COUNTY OF ALBANY

COUNTY ROAD 352 (FOX CREEK ROAD) OVER FOX CREEK BRIDGE REPLACEMENT PROJECT

RFB-2022-130

ADDENDUM #1

November 25, 2022

The following Addendum No. 1 consisting of forty two (42) pages (including this cover page) is hereby issued on the25th day of November 2022, in connection with the Request for Bids 2022-130 as requested by the Albany County Department of Public Works.

COUNTY OF ALBANY

RFB-2022-130
COUNTY ROAD 352 (FOX CREEK ROAD) OVER FOX CREEK BRIDGE REPLACEMENT PROJECT

ADDENDUM #1

The following information is provided as a result of a question(s) posed by vendor(s):

ITEM #1: Note 1 on sheets 21 and 23 (ST-5 and ST-7) states that the concrete for the piles shall have a minimum compressive strength of 4000 psi. Note 5 states that the pile work shall be done in accordance with 551.13 and 551.11 which states the piles shall be filled with Class A concrete (or accepted substitution per NYSDOT specifications), please clarify if a separate 4000 psi mix will be required or if the pile concrete shall be per NYSDOT specifications.

Response #1: Concrete used for the piles shall be in accordance with the requirements of the Standard Specifications. The requirement for 4,000 PSI compressive strength shall not apply.

ITEM #2: Note 7 on Sheets 21 and 23 (ST-5 and ST-7) states that the piles shall be driven to the minimum length in the legend. The legend lists an approximate embedment depth for all piles but does not provide a minimum depth of pile. Please clarify the minimum depth of the pile.

Response #2: Piles must be driven a minimum depth of 10' below the Q500 design scour elevation.

ITEM #3: Please clarify if the dynamic pile testing shall be performed at the time of initial pile installation or if there shall be a "waiting period" from initial driving to the performance of the dynamic pile test as can tend to be a construction practice utilized for resistance type piles.

Response #3: Dynamic pile testing may be performed during initial drive or during re-strike after a waiting period. If the design pile capacity is met during initial drive, then no waiting period or restrike is required. If design pile capacity is not met at the end of initial drive, or not measured during initial drive, then dynamic pile testing should be performed during a restrike after a waiting period of 2-3 days. One vertical pile shall be tested at each abutment. The piles are designed for a factored bearing resistance of 87 kips.

COUNTY OF ALBANY

RFB-2022-130
COUNTY ROAD 352 (FOX CREEK ROAD) OVER FOX CREEK BRIDGE REPLACEMENT PROJECT

ADDENDUM #1

ITEM #4: Please provide the boring logs/report in a separate file as it was stated that the contract documents that the report was to be included in the project manual as some information is difficult to interpret on Sheet 16.

Response #4: The Geotechnical Engineering Report is provided as part of this addendum.

ITEM #5: There are compliants of the bid documents on the Empire State Bidnet website being corrupt. Bidnet is aware of this problem but has been unable to correct it. Please email Maureen.shea@albanycountyny.gov. The documents will be emailed to you in a series of five (5) emails. The USB can also be obtained from the Albany County Purchasing Division, 112 State Street, Room 1000, Albany, NY 12207. The files are too large to email all at once. If you would like a USB sent to you, please email with your address and Fedex account number. The Geotechnical Engineering Report is provided.

End of Addendum #1

Geotechnical Engineering Report

Proposed Bridge Replacement
CR 352 over Fox Creek
Town of Rensselaerville, New York
February 28, 2022
Terracon Project No. JB215239

Prepared for:
Creighton Manning Engineering, LLP
Albany, New York

Prepared by:
Terracon Consultants - NY, Inc.
Albany, New York

February 28, 2022

Creighton Manning Engineering, LLP
2 Winners Circle
Albany, New York 12205

Attn: Mr. Luke Thompson, P.E.
p: (518) 605-1642
e: lthompson@cmellp.com

Re: Geotechnical Engineering Report
Proposed Bridge Replacement
CR 352 over Fox Creek
Town of Rensselaerville, New York
Terracon Project No. JB215239

Dear Mr. Thompson:

We have completed the Geotechnical Engineering services for the referenced project. This study was performed in general accordance with Terracon proposal no. PJB215239 dated November 23, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and abutments 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 us at your convenience.

Sincerely,
Terracon Consultants-NY, Inc.

John T. Odorisio, P.E.
Senior Engineer

John S. Hutchison, P.E.
Senior Engineer

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. 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.

Geotechnical Engineering Report

Proposed Bridge Replacement
CR 352 over Fox Creek
Town of Rensselaerville, New York
Terracon Project No. JB215239
February 28, 2022

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed bridge replacement project on CR 352 in the town of Rensselaerville, New York. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Lateral earth pressures
- Seismic site classification per AASHTO
- Dewatering considerations

The geotechnical engineering Scope of Services for this project included the advancement of two test borings to depths of 51.5 feet below existing site grade, visual classification and limited laboratory testing of recovered soil samples, evaluation of findings and preparation of this summary report.

Maps indicating the site and test boring locations are included as the attached **Site Location** and **Exploration Plan**, respectively.

SITE CONDITIONS

The project site is located at the bridge carrying CR 352 (Fox Creek Road) over Fox Creek in the town of Rensselaerville, Albany County, New York. The approximate project geographic coordinates are 42.4455º N / 74.1941º W.

It is our understanding the existing bridge dates from 1935 and is a single span structure which is approximately 36 feet in length and 30 feet in width. The bridge features a single travel lane in each direction, with its deck at about elevation 920 feet according to USGS topographic mapping. The bridge deck is about 10 feet higher in elevation than the creek bed.

Sometime after its original construction, we understand an invert slab was constructed at the base of the channel beneath the bridge as part of a rehabilitation project, and a scour hole upwards of 5 to 10 feet deep has reportedly developed at the downstream end of the slab.

PROJECT DESCRIPTION

As we understand it, the project entails replacement of the bridge with a new structure with marginally longer span (about 40 feet) and similar width. No substantial change in alignment or grade are anticipated. A precast three sided type structure is anticipated for the replacement bridge. The streambed on the outlet side will be raised to eliminate the scour hole under this scenario.

We understand the new bridge will be designed using AASHTO LRFD Bridge Design Specifications. Anticipated foundation design loads were not available at the time of this report.

If any of the above information is incorrect, please let us know so we can review the conclusions and recommendations provided in this report for applicability to the actual design and update the report as appropriate.

As the design of the project progresses and site grading plans and structural loads are fully developed, we should be retained to assess such additional information relative to the recommendations contained herein.

SUBSURFACE CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, 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 exploration point are indicated on the individual subsurface 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.

Subsurface Conditions

As part of our analysis, 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	**Native Coarse-Grained Soils**	Predominantly sand with varying proportions of silt and gravel, occasional cobbles.
2	**Native Fine-Grained Soils**	Predominantly silt with varying proportions of sand and gravel, occasional fine sand or gravel lenses.

Surface Materials and Fill Soils

Pavement, consisting of about 6 inches of asphalt underlain by 14 inches of crusher run base, was encountered at the ground surface at test boring B-1. Reinforced concrete, about 15 inches in thickness and underlain by 20 inches of crusher run base, was encountered at the ground surface at borehole B-2.

Materials readily identifiable as fill were not encountered, although it is possible the upper few feet of soils beneath the pavements in each boring represent abutment backfill, approach embankment fill, reworked soils or some combination thereof.

Native Soils

Native soils consisting of interbedded layers of either predominantly coarse-grained or fine-grained materials were encountered underlying the surface materials. The coarse-grained soils generally consisted of silty sand with varying amounts of gravel and occasional cobbles (also note that cobbles/boulders appear to line the streambed). Banding and fine sand lenses were occasionally noted in portions of the coarse-grained soils. Laboratory testing indicates the coarse-grained soils have fines contents (i.e., material passing the no. 200 mesh sieve) ranging from 35.5 to 49.1 percent and moisture contents of 10 to 12.4 percent. Based upon the measured standard penetration N-values, the coarse-grained soils were typically medium dense; however, they were occasionally found to be dense to very dense.

Where fine-grained, the native soils generally consisted of sandy silt with gravel or gravelly silt with sand with occasional fine sand or gravel lenses. Laboratory testing indicates the predominantly fine-grained soils had fines contents ranging from 57.2 to 68.7 percent and moisture contents of 11.8 to 16.9 percent. Measured standard penetration N-values indicate these soils are stiff to very stiff.

