soil has a high natural moisture content or is wetted by surface water or seepage. During wetter periods of the year, these soils will pump and rut under the weight of heavy construction equipment, especially rubber-tired vehicles. The contractor should consider using track-mounted (low ground pressure) equipment to reduce subgrade disturbance and/or instability.

If unstable subgrade conditions are encountered, the methods described below can be considered to improve subgrade strength. Common methods include scarification, moisture conditioning and compaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics), and chemical stabilization. The appropriate method of improvement, if required, depends on factors such as schedule, weather, the size of area to be stabilized, and the nature of the instability.

If the exposed subgrade becomes unstable, methods outlined below can be considered.

- **Scarification and Compaction –** It may be feasible to scarify, dry and compact the exposed soils. The success of this procedure would depend primarily upon favorable weather and enough time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near the groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.

- **Crushed Stone –** The use of crushed stone or crushed gravel is the most common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 6 to 30 inches below the finished subgrade elevation. The use of high modulus geosynthetics (i.e., geotextile or geogrid) can also be considered after underground work such as utility construction is completed. Prior to placing the geotextile or geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the geosynthetics. Equipment should not be operated above the geosynthetics until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over the geosynthetics should conform to the manufacturer’s recommendations and generally should not exceed 1½ inches.

Further evaluation of the need for subgrade stabilization should be provided by a qualified geotechnical engineer during construction as the subgrade conditions are exposed on a broad scale.

Temporary excavations will probably be required during grading operations. As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming any responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil, proofrolling, and mitigation of areas delineated by the proof-roll to require mitigation.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

We understand that shallow foundations will be used to support the interior bridge bents. Design parameters for shallow foundations were evaluated in accordance with Federal Highway Administration Report No. FHWA-SA-02-054, Geotechnical Engineering Circular No. 6, Shallow Foundations as well as AASHTO LRFD Section 10. The values provided in the table below were developed based on our analysis of the rock mass quality, degree of alteration, degree of interbedding and our interpretation of the stratigraphy at interior bent borings B-2 and B-3. Suggested resistance factors for the structural limit state for the rock types observed at this project are included in the table.

Design Parameters – Compressive Loads

Design Parameter	Value/Description
Nominal End Bearing	100 ksf
Resistance Factor for Footing on Rock [1]	0.45
Required Bearing Stratum [2]	Limestone bedrock
Minimum Embedment below Finished Grade [3]	24 inches
Estimated Total Settlement from Structural Loads	Less than 1 inch
Estimated Differential Settlement	About 2/3 of total settlement

Design Parameter	Value/Description

1. AASHTO Table 10.5.5.2.2-1
2. Unsuitable, loose or soft rock should be over-excavated to expose solid competent rock. We anticipate that this will require the removal of 1 to 2 feet of weathered, fractured rock.
3. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.

Terracon must be notified if any of the Service, Structural or Extreme Limit states for the bridge structure will require uplift or lateral resistance. Low-strength overburden soils observed above the existing bedrock will not provide adequate resistance; therefore, to resist uplift and lateral loads, a deeper socket into the bedrock may be necessary.

Foundation Construction Considerations

Excavations into the limestone may encounter significant construction difficulties. Given the high unconfined strengths in the limestone, some cost increases above normal excavation costs should be anticipated. Some of the limestone is broken, while other parts are massive. Both will be very difficult to excavate or grade, with conventional excavation equipment and will require other special excavation techniques. Contractors should also be made aware of the relative strength of the limestone, which exhibits intact unconfined strengths in excess of 18,000 psi, which will cause significant wear and damage to conventional excavation equipment. In our opinion and our experience on past projects, the variability of the overall stratum and the hardness of the limestone will incur significantly higher excavation and foundation construction costs compared to normal construction.

The shallow foundations should be constructed under the observation of experienced Terracon personnel. The base of all foundation excavations should be free of water and loose, broken or soft rock prior to placing concrete. Concrete should be placed soon after excavating to reduce foundation bearing disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry materials or any loose/disturbed material in the bottom of the foundation excavations should be removed before foundation concrete is placed. We recommend that a thin concrete seal slab (mud mat) be constructed to protect the foundation and facilitate placement of reinforced steel.