The findings of the subsurface investigation are in general agreement with the Surficial Geologic Map of New York, which indicates outwash sand and gravel overburden soils along the Fox Creek valley floor. With depth, the deposits collectively exhibit the characteristics of glacial till.

Bedrock was not encountered within the depths explored, 51.5 feet. For information purposes, the Geologic Map of New York indicates that bedrock in the area consists of shales and sandstones of the Lower Hamilton Group.

Groundwater Conditions

Groundwater was measured at a depth of 46.5 feet below existing grade at the completion of borehole B-1, about where recovered soil samples became wet. Also note that soil mottling, often indicative of temporarily/seasonally perched groundwater, was noted between the depths of about 1.5 and 3 feet at this location.

At test boring B-2, groundwater was initially measured at a depth 8 feet as the borehole was advanced. With the augers removed upon completion of sampling and prior to backfilling, water was observed running into the open borehole at a depth of about 12 feet. The recovered soil samples at borehole B-2 were found to be intermittently wet, typically corresponding with deposits which were more granular.

In general, we expect that groundwater prevails at or about stream level and below, although some of the underlying deposits were found to be essentially non-water bearing.

As indicated by the findings at borehole B-1, locally perched or trapped groundwater may be present at times within the upper soils nearer the ground surface, particularly during seasonally wet periods and following heavy or extended periods of precipitation. It should be expected that groundwater conditions, and the extent of any perched water, will vary with specific location, seasonal fluctuations in precipitation and runoff, and with accompanying water levels in the stream. Additionally, grade adjustments on and around the site, as well as surrounding drainage improvements, may affect the water table. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

Based on the results of this investigation, it is our opinion the proposed bridge may be supported on deep foundations seated in the native overburden soils, such as drilled micropiles or driven pipe piles. Factored resistances in the range of about 68 to 108 kips or more are estimated for piles situated within the depths explored, depending on the type and size of the pile selected. Greater capacities would likely be justifiable if a suitable end bearing stratum consisting of dense glacial till and/or bedrock is found through further exploration below the current boring depths.

Alternatively, consideration may be given to supporting the bridge on shallow spread foundations provided that adequate scour protection can be provided.

Groundwater is expected to be present at or near the water level in Fox Creek and accordingly, dewatering should be planned for excavations extending below these depths. It should be possible to complete the dewatering with standard sump and pump methods provided excavations are sufficiently isolated from the stream. Dewatering is a means and methods consideration for the contractor.

The following report sections provide applicable geotechnical recommendations to assist in planning for the earthworks and design and construction of foundations. We should be provided with the opportunity to review plans and specifications prior to their release for bidding to confirm that our recommendations were properly understood and implemented, and to allow us to refine our recommendations, if warranted, based upon the final design.

The **General Comments** section provides an understanding of the report limitations.

SEISMIC CONSIDERATIONS

The seismic design requirements for bridges and other structures are based on Seismic Design Category. Assignment of seismic Site Class is required to determine the Seismic Design Category for a structure. The Site Class is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength, in accordance with the AASHTO LRFD specifications in this case.

Seismic Site Classification

In our estimation, the seismic Site Class is D. This classification is made based on the soil properties encountered at the site along with our experience and knowledge of geologic conditions in the general area. Deeper test borings or geophysical testing may be performed to confirm the conditions below the current boring depths if desired.

Liquefaction

The site is situated in Seismic Zone 1 as determined by the AASHTO procedures, and as such, no liquefaction assessment is required per the specifications therein.

EARTHWORK

Earthwork is anticipated to include demolition of the existing structure, excavation for new foundations or pile caps, construction dewatering and backfilling of the excavations. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered suitable in our geotechnical engineering evaluation for foundations and lateral loading.

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 responsibility for construction site safety, or the contractor's activities; such responsibility is neither implied nor shall it be inferred.

Temporary Excavations and Dewatering

The contractor should be made responsible for design of dewatering systems and shoring if required. We strongly recommend that the contractor be provided the opportunity to review the boring logs and data presented in our geotechnical report to determine the most efficient means and methods for excavation and dewatering at the project site.

As a minimum, excavations must be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P and its appendices, along with any state and local codes, as applicable. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed OSHA regulations. Flatter slopes than those stipulated by the regulations or temporary shoring may be required depending upon the soil/groundwater conditions encountered and other external factors. OSHA regulations are strictly enforced and if they are not followed, the owner, contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties.

Excavations should be shored, braced, and drained as necessary to maintain the excavation as safe, secure and free of water at all times. The contractor should select and design a dewatering method to lower groundwater at least two feet below the excavation subgrade to minimize bearing surface disturbance during construction and backfilling of foundations. Dewatering may require installation of closely spaced well-points and possibly sheet pile cutoffs.

If sheet-piles are used for excavation bracing and/or as long-term scour protection, they should be designed by a qualified professional engineer. The soil parameters outlined in the Lateral Earth Pressures section may be assumed for the shoring design purposes. Sheet piles should be left in place if a non-pile supported foundation system is selected as removal of the sheets would likely result in settlement of the foundations.

The contractor should select the means and methods for providing support of excavations and dewatering in accordance with safety requirements, plans and project specifications. The contractor must evaluate soil conditions during excavations since variations in the soil can occur across the site. We recommend that the excavations be monitored continuously for signs of deterioration such as seepage of water or sloughing of soil into the excavation. The contractor is ultimately responsible for all aspects of excavation safety.

Any existing structures or foundations which are present at the location of new structures should be removed as part of the excavation process.

Fill Material Types

For planning purposes, it should be assumed that fill/backfill for the new bridge abutments and wingwalls must be completed using an imported processed sand and gravel or crusher-run stone (Structural Fill) which meets the requirements stipulated for Type 2 or 4 subbase material in section 733-04 of the NYSDOT Standard Specifications for Construction and Materials. Onsite soils which are excavated for foundation construction may be considered for reuse in landscape areas.

Fill Compaction Requirements

Abutment backfill, roadway and embankment fills should be placed in uniform loose layers no more than about one-foot thick where heavy vibratory compaction equipment is used. Thinner lifts should be used where hand operated equipment is required for compaction. Each lift should be compacted to no less than 95 percent of its maximum dry density as determined by the Modified Proctor Compaction Test, ASTM D1557. In landscape areas, the compaction requirement may be relaxed to 90 percent of maximum dry density.

Grading and Drainage

Permanent cut or embankment fill slopes around the bridge and approaches should be made no steeper than about 1V:2H, and thickly vegetated or surfaced with stone to inhibit erosion.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer and include observation of foundation bearing grades, installation of piles, and placement and compaction of fill and backfill as applicable.

It should be understood that subsurface conditions will be more fully known when the site is excavated. The continuation of the Geotechnical Engineer into the construction phase of the project will allow for validation of the subsurface conditions assumed to exist for this study and in the development of the design recommendations in this report, along with assessing any variations, providing interim recommendations as necessary and reviewing associated design changes.

DEEP FOUNDATIONS

In our opinion the use of either drilled micropiles or driven pipe piles is considered feasible for support of the proposed bridge at this site. Recommended design parameters for each pile type are provided below in consideration of the AASHTO LRFD specifications.

Considering the soils encountered and that no significant grade increases are planned for the site, negative skin friction loads on the piles should be negligible. Accordingly, no reduction in the estimated factored bearing resistances presented below should be necessary to account for downdrag loads.

Micropile Design Parameters

Drilled micropiles may be used to support the new bridge structure at this site. The piles should be designed to develop their capacity through grout-to-ground resistance within the native overburden soils. The bond zone should be established below the depth of potential scour, and the piles should be permanently cased through the upper 10 feet. We recommend a nominal pile diameter of 8 inches or greater.

For preliminary planning purposes, the axial resistance of a Type A (gravity grouted) micropile can be based on a nominal unit grout-to-ground bond strength (α_b) of 21 pounds per square inch (psi). Using a resistance factor (φ_{qs}) of 0.55, a factored grout-to-ground bond resistance of 11.5 psi can be used for preliminary design. Accordingly, an 8 inch diameter grout column micropile with 25 feet of effective bond length in the native soil deposits would provide an estimated factored resistance (R_R) of about 86 kips per pile; for an otherwise similar 10 inch diameter micropile the estimated factored resistance (R_R) is about 108 kips per pile. Greater capacity can be achieved with larger diameter piles and/or greater bond lengths. Any resistance offered by the pile tip should be disregarded.