DEEP FOUNDATIONS

Driven Pile Design Parameters

We understand steel HP piles could be used to support the bridge structure at the proposed end abutments. Driven piles will develop their resistance from end bearing in the limestone bedrock. Based on the above information, we recommend that the driven piles at the bridge abutments tip out in the observed limestone bedrock. Based on Section 10.7.3.2.3 of the AASHTO LRFD Bridge Design Specification, the nominal resistance of piles driven to point bearing on competent bedrock is controlled by the structural limit state of the pile. As a result, the nominal compressive resistance of the pile for various limit states should be designed in accordance with the referenced AASHTO specifications. We understand that the piles will be pre-drilled; therefore, according to Section 6.5.4.2 of the AASHTO Specifications, a structural resistance factor of 0.6 should be applied to the H-piles.

Since variation may occur in depth and strength of bedrock due to the distance away from the performed borings, all piles should be driven until satisfactory driving resistance is developed. Considering the above information, the approximate elevations of top of rock observed at borings performed at the end bents are listed below.

Pile Location	Approximate Elevation at Top of Competent Limestone Bedrock[1,2,3]
Boring B-1	1082.5
Boring B-4	1079

1. Based on observations of cores of the bedrock from the borings performed on-site. Conditions can vary away from these performed borings. We recommend predrilling through the upper 3 to 4 feet of limestone bedrock to realize the elevations noted as competent Limestone Bedrock.
2. Nominal resistances are applicable if the center to center spacing of the piles is equal to or greater than 3 times the maximum pile section diameter.
3. The factored resistance values can be calculated by multiplying the nominal resistance by the structural resistance factor (phi) of 0.6.

Driven Pile Lateral Loading

We understand that battered piles will be used to resist lateral loading at the bridge abutments.

Driven Pile Construction Considerations

We understand the driven piles will be pre-drilled to reduce the potential for pile damage. We recommend welding reinforced high strength cast steel tips to the bottom of the H-piles to help key the end of the pile into the limestone bedrock formation and reduce the potential for pile damage.

We anticipate that the long-term settlement of driven piles designed as recommended in this report, constructed in accordance with ARDOT requirements, and observed during construction, would be about ½ inch in addition to elastic shortening of the pile materials for the Service I Limit State Loading.

Pile driving refusal in bedrock is likely to be achieved with limited penetration (+/- 1 to 2 feet) into the bedrock. For refusal criteria when driving piles into bedrock, we recommend the piles be driven to the ultimate bearing capacity with penetration per blow equivalent to or less than a rate of 20 blows per 1 inch. The pile hammer should be sized and operated to maintain driving stresses less than 90 percent of the yield stress of steel. Driving should stop immediately when these criteria are met to avoid damage to the pile.

GENERAL EMBANKMENT SETTLEMENT

Based on the 60% Design Drawings, we anticipate embankments up to 18 feet in height. Borings B-1 and E-1, on the north end of the bridge, encountered bedrock at depths of 3 feet and 6 feet, respectively. Borings B-4 and E-2, on the south end of the bridge, encountered bedrock at depths of 19 and 10 feet, respectively. Thus, we expect more settlement of the new embankment fill on the south end of the bridge versus the north end of the bridge. Most of the embankment settlement observed will likely be due to embankment compression as described in the Fill Embankment Slopes table below. We anticipate about 3 to 4 inches of total settlement in the embankment and native foundation soils at the south end of the bridge. Because there is less overburden at the north end of the bridge, we anticipate that settlement will be slightly less than 3 to 4 inches. We anticipate that settlement will occur over a 4 to 6-month timeframe with about half of the settlement occurring during construction of the embankment.

FILL EMBANKMENT SLOPE CONSIDERATIONS

We understand that bridge approach embankments are planned for this project. Borrow sources for the embankment fill materials have not yet been identified. We assume soils in the embankment will be comparable to the observed on-site soils. From a performed stability analysis, the proposed 2H:1V end bent slope has a factor of safety of 1.5 or greater and is expected to have adequate long-term stability if satisfactory borrow material is utilized to construct the fill. Results of the performed stability analysis are attached in the **Figures** section of this report.