In accordance with the AASHTO specifications, center-to-center spacing of micropiles should not be less than 30 inches or 3.0 pile diameters, whichever is greater. At this spacing, no group reduction to the single pile capacity is considered necessary. All grade beams or pile caps should be embedded a minimum of four feet below finished grades for frost protection.

Assuming these recommendations are adhered to and standard care is employed during their installation, net axial settlement of the piles is not expected to exceed one-half inch.

The factored resistance should be confirmed through at least one static load test per abutment, completed in accordance with ASTM D1143 - Standard Test Method for Piles Under Static Axial Compressive Load and evaluated using the Davisson Method (or other interpretive method as appropriate). A resistance factor of up to 0.70 can be applied to the nominal resistance established by the load test to determine the in-place factored resistance.

Micropile Construction Considerations

The piles should be designed, installed and tested by a specialty micropile contractor who has successfully completed at least five projects in the last five years with construction totaling at least 100 micropiles of similar capacity and design to those required. The contractor should submit for review the design, equipment, means and methods planned for the pile installations. The pile installer should understand that drilling through cobbles and boulders may be required and should be planned for.

In general, all loose soil and/or rock material should be removed from the borehole as piles are installed. A stable neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength of 4,000 psi should be used. Drill fluids flushed from the hole and excess grout should be managed and disposed of properly. The centerline of installed piling should not be more than three inches from its indicated plan location. Micropiles should be plumb within two percent of total length, the top of pile elevation should be within one inch of the planned vertical elevation, and the centerline of reinforcing steel should not deviate more than 0.6 inch laterally from its planned location. In order to prevent disturbance to fresh setting grout, no pile installation should be permitted within six feet of a newly installed pile deriving support within the overburden soils until at least 12 hours has elapsed.

A qualified individual should observe the installation on a full-time basis and should prepare a micropile installation log for each pile installed. The report should include the pile number and location, size and material, depth to and length of bond zone, grout type and estimated take, conditions encountered during installation (including anything unusual), installed top of pile elevation and other relevant notes as appropriate.

Driven Pile Design Parameters

A driven displacement pile seated in the native overburden soils will develop axial resistance through both skin friction and end bearing. The factored axial (compressive) resistances for 12 and 14 inch diameter closed-end steel pipe piles were estimated in general conformance with current AASHTO specifications (LRFD bridge design criteria) and are summarized below. If greater bearing resistance is required, the driven pile length and/or the pile diameter can be increased.

For the purposes of our analysis, we have assumed the bottom of the pile caps will be about 15 feet below existing grade and the piles will be driven to a depth of 50 feet (approximately 40 feet below the streambed). We have neglected any contributing skin friction in the upper five feet of the piles to account for soil disturbance during driving.

Estimated Axial Resistance for Driven Pipe Piles	
Pile Diameter (in)	**Factored Bearing Resistance (R_R) (kips)**
12	68
14	87

The development of skin friction was assumed in our pile capacity analysis. For this reason, we recommend any pre-drilling or jetting be limited to that necessary to properly set and align the pile (3 to 5 feet maximum).

The estimated factored resistances summarized above were determined through engineering interpretation of the conditions disclosed by the test borings and static analysis and should be satisfactory for preliminary design purposes. The actual production pile lengths may vary and should be determined based on the results of a test pile program as described below. Potentially variable soil conditions and the outcome of dynamic testing may impact the actual pile installation requirements. Therefore, it is recommended that contract documents contain provisions to make adjustments to the actual pile lengths required, should the installation conditions and field testing warrant such changes.

Per the AASHTO specifications, the driven piles should be spaced no closer than 2.5 pile diameters or 30 inches center-to-center, whichever is greater. At this spacing, no group reduction to the single pile capacity is considered necessary. All grade beams or pile caps should be embedded a minimum of four feet below finished grades for frost protection.

Steel pipe piles should meet the requirements of ASTM A252 and should have a wall thickness of at least 0.25 inch. A steel plate should be used to close the pile tip prior to driving. The end plate should be cut to the same diameter of the pipe so an oversize hole is not created during installation (or minimally oversized to allow a fillet weld). Driving the piles open ended is not recommended as it may limit the displacement effects. Following driving and acceptance, the piles should be filled with concrete having a 28-day compressive strength (f'_c) of 4,000 psi or greater. All grade beams or pile caps should be embedded a minimum of four feet below finished grades for frost protection.

Assuming these recommendations are adhered to and standard care is employed during their installation, net axial settlement of the piles is not expected to exceed one-half inch.

The piles should be driven using a hammer capable of achieving the design loads and confirmed through dynamic load testing in accordance with ASTM D4945 – Standard Test Method for High Strain Dynamic Testing of Piles. A wave equation analysis should be performed to verify that the hammer and cushion arrangement selected by the contractor achieve the design capacity without over-stressing the pile section. In accordance with AASHTO guidance, pile stresses should not exceed 90 percent of the pile yield stress. Dynamic load testing should be conducted on at least one pile at each abutment. Results of the load testing and wave equation analysis should be used to establish and/or refine the pile driving criteria as necessary.

Driven Pile Construction Considerations

Obstructions may be encountered while attempting to drive the piles through fill materials or cobbles/boulders at this site. If refusal is experienced above the anticipated pile tip elevation, the situation should be evaluated by the Geotechnical Engineer and a replacement pile may need to be driven. In bidding the work, the Contractor should include provisions/costs for pre-drilling or removal of any obstructions and associated delays in the pile driving operations.

Plumbness of the piles should be maintained within one percent of their total length. Any misaligned or damage piles should be replaced. Installed piles should be monitored for potential heaving during installation of adjacent piles. Any piles that heave should be re-driven and reseated as appropriate. Upon completion of driving, piles should be inspected for driving induced damage. Significantly damaged piles should be removed and replaced.

A qualified individual should observe all pile driving and should prepare an individual pile driving report for each pile installed. The report should include pile number and location, hammer and cushion type, pile size and material, installed length, blows per foot, unusual conditions encountered during driving, top of pile elevation following driving and notes on any necessary re-striking.

SHALLOW SPREAD FOUNDATIONS

Spread Foundation Design Parameters

As previously indicated, conventional spread foundations may be used if adequate scour protection can be provided and a non-pile supported foundation system is acceptable. Spread foundations constructed on suitably prepared native soil subgrades, with a base of crushed stone as detailed below, may be proportioned in accordance with AASHTO LRFD Bridge Design criteria using the following parameters:

- Nominal Bearing Resistance (q_n) – 9,000 pounds per square foot (psf)
- Bearing Resistance Factor at Strength Limit State (φ_b) – 0.45
- Factored Bearing Resistance (q_R), where ($q_R = q_n \times \varphi_b$) – 4,050 psf

The foundations should have a minimum width of four feet. They should be seated at last four feet below the streambed for frost protection or deeper if required for scour protection. Assuming the recommendations herein are adhered to and standard care is employed in preparation of the bearing grade surfaces, total settlement of the foundations is not expected to exceed one inch. Any such settlement should occur as construction proceeds and proportionally as loads are applied.

Spread Foundation Construction Considerations

Guideline recommendations for excavation shoring and dewatering are presented in the **Earthwork** section herein. After dewatering is performed, the sand subgrade should be undercut at least 12 inches to allow for the placement of a stabilizing base of crushed stone. Any existing organic or otherwise unsuitable soils should be removed in their entirety. The dewatering should be performed continuously until after the foundation is constructed and backfilled to above the groundwater levels.

Foundation excavation should be completed using an excavator equipped with a smooth-edged bucket to limit disturbance of the exposed grades. A non-woven synthetic filter fabric meeting the requirements of NYSDOT standard specifications table 737-01C for drainage geotextile should be placed along the bottom and sides of the excavation to separate the stone from the native soils. The crushed stone should be an ASTM C33 Blend 57 aggregate which is placed in a single lift and densified using a large reversible plate compactor to form a relatively firm and unyielding surface.

The native soil subgrades should be observed and evaluated by the Geotechnical Engineer prior to placement of the crushed stone base and foundation construction. Water should not be allowed to accumulate on the subgrades and the bearing grades should not be allowed to freeze, either prior to or after construction of foundations. Any water which enters foundation excavations should be promptly removed, together with any softened bearing grade materials. All final bearing grades should be firm, stable, and free of any loose soil, mud, water or frost.

Abutment structure excavations should be backfilled as soon as possible and prior to construction of the superstructure.

LATERAL EARTH PRESSURES

Abutment and Wingwall Design Parameters

Abutments and wingwalls with unbalanced backfill levels on opposite sides should be designed to resist lateral earth pressures. The following design parameters are provided to assist in calculating lateral earth pressures, whichever apply, and to analyze resistance of the structures to sliding and overturning.