SEISMIC CONSIDERATIONS

Code Reference	Site Classification
AASHTO LRFD Bridge Design Specifications [1]	C [1]

1. In general accordance with *AASHTO LRFD Bridge Design Specifications*. Site class determination is based on average properties of the subsurface profile within 100 feet of the ground surface. The exploratory borings extended to maximum depth of about 39 feet at the location of the bridge. Terracon's opinion of site class is based on data from the borings and our knowledge of geotechnical and geologic conditions at this locale.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site investigation. Natural variations will occur between investigation point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, cost estimating, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

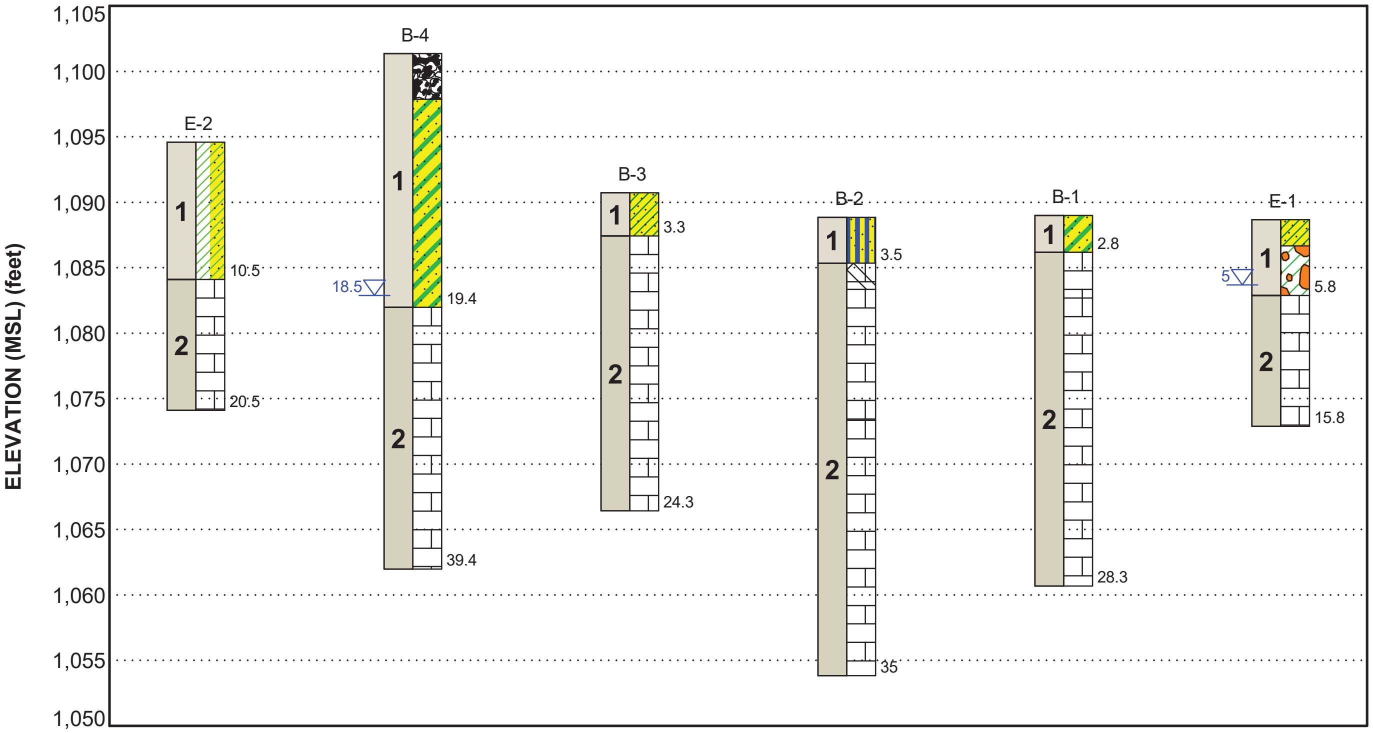
FIGURES

Contents:

GEOMODEL

West Fork Crooked Creek Bridge ■ Boone County, Arkansas
Terracon Project No. 3520P097

Terracon GeoReport



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Embankment and Creek Bed Soils**	Lean clay, silt, and clayey sand soils containing varying amounts of sand and gravel.
2	**Bedrock**	Limestone bedrock with interbedded sandstone layers