- Soil angle of internal friction (Φ_f) - 32 degrees
- Coefficient of At-Rest earth pressure (k_o) - 0.47
- Coefficient of Active earth pressure (k_a) - 0.31
- Coefficient of Passive earth pressure (k_p) - 3.25
- Total unit weight of compacted soil - 130 pcf
- Coefficient of sliding friction - 0.35 (concrete on native soils)
  - 0.45 (concrete on structural fill)
- Resistance factor for sliding resistance (φ_T) - 0.80
- Resistance factor for passive component of sliding resistance (φ_{ep}) - 0.50

The recommended design parameters assume that backfill consists of imported Structural Fill as described in the **Earthwork** section herein, idealized non-sloping conditions on each side of the wall, and that the backfill remains permanently well-drained. Foundation drains and/or weep holes should be installed to prevent surface infiltration and groundwater from becoming trapped in the backfill soils.

Soil Properties for Design of Excavation Support Structures

The parameters above are not applicable to the design of temporary excavation support systems for the project. For soils consistent with those encountered in our explorations, the design of the excavation support may be based on the following parameters. These parameters include no safety factor. Assume groundwater at stream level.

Description	Friction Angle (degrees)	Total Unit Weight (pcf)
Existing overburden soils	30	120

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 exploration. Natural variations will occur between exploration 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.

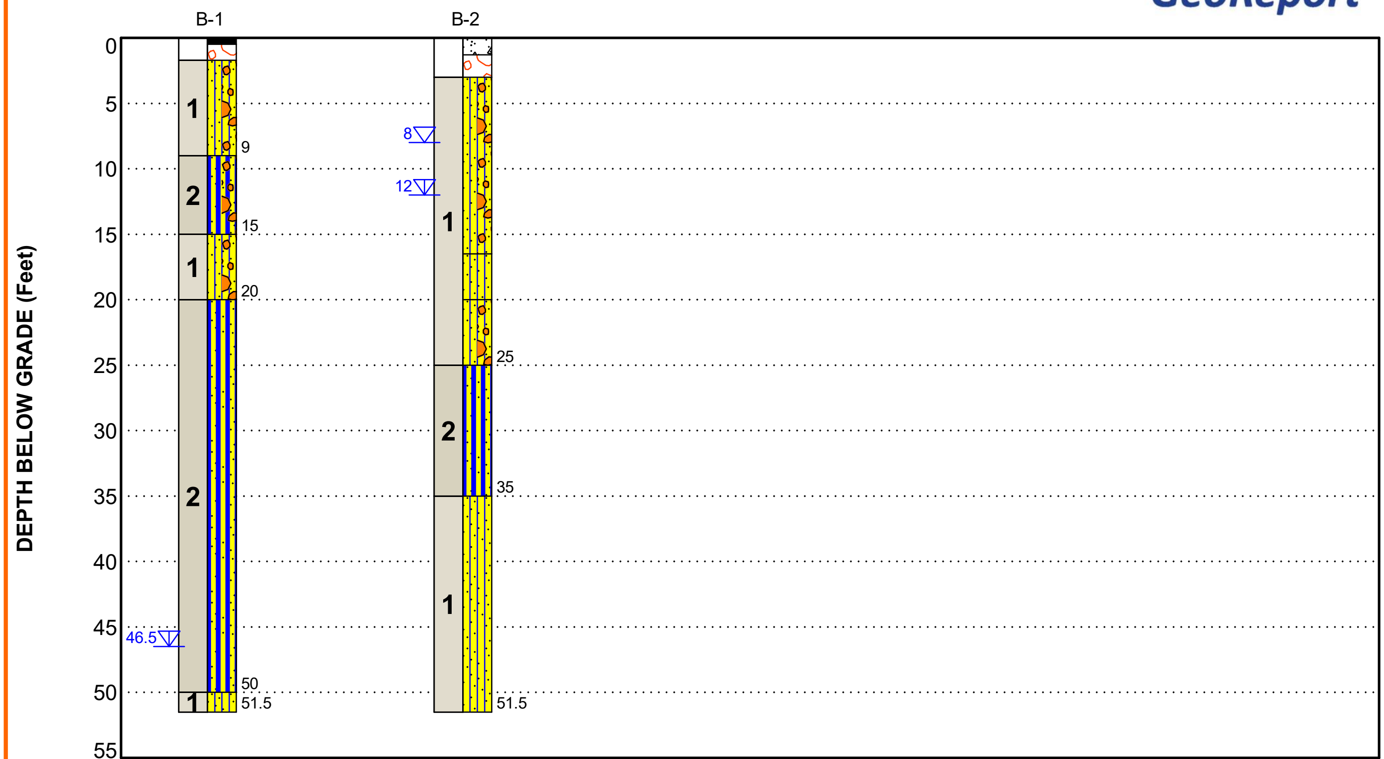
Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

Contents:

GEOMODEL

CR352 Over Fox Creek Bridge Replacement ■ Rensselaerville, NY
Terracon Project No. JB215239



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	Native Coarse-Grained Soils	Predominantly sand with varying proportions of silt and gravel, occasional cobbles
2	Native Fine-Grained Soils	Predominantly silt with varying proportions of sand and gravel, occasional fine sand or gravel lenses

LEGEND

- Asphalt
- Aggregate Base Course
- Silty Sand with Gravel
- Sandy Silt with Gravel
- Sandy Silt
- Silty Sand
- Concrete

- First Water Observation
- Second 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.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Location
B-1 and B-2	51.5	General area of proposed bridge

Test Boring Layout and Elevations: The test boring locations were established in the field by Terracon using a hand-held GPS unit, taped measurements and/or visual reference from existing site features. The boreholes were located as proposed, within the limitations of access, existing structures and utilities.

If more precise locations and/or existing ground surface elevations at the boreholes are desired, the as-drilled boring locations should be surveyed.

Subsurface Exploration Procedures: The test borings were completed using a standard rotary drill rig equipped with hollow-stem augers and/or flush joint casing. As the boreholes were advanced, the soils were sampled at intervals of five feet or less in accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils, ASTM D1586. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling 30-inches. The number of blows required to advance the sampling spoon the middle 12-inches of a normal 24-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the corresponding test depths. Upon completion of drilling the boreholes were backfilled with auger cuttings and/or sand and the surface restored in kind.

Our exploration 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. The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs.

The soil samples were placed in appropriate containers and taken to our soil's laboratory for classification by a Geotechnical Engineer. The soils were described based on the material's color, texture, plasticity and moisture condition, in general accordance with the Unified Soil Classification System (USCS) as summarized herein. Final boring logs were prepared, and they represent the Geotechnical Engineer's interpretation of the field logs and laboratory classifications, along with any laboratory testing performed.

Laboratory Testing

Selected samples recovered from the test borings were submitted for laboratory testing as part of the subsurface investigation, to confirm the visual classifications and to provide quantitative index properties for use in the geotechnical evaluation. This testing was performed in general accordance with the following standard methods:

- ASTM D2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil - and Rock by Mass (5 samples tested)

- ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils (w/o hydrometer) (5 samples tested)

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Fox Creek Bridge Replacement ■ Rensselaerville, NY
February 2022 ■ Terracon Project No. JB215239

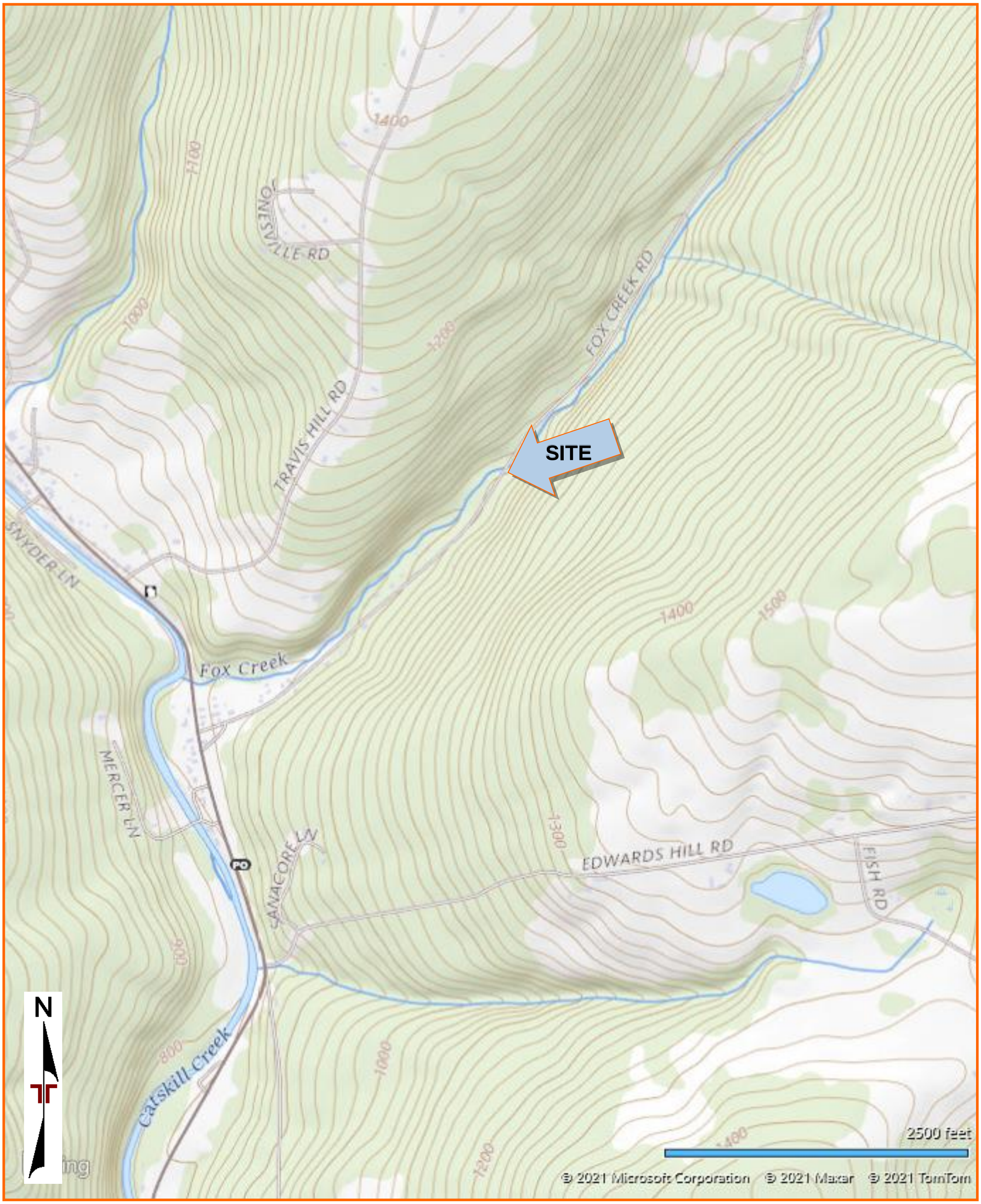


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: DURHAM, NY.

EXPLORATION PLAN

Fox Creek Bridge Replacement ■ Rensselaerville, NY
February 2022 ■ Terracon Project No. JB215239

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: CR352 Over Fox Creek Bridge Replacement

CLIENT: Creighton Manning Engineering LLP
Albany, NY

SITE: Fox Creek Road
Rensselaerville, NY

LOCATION See Exploration Plan

Latitude: 42.4455° Longitude: -74.1940°

MODEL LAYER	DEPTH	DESCRIPTION
	0.5	**6" ASPHALT**
	1.7	**14" CRUSHER RUN BASE**
1	9.0	**SILTY SAND WITH GRAVEL (SM)**, occasional cobbles, gray to brown, loose to medium dense **Mottling noted from about 1.5 to 3'** **Grades to red to brown at about 3'** **Frequent cobbles and boulders from about 7 to 9'**
2	15.0	**SANDY SILT WITH GRAVEL (ML)**, occasional fine sand lenses, red to brown, stiff
1	20.0	**SILTY SAND WITH GRAVEL (SM)**, occasional cobbles, red to brown, medium dense
2		**SANDY SILT (ML)**, occasional fine sand lenses, red to brown, stiff to very stiff **Grades gravelly silt with sand**

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)
~1.5–3	14	12-10-10 N=20	
~3–5	12	5-5-4-4 N=9	
~5–7	8	5-6-4-10 N=10	
~7–9	12	12-14-12-14 N=26	
~9–11	12	7-6-3-4 N=9	
~15–17	19	5-6-7-8 N=13	10.0
~20–21.5	14	12-7-5 N=12	13.9
~25–26.5	17	4-5-9 N=14	
~30–31.5	18	3-5-8 N=13	

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

Hammer Type: Automatic

Advancement Method:
2 1/4" ID HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Sealed with bituminous cold patch at surface.

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:

- Boring was drilled on shoulder line, ~18' from abutment face and ~2.5' from concrete approach
- Logged by: JCH

WATER LEVEL OBSERVATIONS

▽ *46.5' after boring completion*

Terracon
30 Corporate Cir Ste 201
Albany, NY

Boring Started: 12-10-2021	Boring Completed: 12-10-2021
Drill Rig: CME 750	Driller: J. Lamm
Project No.: JB215239	

BORING LOG NO. B-1

PROJECT: CR352 Over Fox Creek Bridge Replacement

CLIENT: Creighton Manning Engineering LLP
Albany, NY

SITE: Fox Creek Road
Rensselaerville, NY

LOCATION See Exploration Plan

Latitude: 42.4455° Longitude: -74.1940°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)
2		**SANDY SILT (ML)**, occasional fine sand lenses, red to brown, stiff to very stiff *(continued)*						
			35		X	18	7-12-18 N=30	
		Occasional gravel lenses noted	40		X	17	8-8-13 N=21	11.8
		Grades silt with sand and gravel	45	▽	X	18	4-10-13 N=23	
		50.0						
1		**BANDED SILTY SAND (SM)**, fine sand lenses, brown, medium dense	50		X	18	6-9-13 N=22	
		51.5						
		Boring Terminated at 51.5 Feet						

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

Hammer Type: Automatic

Advancement Method:
2 1/4" ID HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Sealed with bituminous cold patch at surface.

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

▽ *46.5' after boring completion*

Terracon
30 Corporate Cir Ste 201
Albany, NY

Boring Started: 12-10-2021	Boring Completed: 12-10-2021
Drill Rig: CME 750	Driller: J. Lamm
Project No.: JB215239	

BORING LOG NO. B-2

PROJECT: CR352 Over Fox Creek Bridge Replacement

CLIENT: Creighton Manning Engineering LLP Albany, NY

SITE: Fox Creek Road Rensselaerville, NY

LOCATION See Exploration Plan

Latitude: 42.4453° Longitude: -74.1942°

MODEL LAYER	DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)
	1.3	**15" REINFORCED CONCRETE**						
	3.0	**20" CRUSHER RUN BASE**			X	12	12-8-6 N=14	
1		**SILTY SAND WITH GRAVEL (SM)**, occasional cobbles, red to brown, medium dense to very dense	5		X	12	5-6-8 N=14	
				▽	X	15	5-7-12-8 N=19	
			10		X	18	15-22-45-23 N=67	
				▽	X	6	8-15-12-12 N=27	
	16.5	**Occasionally clayey**	15		X	17	5-8-5-9 N=13	
	20.0	**BANDED SILTY SAND (SM)**, fine sand lenses, red to brown, medium dense						
		SILTY SAND WITH GRAVEL (SM), red to brown, medium dense	20		X	14	5-11-8-9 N=19	
	25.0	**Occasionally clayey**						
2		**SANDY SILT (ML)**, occasional fine sand or gravel lenses, red to brown, very stiff	25		X	17	7-14-15 N=29	
		Grades gravelly silt with sand	30		X	17	8-10-13 N=23	16.9

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

Hammer Type: Automatic

Advancement Method:
2 1/4" ID HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Sealed with 8" of concrete underlain by 10" of pea stone at surface.