LEGEND

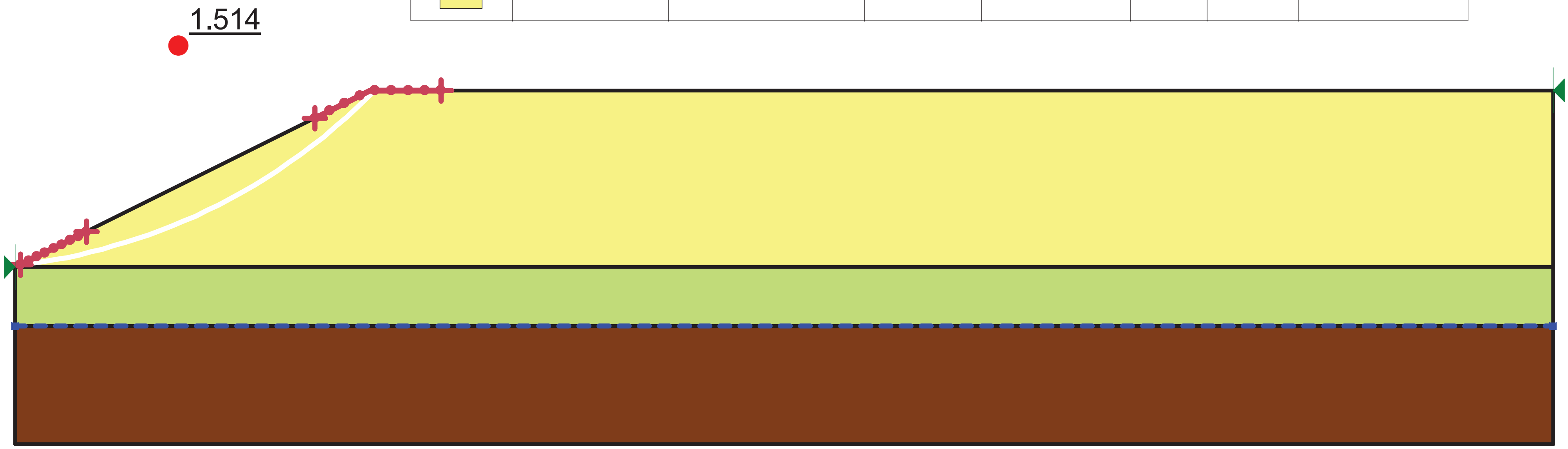
▨ Clayey Sand
☐ Limestone
▥ Sandy Silt
▧ Weathered Limestone
▨ Sandy Lean Clay
▩ Fill
▨ Clayey Gravel
▨ Lean Clay with Sand

▽ First Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟫	bedrock	Bedrock (Impenetrable)					1
🟩	native overburden	Mohr-Coulomb	120	0	28	0	1
🟨	onsite fill	Mohr-Coulomb	125	20	32	0	1



ATTACHMENTS

INVESTIGATION AND TESTING PROCEDURES

Field Investigation

Number of Borings	Boring Depth (feet)	Planned Location
4	24 to 40	Bridge borings
2	15 to 20	Embankment borings

Boring Layout and Elevations: The locations of the field investigation (borings) were measured in the field by Terracon's investigation team using a hand-held GPS unit to measure the latitude and longitude coordinates. The accuracy of the investigation points is usually within about +/- 20 feet horizontally of the noted location. After completion of the borings, Terracon surveyed the borings. The latitude and longitude and northing and easting coordinates as well as the ground surface elevations of the borings are provided on the borings logs from a performed field survey.

Subsurface Investigation Procedures: We advanced the borings with a track-mounted, drill rig using continuous flight augers to auger refusal. Upon encountering bedrock or refusal-to-drilling conditions, rock coring (using an NQ rock core barrel) was performed. Rock coring was performed in the borings to depths of at least 20 feet beyond auger refusal. Water was used as a drilling fluid for rock coring and the spent water was discharged onsite. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. For the rock cores, the percent recovered and rock quality designation (RQD) were measured in the field and are also reported on the boring logs. We observed and recorded groundwater levels during auger drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our investigation team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

Representative soil samples were tested in the laboratory to measure their natural water content, gradation and Atterberg limits. The test results are provided on the appended boring logs and laboratory test reports.

The soil samples were classified in the laboratory based on visual observation, texture, plasticity, and the laboratory testing described above. The soil descriptions presented on the boring logs are in accordance with the enclosed General Notes and Unified Soil Classification System (USCS). The estimated USCS group symbols for native soils are shown on the boring logs, and a brief description of the USCS is included in this report.

The bedrock materials encountered in the borings were described in accordance with the appended Description of Rock Properties on the basis of visual classification of disturbed auger cuttings and drilling characteristics. Core samples and petrographic analysis may indicate other rock types.