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:
- Boring was drilled on shoulder line, ~22' from abutment face
- Logged by: JCH
- Water runs into borehole at depth of +/- 12' with augers removed

WATER LEVEL OBSERVATIONS

▽ *8' after 8-10' sample*

▽

Terracon
30 Corporate Cir Ste 201
Albany, NY

Boring Started: 12-09-2021	Boring Completed: 12-09-2021
Drill Rig: CME 750	Driller: J. Lamm
Project No.: JB215239	

BORING LOG NO. B-2

PROJECT: CR352 Over Fox Creek Bridge Replacement

CLIENT: Creighton Manning Engineering LLP Albany, NY

SITE: Fox Creek Road Rensselaerville, NY

LOCATION See Exploration Plan

Latitude: 42.4453° Longitude: -74.1942°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)
2		**SANDY SILT (ML)**, occasional fine sand or gravel lenses, red to brown, very stiff *(continued)*						
		35.0	35		X	17	6-8-10 N=18	
1		**BANDED SILTY SAND (SM)**, fine sand lenses, red to brown, medium dense to dense						
		Occasional bands of gray varved silt and f. sand noted	40		X	21	4-7-5-7 N=12	12.4
		Seams of gravelly silt with sand noted from 40 to 51.5'	45		X	17	5-7-12 N=19	
		51.5	50		X	17	7-15-15 N=30	
		Boring Terminated at 51.5 Feet						

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

Hammer Type: Automatic

Advancement Method:
2 1/4" ID HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Sealed with 8" of concrete underlain by 10" of pea stone at surface.

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

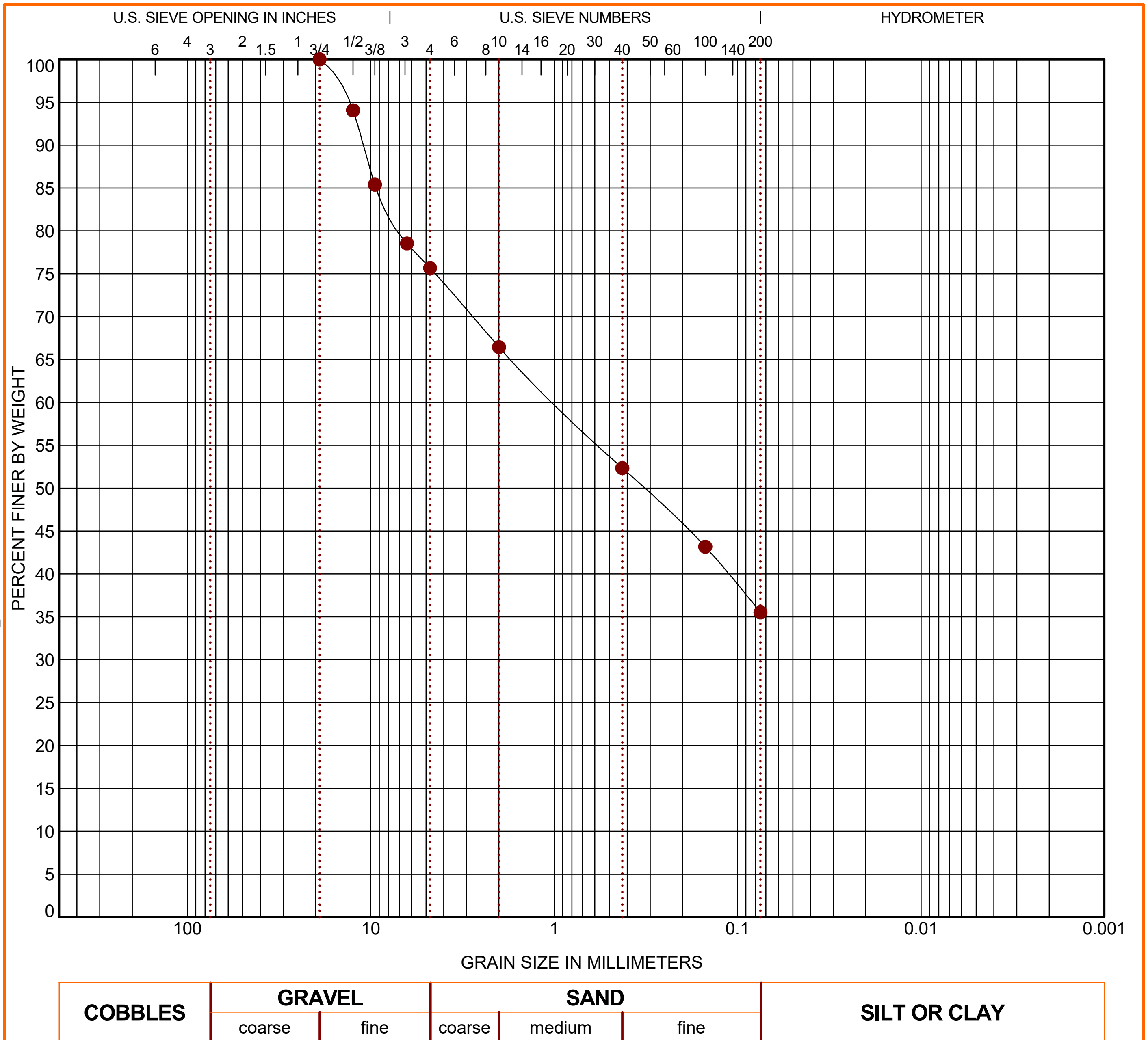
8' after 8-10' sample

Terracon
30 Corporate Cir Ste 201
Albany, NY

Boring Started: 12-09-2021	Boring Completed: 12-09-2021
Drill Rig: CME 750	Driller: J. Lamm
Project No.: JB215239	

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID		Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	15 - 17	SILTY SAND with GRAVEL (SM)	10.0	NP	NP	NP		

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	15 - 17	19	0.985			0.0	24.3	40.2		35.5	

PROJECT: CR352 Over Fox Creek Bridge Replacement

SITE: Fox Creek Road
Rensselaerville, NY

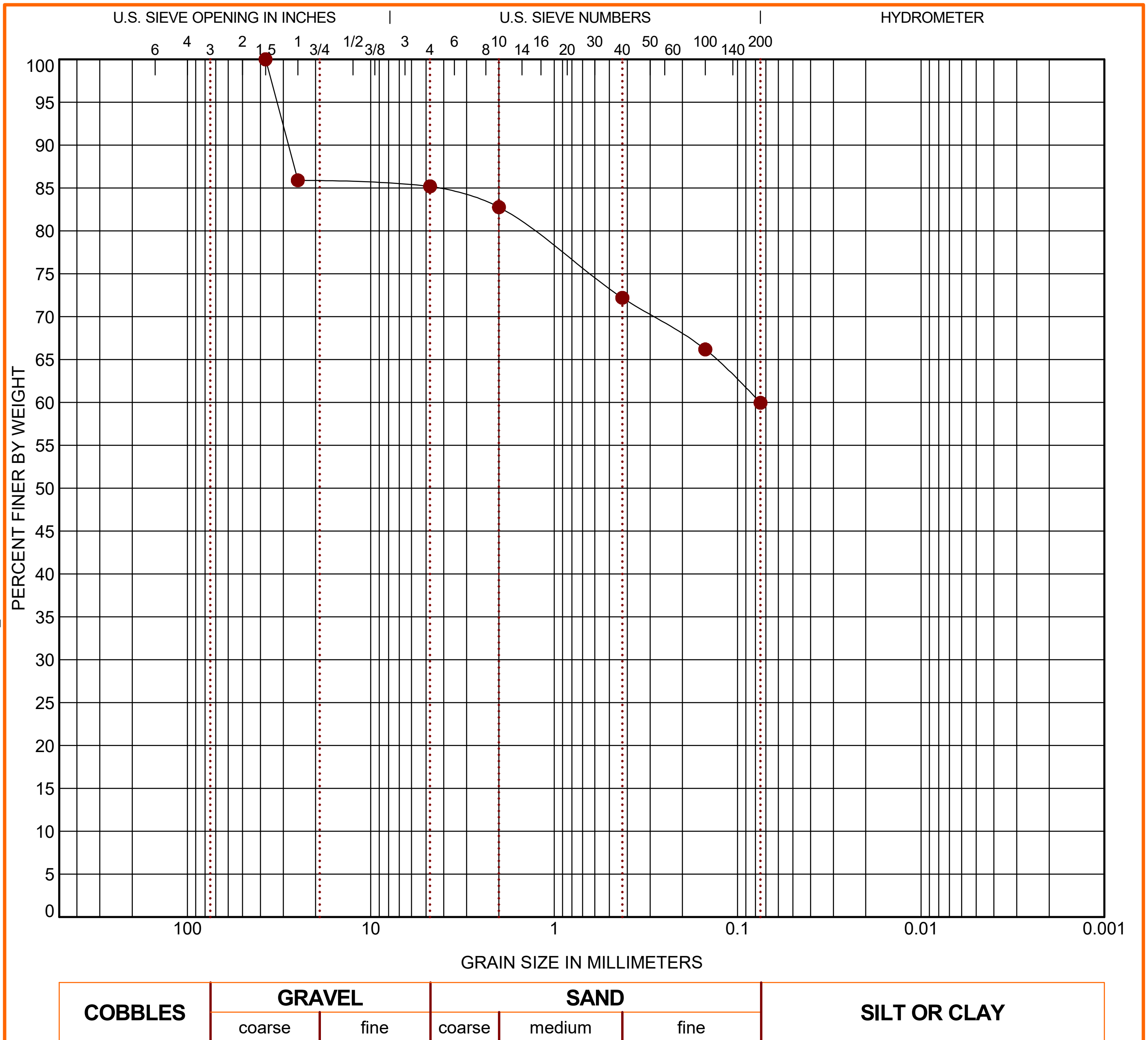
Terracon
30 Corporate Cir Ste 201
Albany, NY