SITE LOCATION AND INVESTIGATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Job No. 090555, West Fork Crooked Creek Structures & Approaches ■ Boone County, Arkansas
September 28, 2020 ■ Terracon Project No. 3520P097.R1

Terracon GeoReport

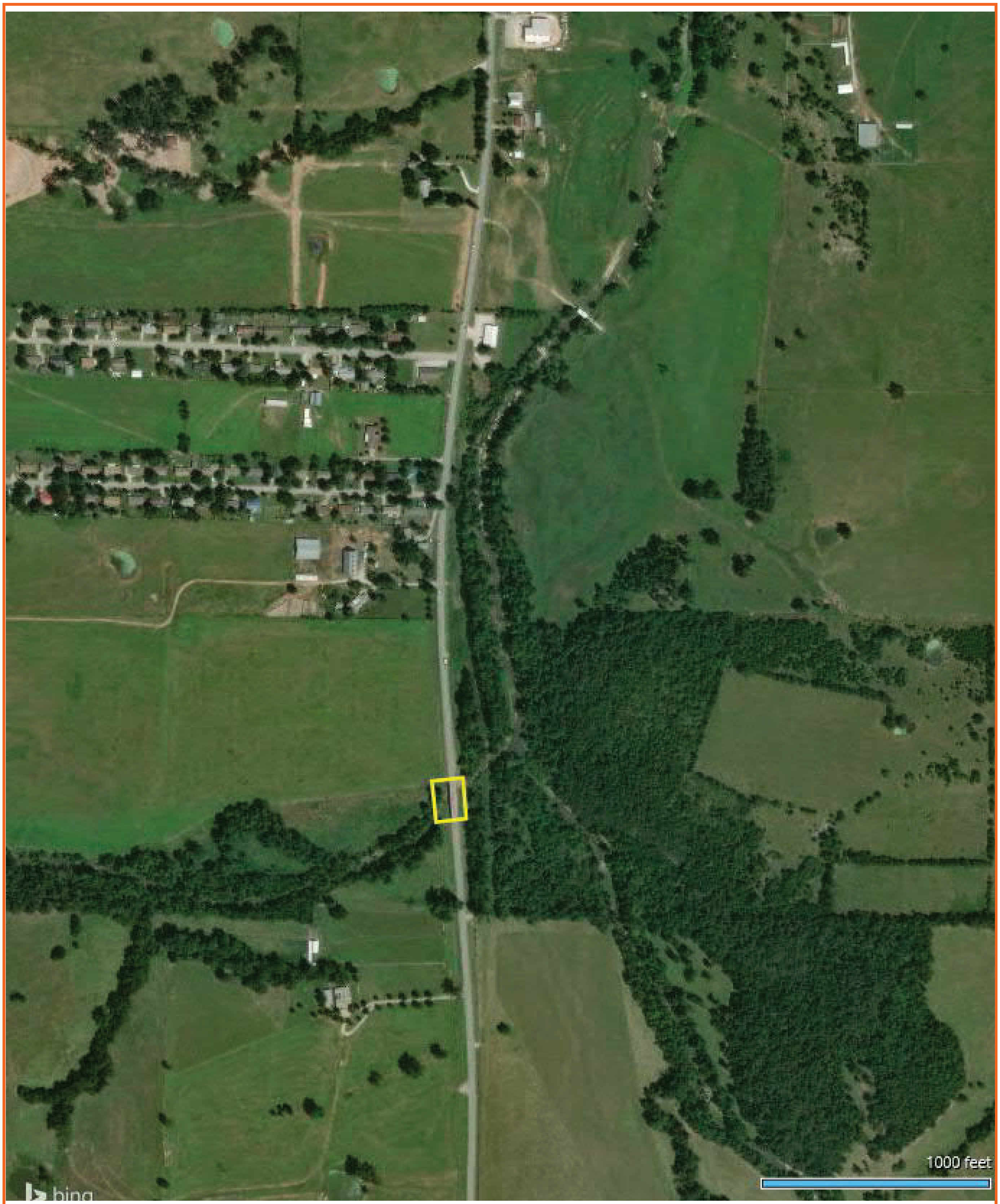


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

INVESTIGATION PLAN

Job No. 090555, West Fork Crooked Creek Structures & Approaches ■ Boone County, Arkansas
September 28, 2020 ■ Terracon Project No. 3520P097.R1

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Boring Logs (B-1 through E-2)

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

Page 1 of 2

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675691.319 Easting: 980698.558

Surface Elev.: 1088.983 (Ft.)

MODEL LAYER	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST TEST TYPE	STRENGTH TEST COMPRESSIVE STRENGTH (psi)	STRENGTH TEST STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	**CLAYEY SAND (SC)**, with gravel, brown, medium dense to very dense					3-5-14 N=19				7.8		26-16-10	35
						3-50/3"				8.4			
	2.8	1086											
2	**LIMESTONE**, gray, moderately hard rock, concrete in sample from about 5 to 7.5 feet. Possible filled void		5			REC = 40% RQD = 14%							
	6.3	1082.5											
	LIMESTONE, with interbedded sandstone layers, gray, hard rock, moderately fractured, close fracture spacing, slightly weathered		10			REC = 77% RQD = 57%	UC	10506					
			15			REC = 100% RQD = 80%							
			20			REC = 100% RQD = 90%	UC	16674					
			25			REC = 100% RQD = 100%							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 2.8 feet: Hollow-stem auger
2.8 to 28.3 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-16-2020	Boring Completed: 07-16-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

BORING LOG NO. B-1

PROJECT: **West Fork Crooked Creek Bridge**

CLIENT: **Arkansas Department of Transportation**
Little Rock, Arkansas

SITE: **HWY-7**
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675691.319 Easting: 980698.558

Surface Elev.: 1088.983 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS	PERCENT FINES
							TEST TYPE	COMPRESSIVE STRENGTH (psi)	STRAIN (%)			LL-PL-PI	
2		**LIMESTONE**, with interbedded sandstone layers, gray, hard rock, moderately fractured, close fracture spacing, slightly weathered *(continued)* 28.3 1060.5				REC = 100% RQD = 92%							
		Boring Terminated at 28.3 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 2.8 feet: Hollow-stem auger
2.8 to 28.3 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-16-2020
Boring Completed: 07-16-2020
Drill Rig: CME #763
Driller: ME
Project No.: 3520P097

BORING LOG NO. B-2

Page 1 of 2

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675669.308 Easting: 980687.604

Surface Elev.: 1088.848 (Ft.)

MODEL LAYER	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		**SANDY SILT (ML)**, brown, stiff to hard					4-4-4 N=8				8.5		NP	51
	3.5		1085.5				3-2-50 N=52				11.4			
2	5.5	**LIMESTONE**, gray, moderately hard rock, moderately fractured, very close fracture spacing, moderately weathered	1083.5	5			REC = 100% RQD = 46%							
		LIMESTONE, with interbedded sndstone layers, gray, moderately hard to hard rock, moderately fractured, very close fracture spacing, slightly weathered		10			REC = 100% RQD = 83%	UC	15768					
	15.5	- apparent weaker sandstone seam from about 12.5 feet to 14.5 feet	1073.5	15			REC = 50% RQD =40%							
		LIMESTONE, gray, moderately hard to hard rock, slightly fractured, close fracture spacing, slightly weathered		20			REC = 97% RQD = 68%	UC	18749					
				25			REC = 93% RQD = 68%							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 3.5 feet: Hollow-stem auger
3.5 to 35 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-16-2020	Boring Completed: 07-16-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

BORING LOG NO. B-2

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Northing: 675669.308 Easting: 980687.604 Surface Elev.: 1088.848 (Ft.) DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**LIMESTONE**, gray, moderately hard to hard rock, slightly fractured, close fracture spacing, slightly weathered *(continued)*	30			REC = 100% RQD = 92%							
		35.0 / 1054	35			REC = 100% RQD = 72%	UC	14880					
		Boring Terminated at 35 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 3.5 feet: Hollow-stem auger
3.5 to 35 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-16-2020	Boring Completed: 07-16-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

BORING LOG NO. B-3

Page 1 of 1

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675563.94 Easting: 980706.951

Surface Elev.: 1090.715 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	▨	**SANDY LEAN CLAY (CL)**, brown, stiff to hard			☒	3-3-4 N=7				9.0			
					☒	2-2-50/3"				12.0			
		3.3 / 1087.5											
2		**LIMESTONE**, with interbedded sandstone layers, gray, light gray and brown, moderately hard to hard rock, moderately to slightly fractured, close fracture spacing, slightly weathered				REC = 92% RQD = 33%							
			5			REC = 70% RQD = 15%	UC	6811					
			10			REC = 100% RQD = 68%							
			15			REC = 97% RQD = 78%	UC	8753					
			20			REC = 98% RQD = 68%							
		24.3 / 1066.5											

Boring Terminated at 24.3 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 3.3 feet: 4-inch casing with drag bit
3.3 to 24.3 feet: Diamond bit rock core