PROJECT NUMBER: JB215239

CLIENT: Creighton Manning Engineering LLP
Albany, NY

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID		Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	20 - 21.5	SANDY SILT (ML)	13.9	NP	NP	NP		

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	20 - 21.5	37.5	0.075			0.0	14.8	25.2		60.0	

PROJECT: CR352 Over Fox Creek Bridge Replacement

SITE: Fox Creek Road
Rensselaerville, NY

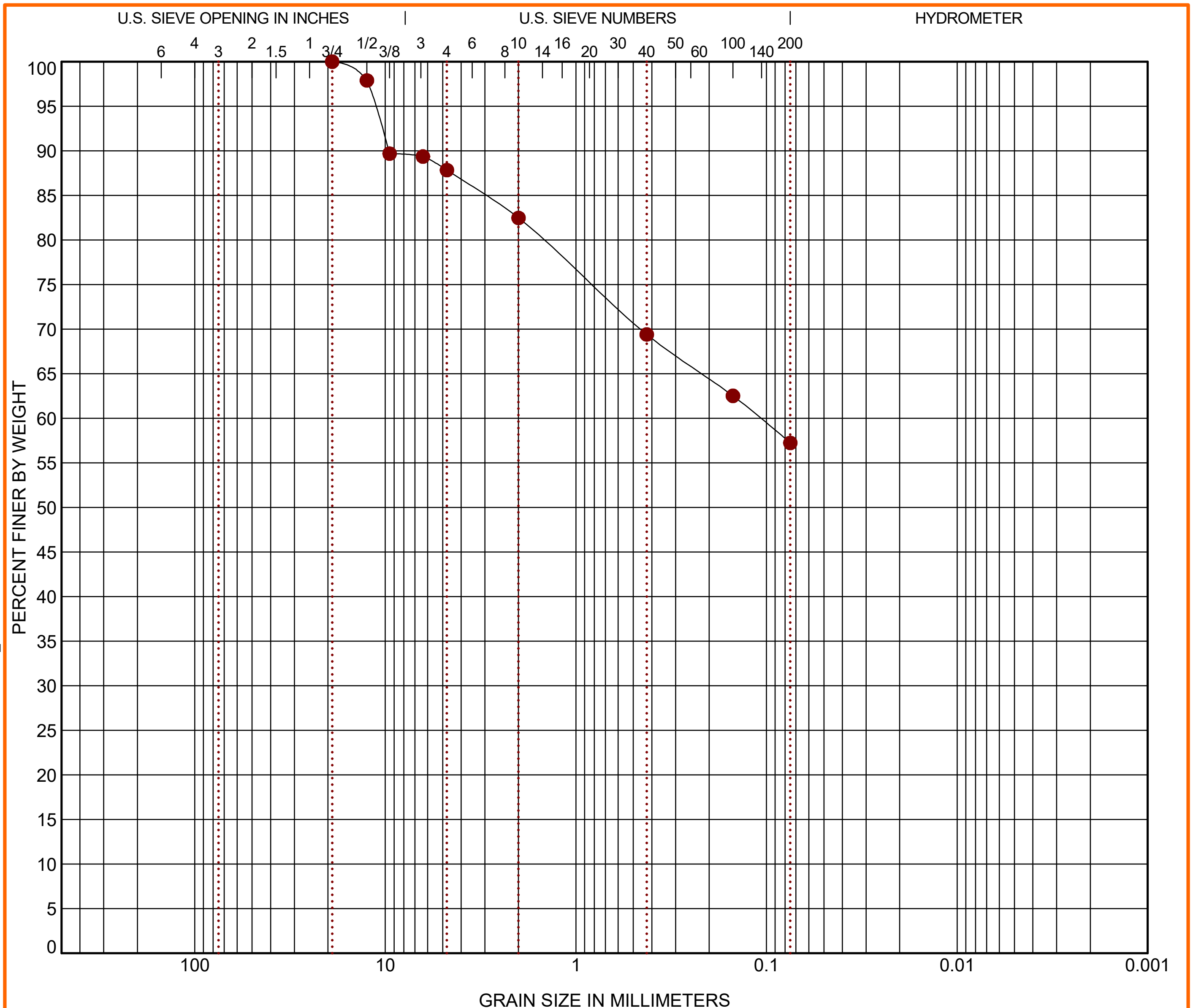
Terracon
30 Corporate Cir Ste 201
Albany, NY

PROJECT NUMBER: JB215239

CLIENT: Creighton Manning Engineering LLP
Albany, NY

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	40 - 41.5	SANDY SILT (ML)	11.8	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	40 - 41.5	19	0.108			0.0	12.2	30.6		57.2	

PROJECT: CR352 Over Fox Creek Bridge Replacement

SITE: Fox Creek Road Rensselaerville, NY

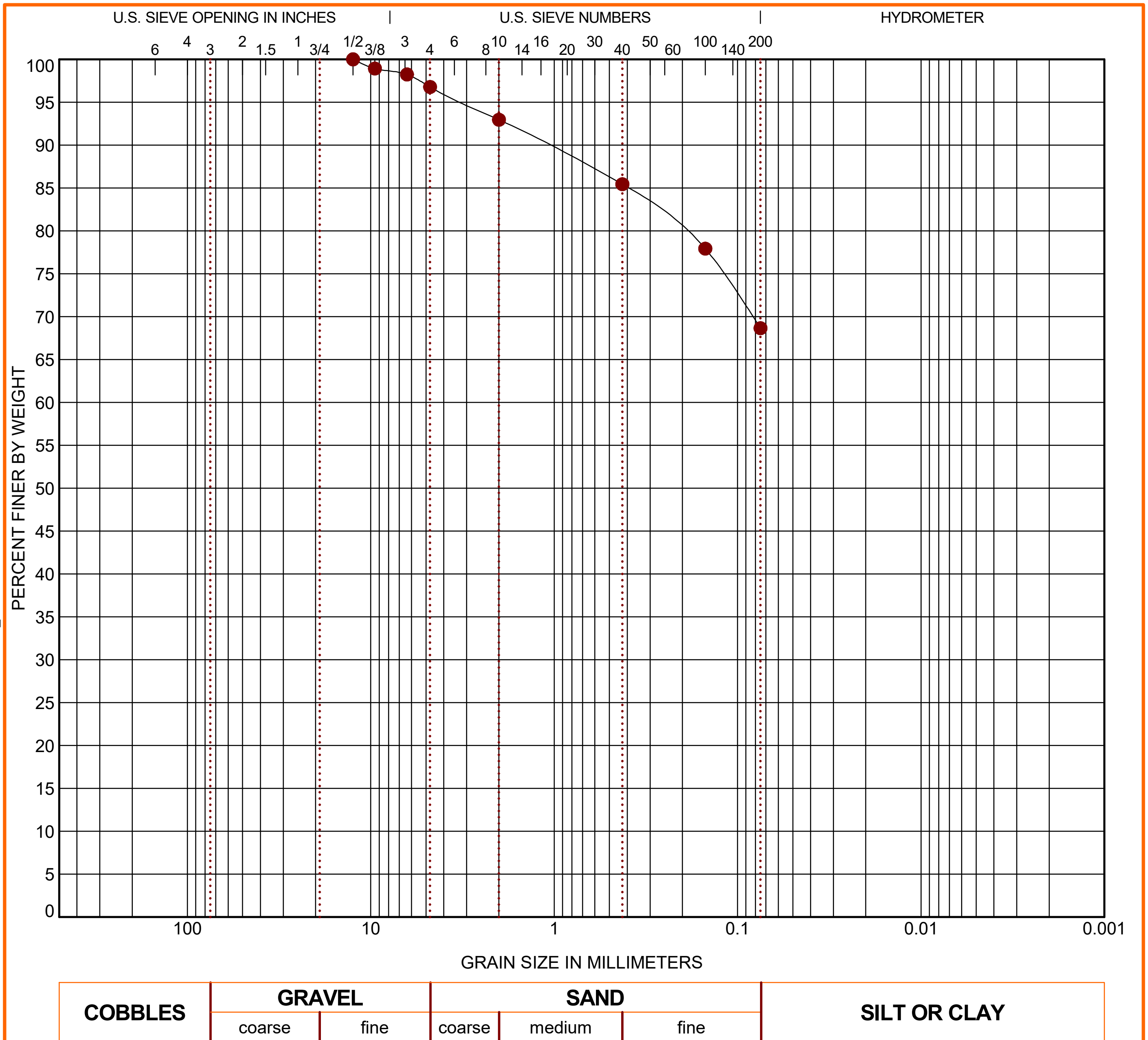
Terracon
30 Corporate Cir Ste 201
Albany, NY