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-13-2020	Boring Completed: 07-13-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 3520P097 WEST FORK CROOKED KIMS COPY.GPJ TERRACON_DATATEMPLATE.GDT 8/26/20

BORING LOG NO. B-4

Page 1 of 2

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675477.594 Easting: 980719.301

Surface Elev.: 1101.368 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	▩		**FILL - SILTY SAND**, with gravel, dark brown				☒	4-7-7 N=14				3.5			
	▩						☒	11-6-5 N=11				10.4		NP	45
	▨	3.5	**CLAYEY SAND (SC)**, brown, loose to very dense	1098			☒	2-2-4 N=6				13.7			
	▨				5		☒	5-6-15 N=21				14.0			
	▨				10		☒	3-2-2 N=4				16.7			46
	▨				15		☒	2-3-5 N=8				16.4			
	▨		- rock fragments at about 19 feet			▽	☒	3-50/5"				21.8			
2	▦	19.4	**LIMESTONE**, with interbedded sandstone seams, gray, moderately hard to hard rock, moderately fractured, close fracture spacing, slightly weathered	1082	20		▮	REC= 64% RQD = 25%							
	▦				25		▮	REC = 97%							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 19.4 feet: Hollow-stem auger
19.4 to 39.4 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *18.5 feet while drilling*

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-14-2020	Boring Completed: 07-15-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 3520P097 WEST FORK CROOKED KIMS COPY.GPJ TERRACON_DATATEMPLATE.GDT 8/26/20

BORING LOG NO. B-4

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675477.594 Easting: 980719.301

Surface Elev.: 1101.368 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**LIMESTONE**, with interbedded sandstone seams, gray, moderately hard to hard rock, moderately fractured, close fracture spacing, slightly weathered *(continued)*				RQD = 62%	UC	7320					
			30			REC = 98% RQD = 55%							
			35			REC = 100% RQD = 40%	UC	8896					
		39.4 1062				REC = 100% RQD = 71%							
		Boring Terminated at 39.4 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 19.4 feet: Hollow-stem auger
19.4 to 39.4 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *18.5 feet while drilling*

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-14-2020	Boring Completed: 07-15-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

BORING LOG NO. E-1

Page 1 of 1

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: HWY-7
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675689.019 Easting: 980669.352

Surface Elev.: 1088.674 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		2.0	**SANDY LEAN CLAY (CL)**, trace gravel, brown, very stiff	1086.5			☒	5-11-11 N=22				7.0		32-16-16	51
		5.8	**CLAYEY GRAVEL (GC)**, brown, medium dense to very dense	1083			☒	15-13-8 N=21				14.1			
					5	▽	☒	3-50/3"				24.5			
2		15.8	**LIMESTONE**, with interbedded sandstone layers, gray, moderately hard rock, moderately fractured, very close fracture spacing, slightly weathered	1073			▮	REC = 75% RQD = 0%							
					10		▮	REC = 57% RQD = 47%							
					15		▮	REC = 81% RQD = 50%							

Boring Terminated at 15.8 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 5.8 feet: Hollow-stem auger
5.8 to 15.8 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *5 feet while drilling*

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-17-2020
Boring Completed: 07-17-2020
Drill Rig: CME #763
Driller: ME
Project No.: 3520P097

BORING LOG NO. E-2

Page 1 of 1

PROJECT: West Fork Crooked Creek Bridge

CLIENT: Arkansas Department of Transportation
Little Rock, Arkansas

SITE: **HWY-7**
Boone County, Arkansas

LOCATION See Exploration Plan

Northing: 675442.152 Easting: 980694.484

Surface Elev.: 1094.592 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psi)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	▨	**LEAN CLAY WITH SAND (CL)**, brown, medium stiff to stiff			☒	5-5-4 N=9				9.6			
					☒	2-2-3 N=5				15.3		23-10-13	73
					☒	2-3-3 N=6				13.9			
			5		☒	4-5-6 N=11				15.0			
					☒	4-6-7 N=13				13.5			
		10.5 / 1084	10										
2	▦	**LIMESTONE**, with interbedded sandstone layers, gray, slightly fractured, close fracture spacing, slightly weathered	15		▮	REC = 85% RQD = 38%							
			20		▮	REC = 92% RQD = 70%							
		20.5 / 1074											

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0 to 10.5 feet: Hollow-stem auger
10.5 to 20.5 feet: Diamond bit rock coring

Abandonment Method:
Boring backfilled with Auger Cuttings and bentonite chips

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 07-14-2020	Boring Completed: 07-14-2020
Drill Rig: CME #763	Driller: ME
Project No.: 3520P097	

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

West Fork Crooked Creek Bridge ■ Boone County, Arkansas
Terracon Project No. 3520P097

SAMPLING

▮ Rock Core

☒ Standard Penetration Test

WATER LEVEL

▽	**Water Initially Encountered**
▽	**Water Level After a Specified Period of Time**
▼	**Water Level After a Specified Period of Time**
▨	**Cave In Encountered**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
UC	**Unconfined Compressive Strength**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psi)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 3.50	0 - 1
Loose	4 - 9	Soft	3.5 to 7.0	2 - 4
Medium Dense	10 - 29	Medium Stiff	7.0 to 14.0	4 - 8
Dense	30 - 50	Stiff	14.0 to 28.0	8 - 15
Very Dense	> 50	Very Stiff	28.0 to 55.5	15 - 30
		Hard	> 55.5	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	**Group Name [B]**
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$\text{Cu} \geq 4$ and $1 \leq \text{Cc} \leq 3$ [E]		GW	Well-graded gravel [F]
			$\text{Cu} < 4$ and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$\text{Cu} \geq 6$ and $1 \leq \text{Cc} \leq 3$ [E]		SW	Well-graded sand [I]
			$\text{Cu} < 6$ and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$\text{PI} > 7$ and plots on or above “A”		CL	Lean clay [K, L, M]
			$\text{PI} < 4$ or plots below “A” line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K, L, M]
			PI plots below “A” line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $\text{Cu} = D_{60}/D_{10} \qquad \text{Cc} = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

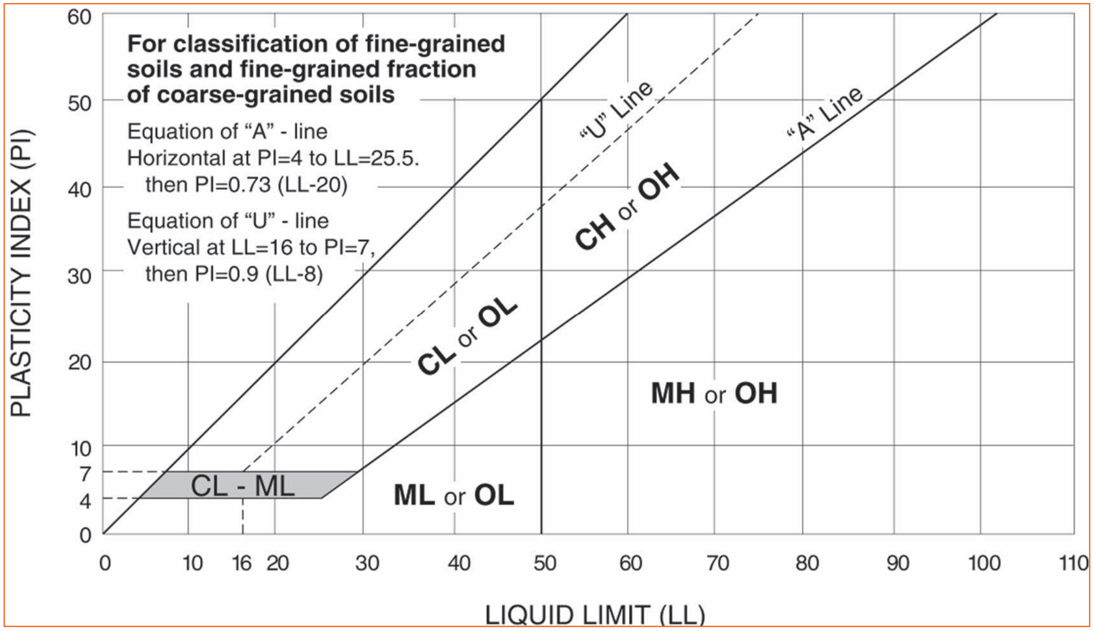
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] $\text{PI} \geq 4$ and plots on or above “A” line.

[O] $\text{PI} < 4$ or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



For classification of fine-grained soils and fine-grained fraction of coarse-grained soils

Equation of “A” - line
Horizontal at PI=4 to LL=25.5.
then PI=0.73 (LL-20)

Equation of “U” - line
Vertical at LL=16 to PI=7,
then PI=0.9 (LL-8)

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.