PROJECT NUMBER: JB215239

CLIENT: Creighton Manning Engineering LLP Albany, NY

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-2	30 - 31.5	SANDY SILT (ML)	16.9	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-2	30 - 31.5	12.5				0.0	3.2	28.1		68.7	

PROJECT: CR352 Over Fox Creek Bridge Replacement

SITE: Fox Creek Road
Rensselaerville, NY

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30 Corporate Cir Ste 201
Albany, NY

PROJECT NUMBER: JB215239

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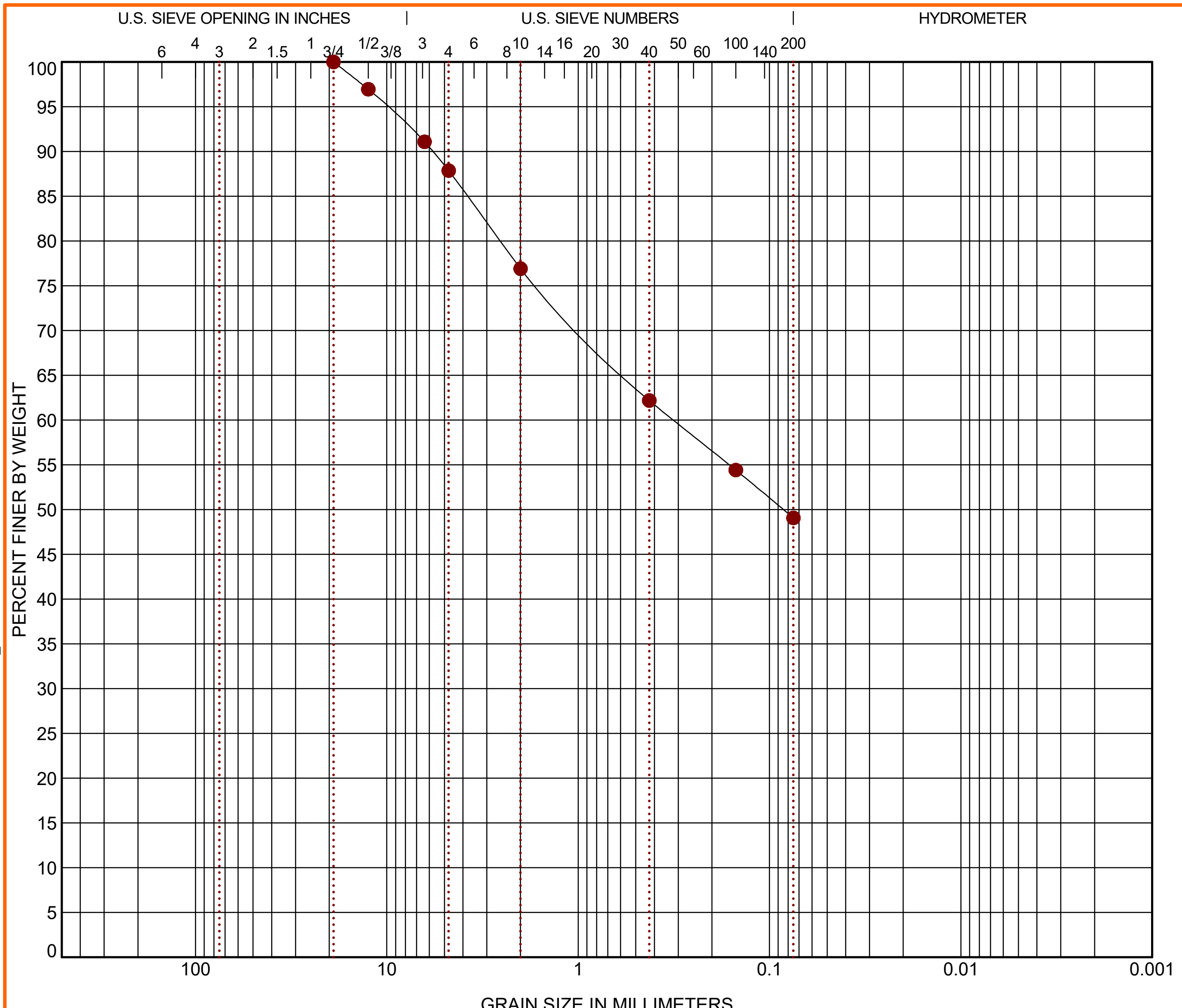
Albany, NY

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-2	40 - 42	SILTY SAND (SM)	12.4	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-2	40 - 42	19	0.317			0.0	12.1	38.8		49.1	

PROJECT: CR352 Over Fox Creek Bridge Replacement

SITE: Fox Creek Road
Rensselaerville, NY

Terracon
30 Corporate Cir Ste 201
Albany, NY

PROJECT NUMBER: JB215239

CLIENT: Creighton Manning Engineering LLP
Albany, NY

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

CR352 Over Fox Creek Bridge Replacement ■ Rensselaerville, NY

Terracon Project No. JB215239

Terracon GeoReport

SAMPLING

Split Spoon

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, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 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	Soil Classification: 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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ 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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ 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:**	$PI > 7$ and plots on or above “A” line	CL	Lean clay [K, L, M]
			$PI < 4$ or plots below “A” line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					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 / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 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 $\geq$ 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 $\geq$ 30% plus No. 200 predominantly sand, add “sandy” to group name.

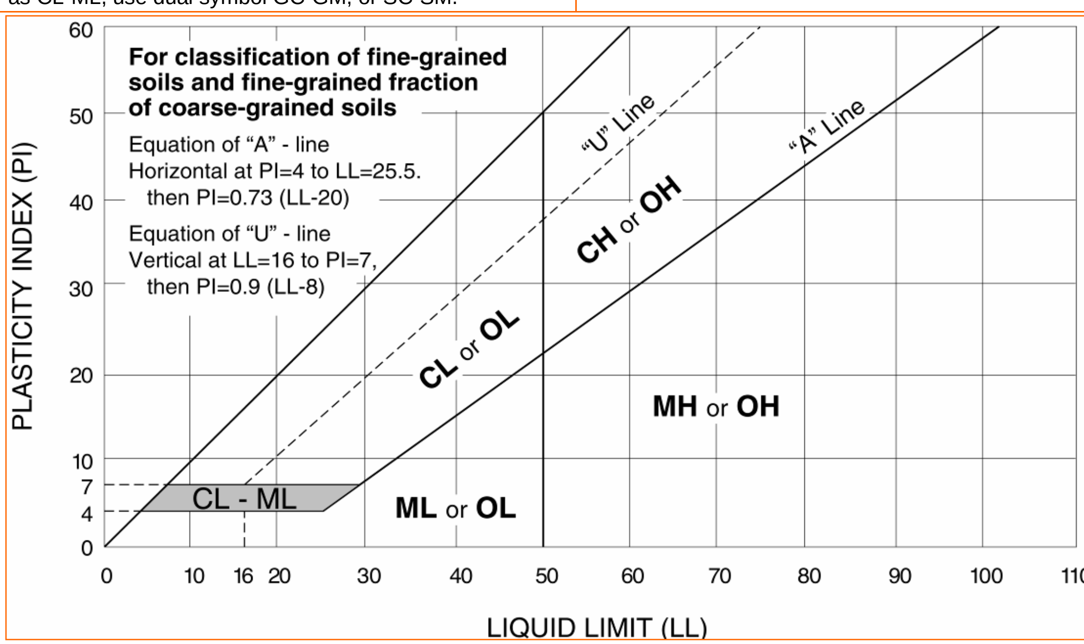
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

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

[O] $PI < 4$ or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



DESCRIPTION OF ROCK PROPERTIES

Terracon GeoReport

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements