Structure Geotechnical Report

IL Route 31 Culvert Crossing Unnamed Ditch
South Elgin, Illinois

January 28, 2022
Terracon Project No. MR195107 (Rev. 2)

Prepared for:
SE3
Lisle, Illinois

Prepared by:
Terracon Consultants, Inc.
Glendale Heights, Illinois

Terracon
GeoReport

January 28, 2022

SE3
1111 Burlington Avenue, Suite 111
Lisle, Illinois 60532

Attn: Mr. Philip Minga, P.E.
P: 630.641.9900
E: PMinga@se3.us

Re: Structure Geotechnical Report
IL Route 31 Culvert Crossing Unnamed Ditch
IL Route 31 and West Plum Street
South Elgin, Illinois
Terracon Project No. MR195107 (Rev. 2)

Dear Mr. Minga:

We have completed a subsurface exploration and geotechnical engineering evaluation for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PMR195107R3 dated June 26, 2019. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

This report was revised in November 2019 to include a discussion about supporting a temporary one-way slab above the existing culvert during construction of the new culvert. Construction considerations for the mechanically-stabilized earth (MSE) wingwalls have also been added.

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.

Sincerely,
Terracon Consultants, Inc.

NICHOLAS L. HUSSEY
062-071482

Nicholas L. Hussey, P.E.
Department Manager

Paul J. Koszarek, P.E.
Department Manager

Reviewed by Kole C. Berg, P.E.

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.

Structure Geotechnical Report

IL Route 31 Culvert Crossing Unnamed Ditch
IL Route 31 and West Plum Street
South Elgin, Illinois
Terracon Project No. MR195107 (Rev. 2)
January 28, 2022

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed replacement culvert to be located on Illinois Route 31 (South La Fox Street) to the south of West Plum Street in South Elgin, Illinois. 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
- Foundation design and construction
- Seismic site classification per IBC
- Lateral earth pressures

The geotechnical engineering Scope of Services for this project included the advancement of four test borings to depths ranging from approximately 15 to 19 feet below 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 exploration are included on the boring logs in the **Exploration Results** section.

PROJECT DESCRIPTION AND SCOPE

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available aerial imagery.

Item	Description
Parcel Information	■ The project site is located approximately 250 feet south of Plum Street, crossing IL Route 31 in South Elgin, Illinois.

Item	Description
Existing Improvements	■ An existing concrete and stone arched culvert is located at the project site. The segment of IL Route 31 (also known as S La Fox Street) consists of a two-lane undivided road consisting of concrete curb and gutter on the west side and aggregate shoulder along the east of the culvert. A section of historical railroad belonging to the Fox River Trolley Museum terminates to the north of the existing culvert. It is not understood if this section of rail will be removed and abandoned or rebuilt after the installation of the new culvert.
Current Ground Cover	■ Asphalt paved with gravel shoulders within the road bed. Outside of the road bed, vegetated soil.
Existing Topography (Kane County GIS)	■ Surface elevations at the boring locations are approximately 723 feet.

Project Understanding

Our initial understanding of the project was provided in our proposal, and our current understanding of the project conditions is as follows:

Item	Description
Project Description	■ We understand that the project will include the replacement of the existing arch culvert with a box type reinforced concrete culvert. The dimensions of the new culvert are 10 feet wide and 6 feet high. After installation, the road will be replaced with a similar asphalt paved road to what is currently there. ■ The interaction of the railroad to the planned construction was not part of our current work scope. It is anticipated that this section of the railroad will be abandoned once the new culvert is in place. If the railroad within 30 feet of the edge of the planned excavation for the culvert is planned to be reconstructed and used, then additional recommendations pertaining to the backfilling of the culvert should be provided.
Invert Elevation	■ 709.39 feet on the west side (upstream) and 709.19 feet on the east side (downstream)
Grading	■ The new culvert is larger than the existing culvert. Based on the planned invert elevation, we anticipate that grade changes on the order of 3 feet or less in cuts/fills will be required for the proposed construction. ■ If MSE walls are used for the culvert wingwalls, excavations up to about 17 feet are expected based on the planned wall heights.

FIELD EXPLORATION AND LABORATORY TESTING

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
4	15.3 to 18.8	Adjacent to culvert

Boring Layout and Elevations: The soil borings were performed on August 1, 2019. Terracon used handheld GPS equipment to locate borings with an estimated horizontal accuracy of +/-20 feet. Approximate surface elevations were obtained from the Kane County GIS.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using continuous flight augers. Samples were generally obtained at intervals of 2.5 feet. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-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 test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings and bentonite chips after their completion. Pavements were patched with pre-mixed concrete.

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 an engineer or geologist. 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. Computer-generated boring logs were prepared from the field logs. The 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

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil and rock strata, as necessary, for this project. The following tests were performed for this project.

- Water content
- Hand penetrometer

The soils were classified in general accordance with the IDOT textural classification chart. Additional descriptions and classifications in accordance with the Unified Soil Classification System have been provided.

Rock classification was conducted using locally accepted practices for engineering purposes. Boring log rock classification was determined using the Description of Rock Properties.

Subsurface Profile

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 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 and IDOT Classification
1	**Pavement Section**	Asphalt and Portland cement concrete, base course
2	**Existing Fill**	Existing fill – Sandy clay and silty clay loam
3	**Lean Clay**	Silty clay
4	**Sandy Clay**	Silty clay loam and sandy clay
5	**Residual Soils**	Fine to medium clayey gravel and sandy clay (residual weathered bedrock)
6	**Bedrock**	Weathered limestone bedrock

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in the **Exploration Results** section. Groundwater was encountered at depths ranging from 12.5 to 14 feet below grade.

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 structure may be higher or lower than the levels indicated on the boring logs. Also, trapped or “perched” water could be present within the sand or silt seams within native clay soils and/or in cohesionless soils (fill and native) above lower permeability clay soil layers. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS

Groundwater was encountered in a layer of sandy lean clay/lean clay with sand overlying residual soils. If excavations extend into water-bearing soils, additional dewatering efforts may be necessary on top of the cofferdam recommended to temporarily divert the creek. A contractor specializing in dewatering should design and install the dewatering system. At the time of the culvert installation, the groundwater level should be lowered and maintained at least 2 feet below the base of the excavations.

We understand that various options are being considered for the culvert wingwalls, including mechanically-stabilized earth (MSE) walls, drilled soldier pile walls, and cast-in-place concrete T-walls. The **Foundation Recommendations** section provides further details about these wall systems.

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

FOUNDATION RECOMMENDATIONS

Based on the subsurface conditions encountered at the boring locations, the reinforced concrete box culvert can be supported directly on the existing stiff/dense native soils or on a working mat of CA-6 material for stability. In general, considering the provided invert elevation of the culvert and the existing grades, we anticipate that the bottom of the culvert will be bear on either stiff sandy lean clay or dense clayey gravel at about 708 feet. However, medium stiff clays were encountered at this elevation in Boring B-4. If a precast culvert is used, we recommend that at least 12 inches of the lower strength clay be removed and replaced with CA-6 crushed stone. If a cast-in-place culvert is used, we recommend at least 2 feet of the lower strength clays be removed and replaced with CA-6 crushed stone. The horizontal limits of the removal and replacement should extend 2 feet below the footprint of the structure regardless of the culvert type.

For reinforced concrete box culverts, we anticipate that the contact pressures transmitted to the bearing soils will be relatively low due to the large structural area in contact with the soil. If strip foundations are used with a base slab to support the culvert, our engineer should be contacted to provide updated recommendations once more information is provided to Terracon. A design resistance of 1,000 psf for a reinforced mat foundation could be used for this type of culvert system. If strip footings are supporting the walls, then a factored bearing resistance of 3,000 psf may be used for design of the strip footings.

The replacement culvert is larger than the existing culvert and may extend into areas of loose/soft, saturated creek bed soils. We recommend that these materials be removed from below the new culvert and replaced with properly compacted CA-6 backfill to help provide positive support for the culvert. In order to prevent the creek from subverting the new culvert, the gravel backfill should be encased in concrete that is keyed into the native clay soils. At a minimum, we recommend that the new culvert bear on at least 12 inches of properly compacted, well-graded, crushed stone to increase subgrade stability and help expedite construction. To ensure proper performance, it is essential that all lower strength soils be removed, and proper dewatering measures are taken prior to surficially compacting the native soils and any additional fill materials.

As mentioned in the **Geotechnical Evaluations and Recommendations**, we recommend that a temporary cofferdam be constructed in order to properly dewater the construction area. This may require diversion of the creek during construction.

The culvert and backfill materials should be allowed to remain in place for as long as possible prior to the replacement of the pavement section. This will allow any settlement of the culvert and/or backfill to occur without causing premature pavement distress. For an asphaltic cement concrete pavement section, consideration could be given to placing the base course and then the surface course at a later date.

This section provides geotechnical recommendations for footings to support the wingwalls for the culvert. Spread footing foundations should bear on stiff native soils or on newly placed structural fill. We expect that stiff clay soils will be encountered at the anticipated foundation bearing elevation of approximately 708 feet. If the site has been prepared in accordance with the requirements noted in **Construction Considerations**, the following design parameters are applicable for shallow foundations.

Shallow Foundation Design Parameters

Item	Description
Factored Bearing Resistance for Strength Limit State	■ 2,700 psf for wingwalls
Bearing Resistance for Service Limit State	■ 2,000 psf for wingwalls
Required Bearing Stratum [2]	■ Stiff native clay soil, or ■ Compacted CA-6 stone/gravel extended to suitable soils or lean mix concrete
Minimum Foundation Width	■ 18 inches for cast-in-place concrete wingwalls
Anticipated Foundation Bearing Elevation	■ West side of the culvert: 706 feet ■ East side of the culvert: 706 feet near the culvert and 712 to 714 feet away from the culvert
Ultimate Coefficient of Sliding Friction [3]	■ 0.30 (native clay) ■ 0.40 (granular material)
Minimum Embedment below Finished Grade for Frost Protection	■ Exterior footings in unheated areas: 48 inches

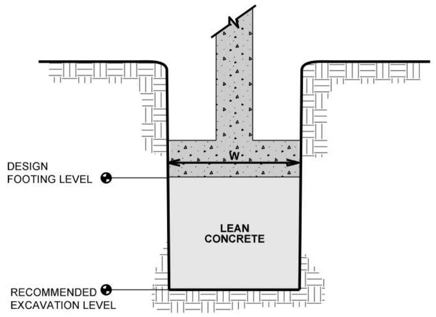
Item	Description
Estimated Total Settlement from Structural Loads	■ Less than about 1 inch
Estimated Differential Settlement	■ About 2/3 of total settlement (along wingwall)

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. Value includes a factor of safety of 3 against bearing capacity failure.
2. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in the **Earthwork**.
3. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.

Shallow Foundation Construction Considerations

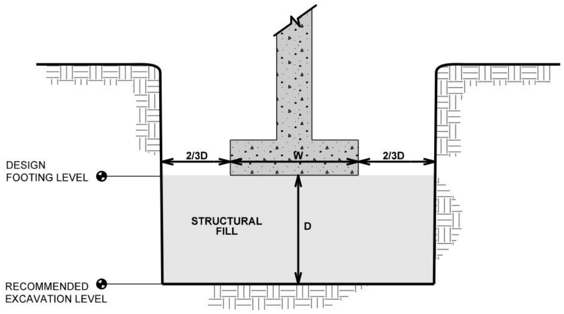
As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level, on CA-6 crushed stone/gravel, or on lean concrete backfill placed in the excavations. If CA-6 is used, it should be encased by concrete from the creek flow in order to prevent scour and subversion of the culvert or its wingwalls. Overexcavation for structural fill placement below footings should be conducted as shown below. These do not show the placement of concrete for protection of the stone. The overexcavation should be backfilled up to the Design Footing Level as recommended in the **Construction Considerations** section. This is illustrated on the sketches below.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY



OVER-EXCAVATION / BACKFILL ZONE

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

Culvert Wingwalls

We understand that cast-in-place concrete wingwalls are planned to be used for this structure and that MSE walls are no longer being considered. Based on the provided TSL plans, the wingwalls are planned to be about 12 to 17 feet tall at the connection to the culvert. Cast-in-place concrete walls are suitable for use at this site based on the design and the soil conditions encountered, provided the bearing soils are improved as discussed in the **Foundation Recommendations** section. The Lateral Earth Pressures section provides design recommendations for the lateral design.

Other types of walls were considered for this project including soldier pile and lagging and mechanically stabilized earth walls. Due to the relatively shallow bedrock and dense overburden soils, the soldier pile and lagging walls would likely not be a cost effective solution. The MSE walls are not being considered due to the relatively higher exposed wall heights and not having enough area behind the face of the wall need for insertion of the required minimum length of geogrid.

Wingwall Stability

An evaluation of stability was not included in our Scope of Services. External stability of the wall system (i.e., direct sliding, bearing capacity, overturning, and eccentricity analyses) should be analyzed using both effective stress and total stress strength parameters to evaluate long term (effective stress) and end-of-construction (total stress) conditions. Internal stability and external stability analyses for each wall design should take into account slopes and loading conditions (e.g., surcharges from building foundations, pavements, etc.), above and below the proposed wall system.

Global stability of the wall system should be analyzed using both effective stress and total stress strength parameters to evaluate long term (effective stress) and end-of-construction (total stress) conditions. The wall contractor should be required to provide these analyses based on the planned final cross sections, including the topography above and below the wall and the subsurface conditions considered in the wall design.

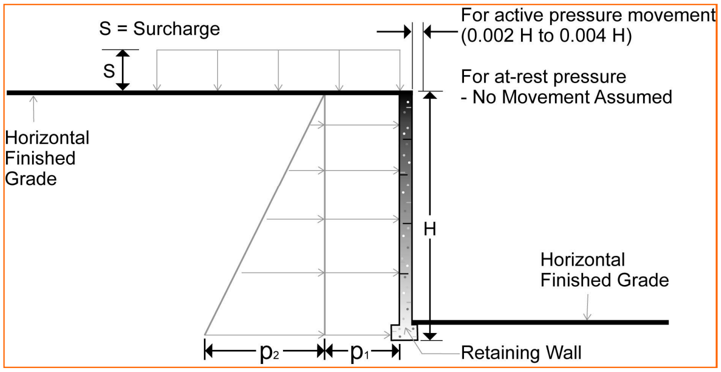
Effective surface and subsurface drainage should be provided away from the wall areas during and after construction and should be maintained throughout the life of the structures. Appropriate drainage measures should also be incorporated into the wall design and construction. Water retained behind or above the wall can result in soil movements causing unacceptable settlement and cracking of the block facing, can increase the potential for hydrostatic pressure developing on the walls if backfill drainage is insufficient, and can increase the potential occurrence of the critical design event for slope stability (seepage forces in combination with saturated shear strength).

The evaluation of erosion and scour potential was not included in our Scope of Services. Placement of riprap or other slope reinforcement on the stream bank slopes could be considered to help reduce the potential for erosion. If scour is a potential concern, a cutoff wall at the upstream side of the culvert could be considered.

LATERAL EARTH PRESSURES

Lateral Earth Pressure Design Parameters

Structures with unbalanced backfill levels on opposite sides (such as cast-in-place or precast culvert wingwalls) should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for loading dock walls or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters

Earth Pressure Condition [1]	Coefficient for Backfill Type [2]	Surcharge Pressure [3, 4, 5] p_1 (psf)	Effective Fluid Pressures (psf) [2, 4, 5]	
			Unsaturated [6]	Submerged [6]
Active (Ka)	Granular - 0.31	(0.31)S	(40)H	(80)H
	Fine Grained - 0.41	(0.41)S	(50)H	(85)H
At-Rest (Ko)	Granular - 0.47	0.47)S	(55)H	(90)H
	Fine Grained - 0.58	(0.58)S	(70)H	(95)H
Passive (Kp)	Granular - 3.25	---	(390)H	(250)H
	Fine Grained - 2.46	---	(295)H	(205)H

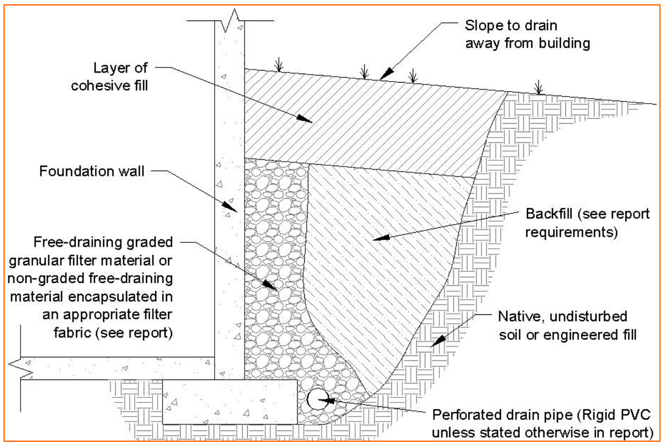
Lateral Earth Pressure Design Parameters				
Earth Pressure Condition[1]	Coefficient for Backfill Type[2]	Surcharge Pressure[3, 4, 5] p_1 (psf)	Effective Fluid Pressures (psf)[2, 4, 5]	
			Unsaturated[6]	Submerged[6]

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95% of the standard Proctor maximum dry density as determined by AASHTO T-99, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. To achieve “Unsaturated” conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. “Submerged” conditions are recommended when drainage behind walls is not incorporated into the design.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic or metal drain line installed behind the base of walls that extend below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around an exterior wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage. The drain line should be surrounded by clean, free-draining granular material having less than 6 percent passing the No. 200 sieve, such as IDOT Gradation CA-13. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

TEMPORARY SLAB

We understand that a temporary one-way structural slab is being considered to span across the existing culvert during the construction of the new culvert. The structural slab is planned to be about 30 feet long and will span the entire width of the existing roadway. We have been requested to provide some potential options for supporting the structural slab.

Approach Slabs

The structural slab could potentially be supported on approach slabs at either end of the culvert that are supported on the existing subsurface material. As described in this report, the soils on both sides of the culvert are existing fill material generally composed of sandy lean clay with gravel. The blow counts and hand penetrometer strength values were variable, and the moisture contents ranged from about 4 to 25 percent, indicating a material that was not placed with uniform control of moisture and density. To support the approach slabs, we recommend that the existing material be undercut at least 2 feet. The undercut should be backfilled in 8-inch lifts of compacted CA-6 crushed stone. Two layers of a biaxial geogrid (such as BX1200) should be used within the crushed stone lifts.

If the one-way slab was supported on approach slabs, there would be a potential for differential movement if the approach slabs settled. This would manifest as a noticeable bump at the interface of the roadway and the temporary slab. There is also the potential for excessive settlement of the approach slabs if the existing culvert were to suddenly collapse during staged construction.

Sheet Pile

Sheet pile sections could be driven on the outside of the existing culvert to retain the soil in the event that a portion of the culvert collapses during construction. At this site, the sheet pile would likely be driven to refusal on the underlying limestone bedrock layer. We have been provided with a set of plans indicating that the invert elevation of the culvert is planned to be approximately 709 feet. Based on the elevations from the boring logs, the top of bedrock elevation is approximately 704 to 707 feet. Assuming limited sheet pile penetration into the bedrock, we do not anticipate that the sheet pile would develop enough lateral resistance to make this option viable for protecting the slab from excess settlement in the event of culvert collapse.

Precast Concrete Panels or Cast-in-Place Slab

Another option to protect the slab from excess settlement is to construct a series of trench footings on the sides of the culvert. The trench footings could be backfilled with lean concrete and precast concrete panels could be supported on the trench footings. This would require the precast panels to be designed to structurally span the distance between trenches in the event that the culvert fails during staged construction. The benefit to the precast panels and trench footings would be that even if the soil fell away from the temporary slab due to culvert failure, the trench footings would still be present to support the precast panels supporting the slab.

As an alternative to precast concrete panels, a trench footing could be constructed on either side of the culvert and the trenches could be filled with cast-in-place concrete to create a concrete wall. The structural slab could be connected to these walls to support.

Micropiles

Another option for supporting the temporary slab during potential culvert failure is to install a series of micropiles. Micropiles are small diameter steel piles installed into the subgrade until sufficient resistance or a design capacity is achieved. Due to shallow bedrock at this site, we anticipate that micropiles would need to be installed into holes that have been prebored some distance into the limestone bedrock to develop lateral resistance. This would help to avoid the scenario where soil sloughs away from the piles and results in unbraced lengths of pile. While likely more expensive than other options, micropiles could potentially be installed quickly and would not require significant earthwork to construct. However, pile caps would likely be needed to connect the temporary slab to the piles.

CONSTRUCTION CONSIDERATIONS

Site Preparation

Vegetation, organic soils, pavements, gravel, and any loose, soft, or otherwise unsuitable materials should be removed from proposed construction areas. Stripping depths will likely vary across the site and should be adjusted based on conditions encountered during site preparation.

Dewatering Considerations

The presence of water has the potential to negatively impact construction activities at this site. Depending on seasonal conditions, it is possible that the creek will have flowing water at the time of construction. Whether or not this is the case, we recommend that strong consideration be given to constructing a temporary cofferdam structure on the creek upstream of the project site. The water retained behind the cofferdam could then be pumped around the project site and released back into the creek at a downstream location. The temporary cofferdam will allow the installation of the new box culvert and fill placement to take place in dry conditions.

After temporarily diverting the creek, we anticipate that saturated soils may be found in the creek bed. The soils in each boring at the anticipated invert elevation appeared to generally be stiff, but it is possible that lower strength soils could be present outside the limits of the existing culvert. If lower strength materials are encountered, we recommend that these soils be completely removed and replaced per the **Foundation Recommendations** section.

Railroad Track Subgrade

The end of the historic Aurora, Elgin, and Fox River Electric Company Railroad line is located at the project site. We understand that the railroad ended its commercial operation in 1972, but it is still used by the Fox River Trolley Museum one day per week between May and November for short trolley excursions.

It is recommended that the track bed be proofrolled prior to placement of any ballast or subballast before replacing the track. Proofrolling should be accomplished using a loaded tandem axle dump truck. It is recommended that proofrolling equipment have a minimum gross weight of 30 tons. This surficial proofroll would help to provide a stable base for the compaction of new structural fill, and delineate low density, soft, or disturbed areas that may exist below subgrade level. Soft, low density, and disturbed areas should be scarified, moisture conditioned, and recompacted or replaced with approved CA-6 material. A drain tile should be placed at the bottom of any overexcavated areas and outlet to a suitable discharge location to avoid the “bathtub effect.”

Fill Material Types and Compaction Requirements

All fill materials should be approved by the site engineer. Backfill material should meet and be placed and compacted in accordance with applicable IDOT 2016 Standard Specifications for Road and Bridge Construction.

Backfill material around the culvert should be CA-6 crushed stone, gravel, or concrete. The use of granular backfill around the culvert will reduce the potential for differential settlement at the interface of the rigid culvert structure and the backfill zone. The backfill should be placed in lifts and compacted as indicated above. The granular backfill material should be encased in a layer of concrete to protect it from erosion and scour in the event that the creek level rises. The granular backfill should also be keyed into the native clay soils to reduce the potential for the creek flow diverting into the granular material.

Earthwork Construction Considerations

Construction monitoring should be performed in accordance with IDOT Standard Specifications. Density and moisture content tests should be performed during fill/backfill placement. Where the test results indicate the fill materials represented by the test do not meet the project specifications, the material should be recompacted until the specifications are met. If this cannot be achieved, the material should be removed and replaced with properly compacted fill.

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 shall neither be implied nor inferred.

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 the ***GeoReport*** 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.

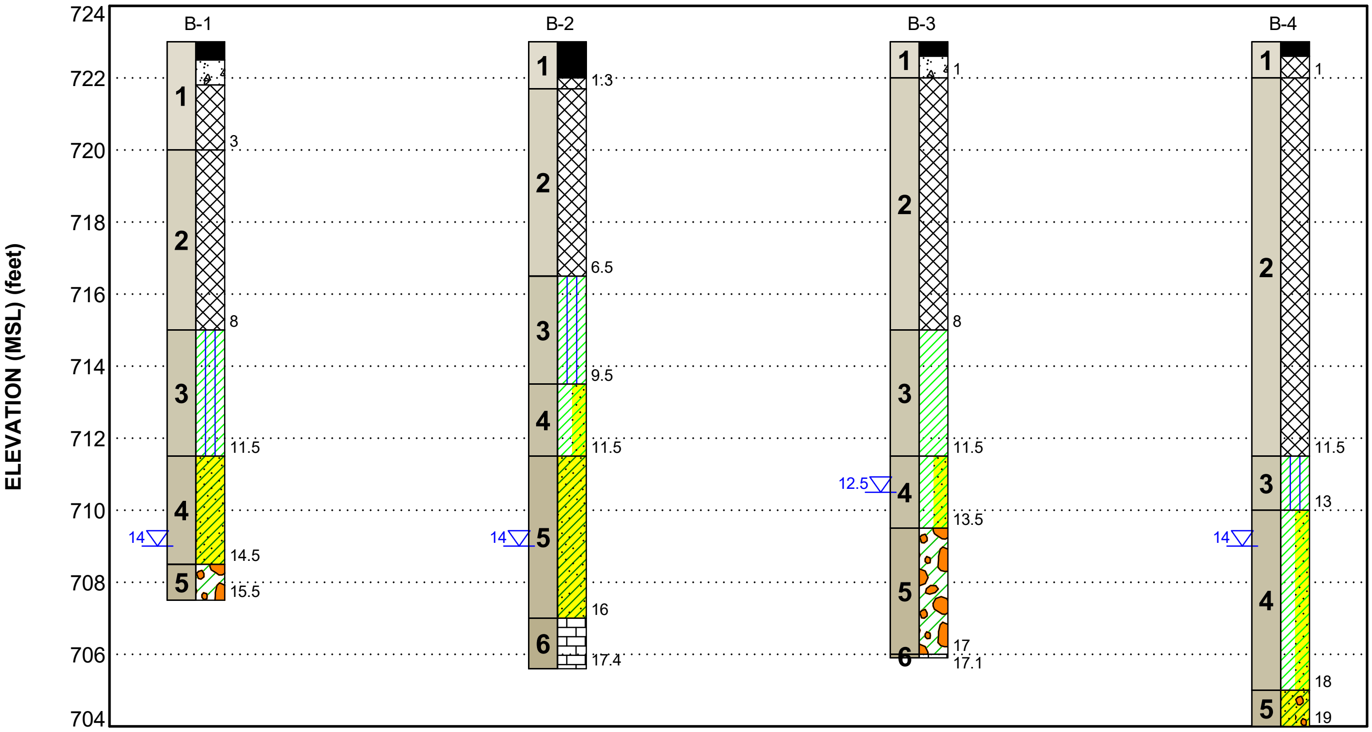
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation 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

IL Route 31 Culvert Replacement ■ South Elgin, IL
9/12/2019 ■ Terracon Project No. MR195107



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

LEGEND

- ■ Asphalt
- ▨ Fill
- ▨ Sandy Lean Clay
- ▨ Lean Clay with Sand
- ▨ Lean Clay
- ▨ Concrete
- ▨ Silty Clay
- ▨ Clayey Gravel
- ▦ Highly Weathered Limestone
- ▨ Sandy Lean Clay with Gravel

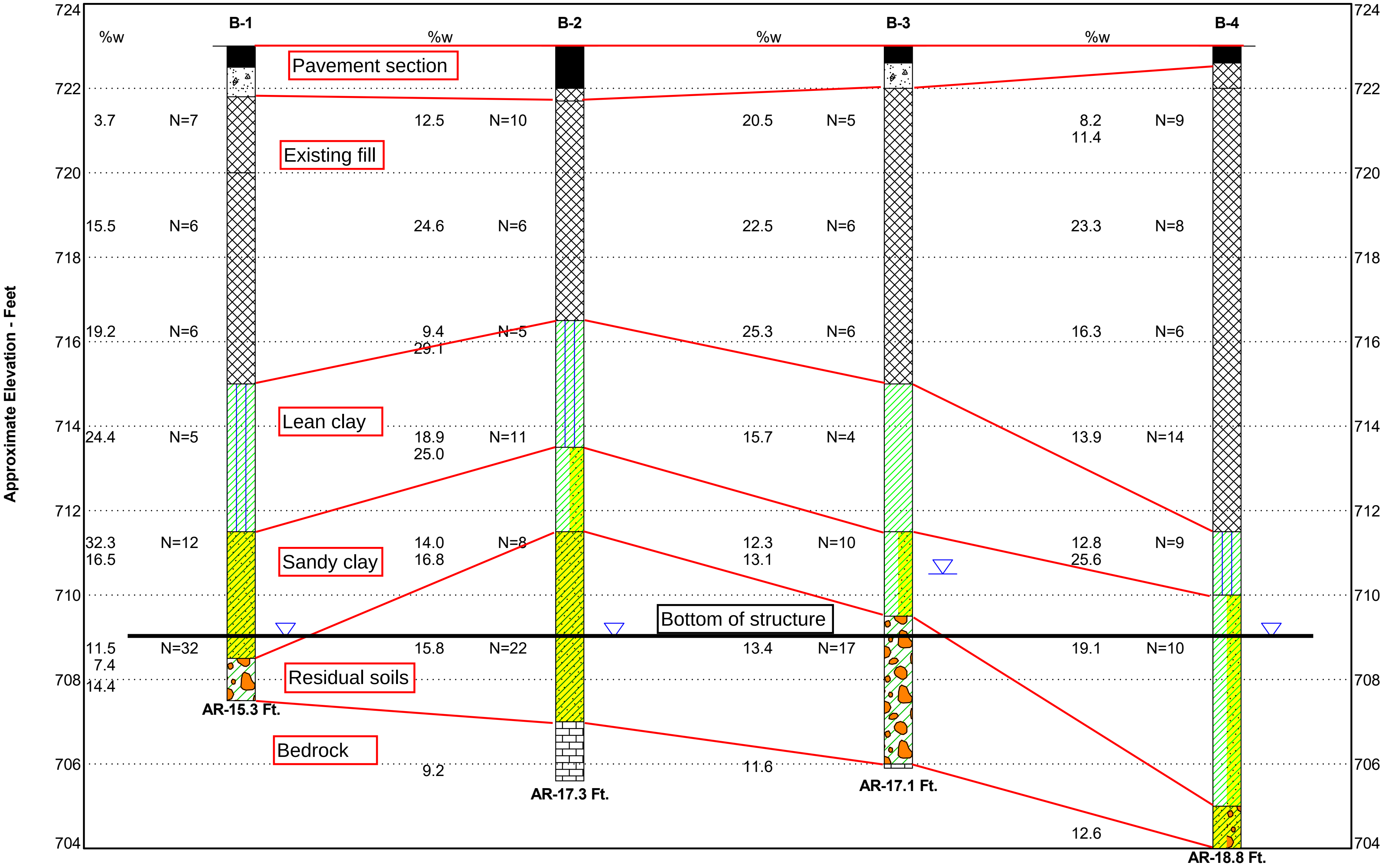
Model Layer	Layer Name	General Description
1	**Pavement Section**	Asphalt and Portland cement concrete, base course
2	**Existing Fill**	Existing fill - Sandy clay and silty clay loam (IDOT)
3	**Lean Clay**	Silty clay (IDOT)
4	**Sandy Clay**	Silty clay loam and sandy clay (IDOT)
5	**Residual Soils**	Fine to medium clayey gravel and sandy clay (residual weathered bedrock) (IDOT)
6	**Bedrock**	Weathered limestone bedrock

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.

▽ First Water Observation
▽ Second Water Observation
▼ Third 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.



Explanation

B-1 — Borehole Number

Moisture Content — %w

LL PL — Liquid and Plastic Limits

Sampling — Borehole Lithology

AR BT — Borehole Termination Type

▽ Water Level Reading at time of drilling.

▼ Water Level Reading after drilling.

See Exploration Plan for orientation of soil profile.
See General Notes in Supporting Information for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

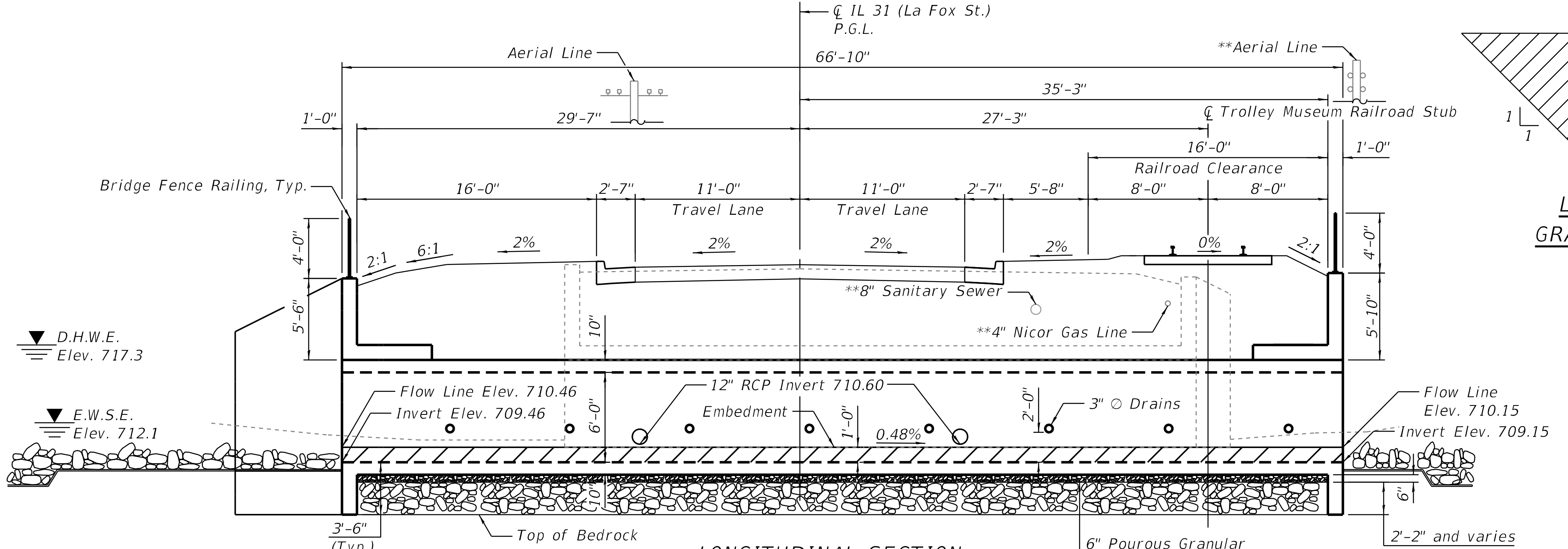
Project Manager: NLH	Project No.: MR195107	Terracon 650 W Lake St, Ste 420 Chicago, IL PH. 312-575-0014 FAX. 312-575-0111	**SUBSURFACE PROFILE** SUBSURFACE DATA PROFILE PLOT IL ROUTE 31 CULVERT REPLACEMENT IL RTE. 31 & W. PLUM ST. SOUTH ELGIN, IL
Drawn by: NLH	Scale: NTS		
Approved by:	File Name: MR195107		
Date: 1/13/2022			

EXHIBIT

Benchmark: Mag Nail at Station 50+00 center of roadway, Elev. 722.63

Existing Structure: SN 045-0218 built in an unknown year under an unknown project as a 7.5' W x 4' H to 6' H concrete and stone arched culvert with a length of 42'-0". Existing culvert to be removed and replaced. Traffic to be maintained utilizing a detour.

No Salvage



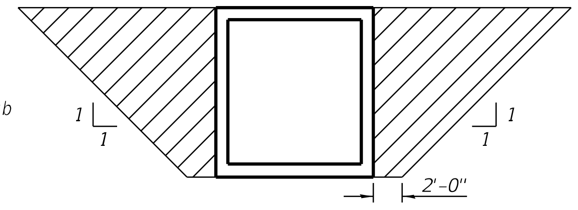
LONGITUDINAL SECTION

All roadway dimensions are at right L's to the roadway ℄
(Looking North)

**Utility field location to be verified and relocated

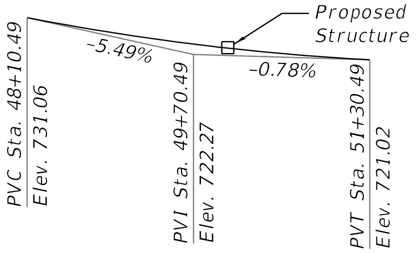
GENERAL NOTES

The design fill height for this box is 9 ft. This is an equivalent fill height to account for railroad loading over the culvert. The precast box culvert sections shall conform to the requirements of ASTM C 1577.



LIMITS FOR POROUS GRANULAR EMBANKMENT

(Hatched area)



Length of V.C. = 320.00'

PROFILE GRADE

(FAU 3887 Along ℄ of Roadway)

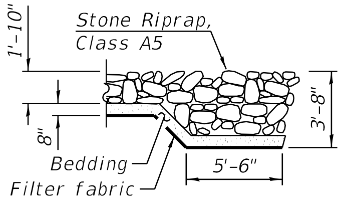
WATERWAY INFORMATION

Ex. Overtopping Elev. = 720.88* @ Sta. 51+12 ◪

Drainage Area = 0.41719 sq. mi. Pr. Overtopping Elev. = 720.88* @ Sta. 51+12 ◪

Flood	Freq. Yr.	Q C.F.S.	Opening Ft²		Nat. H.W.E.	Head - Ft.		Headwater El.	
			Exist.	Prop.		Exist.	Prop.	Exist.	Prop.
	10	146.8	34.6	46.2	715.0	0.3	0.0	715.3	715.0
Design	50	272.5	41.8	50.0	717.3	1.0	0.6	718.3	717.9
Base	100	349.3	41.8	50.0	717.7	1.8	1.0	719.5	718.7
Overtop Existing	>100	457.0	41.8	N/A	N/A	N/A	N/A	720.9	N/A
Overtop Proposed	>100	593.0	N/A	50.0	N/A	N/A	N/A	N/A	720.9
Max. Calc.	500	349.3	41.8	50.0	717.7	1.8	1.0	719.5	718.7

◪ This location is the lowest elevation where water would flood the pavement: back of the curb on the upstream end of the culvert at station 51+12.



SECTION A-A

HIGHWAY CLASSIFICATION

FAU Rte. 3887 - IL Rte. 31
Functional Class: Minor Arterial
ADT: 6,100 (2021); 12,000 (2040)
ADTT: 335 (2021); 576 (2040)
DHV: 1,200 (2040)
Design Speed: 40 m.p.h.
Posted Speed: 40 m.p.h.
2-Way Traffic
Directional Distribution: 50:50

LOADING HL-93 AND MUSEUM RAIL

Allow 50#/sq. ft. for future wearing surface.
286,000 lbs for gross car weight assuming 4 axles.

DESIGN SPECIFICATIONS

2020 AASHTO LRFD Bridge Design Specifications, 9th Edition

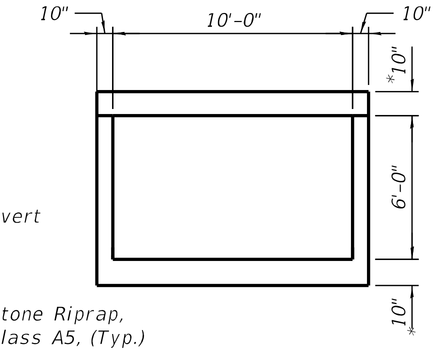
DESIGN STRESSES

FIELD UNITS

f'c = 3,500 psi
fy = 60,000 psi (Reinforcement)

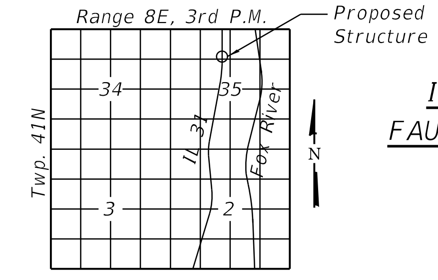
PRECAST UNITS

f'c = 5,000 psi
fy = 60,000 psi (Reinforcement)



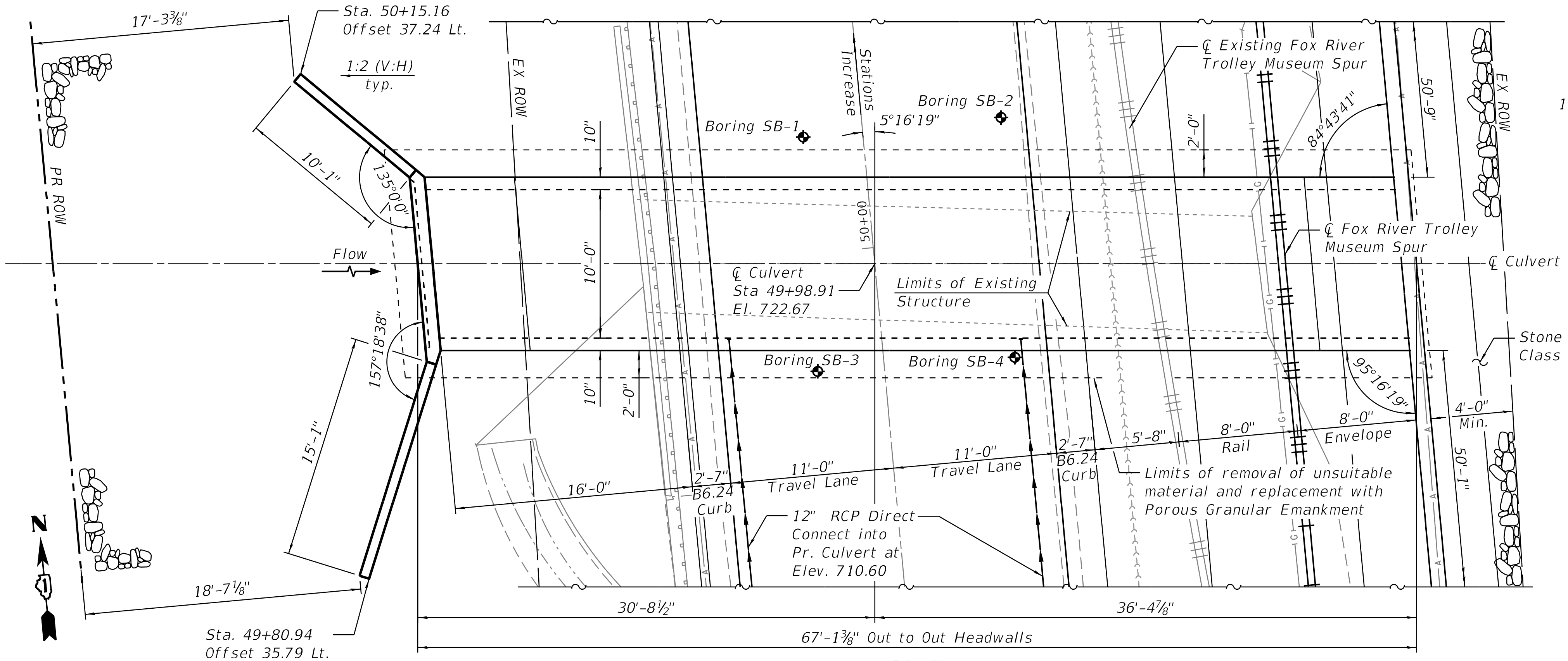
SECTION THRU BARREL

*Subject to Refinement during final design



LOCATION SKETCH

GENERAL PLAN & ELEVATION
ILLINOIS ROUTE 31 OVER DITCH
FAU ROUTE 3887 - SEC. 2018-042-CR
KANE COUNTY
STATION 49+98.91
STRUCTURE NO. 045-8302

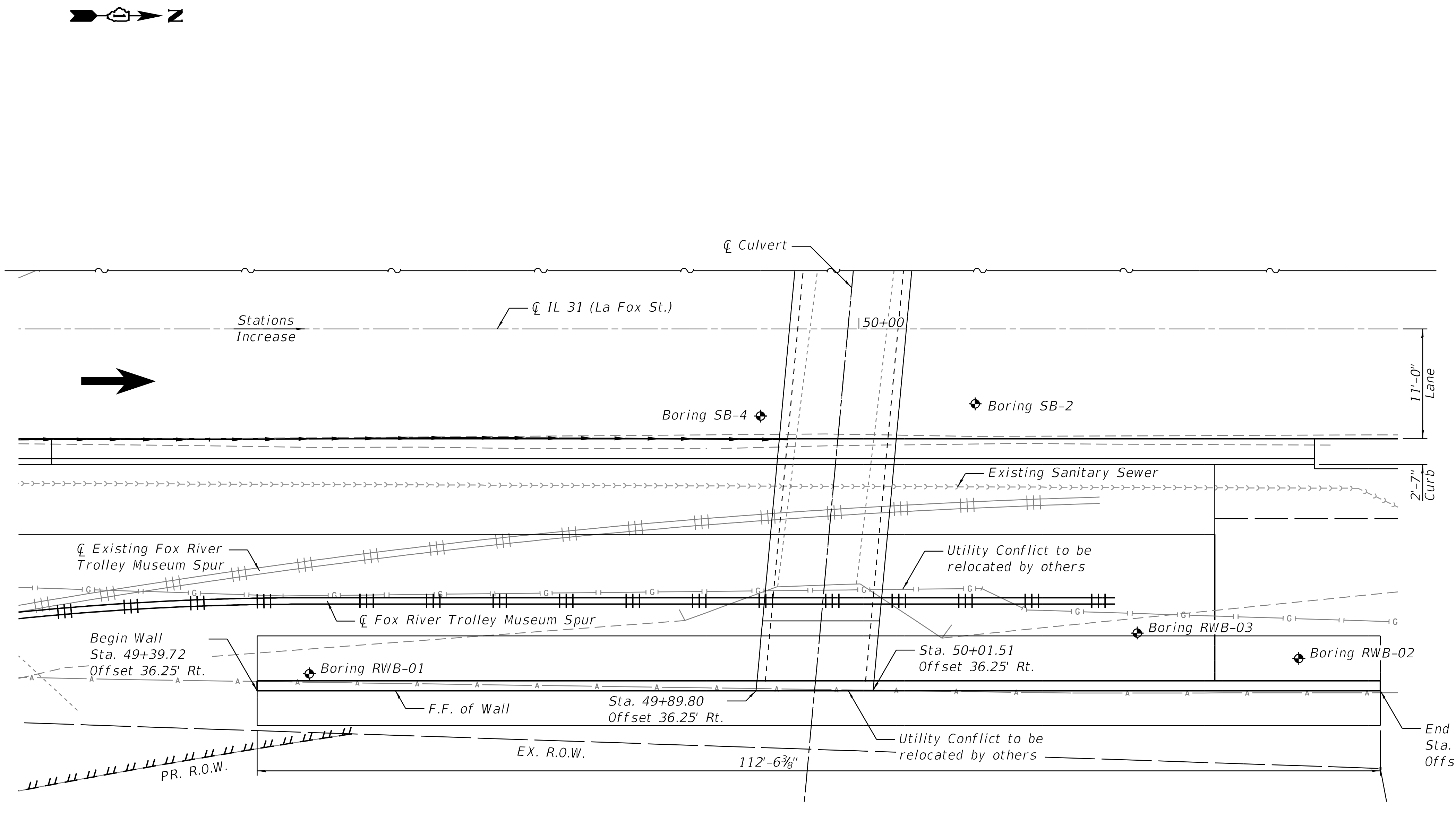


PLAN

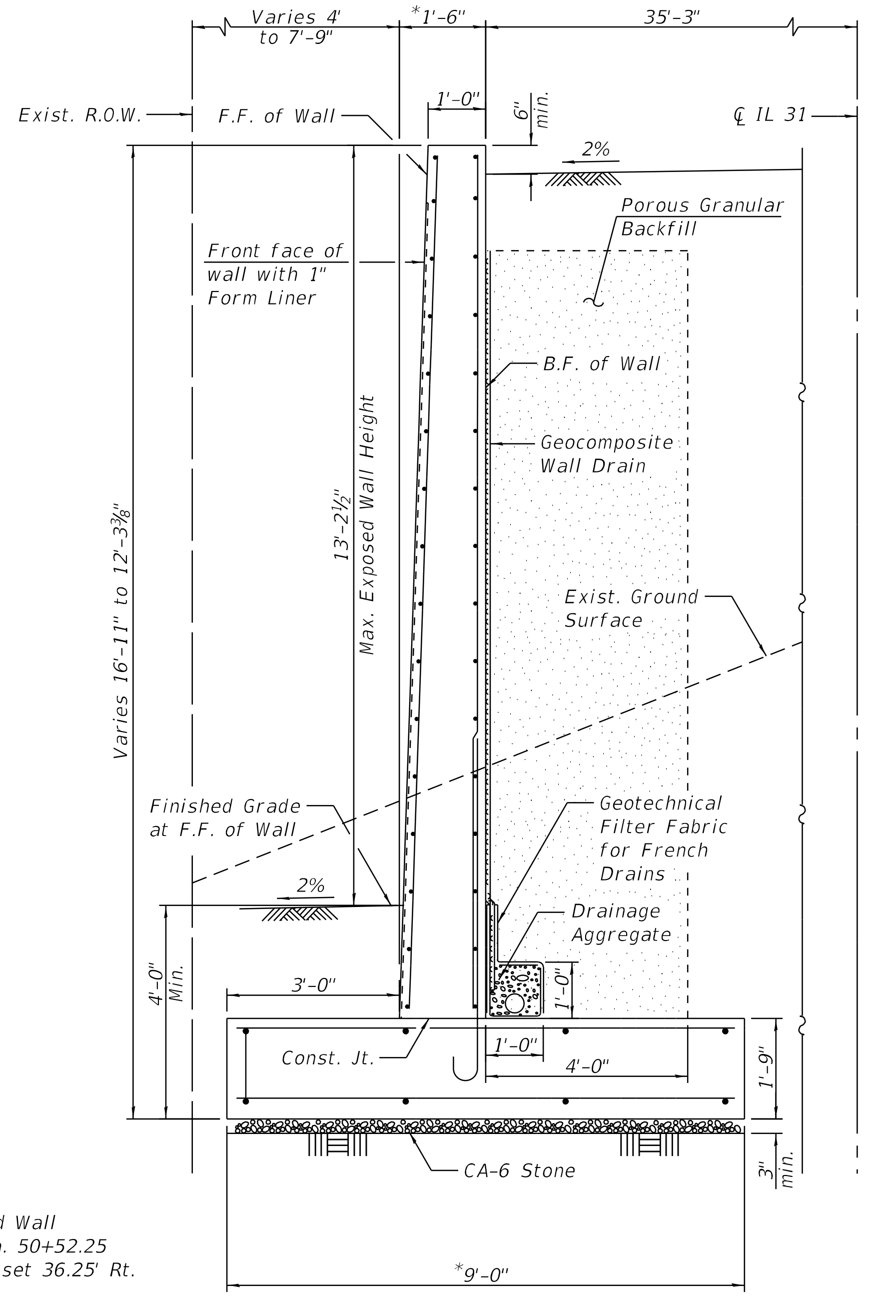
PEN TABLE = pdfNOLAYERSbw.pltcfg	DESIGNED - JES	REVISED -	STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION	GENERAL PLAN & ELEVATION
PLOT DRIVER = D162H02-PreFinal.tbl	CHECKED - RRD	REVISED -		
PLOT SCALE =	DRAWN - SVJ	REVISED -		
PLOT DATE = 12/14/2021 4:52:05 PM	DATE - 12/14/2021	REVISED -		SHEET OF SHEETS

F.A.U. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
3887	2018-042-CR	DUPAGE	2	1
		CONTRACT NO. 62H02		
	ILLINOIS	FED. AID PROJECT		

USER: jstapleton
MODEL: Default
FILE NAME: P:\02_209_004_IDOT PTB 190_14 Phase II Var-Var\Design\WO 2 62H02\CADD\CADD_Sheets\D162H02-sht-TSL-1-2021.dgn



PLAN



TYPICAL CROSS SECTION T-TYPE WALL

*Subject to refinement during final design

WALL GENERAL PLAN AND TYPICAL CROSS SECTION
ILLINOIS ROUTE 31 OVER DITCH
FAU ROUTE 3887 - SEC. 2018-042-CR
KANE COUNTY
STATION 49+39.72 TO STATION 50+52.25
STRUCTURE NO. 045-8302

USER: jstapleton
MODEL: Default
FILE NAME: P:\02_209_004_IDOT PTB 190_14 Phase II Var-Var\Design\WO 2 62H02\CADD\CADD_Sheets\D162H02-sht-TSL-2-2021.dgn

PEN TABLE = pdfNOLAYERSbw.pltcfg	DESIGNED - JES	REVISED -	
PLOT DRIVER = D162H02-PreFinal.tbl	CHECKED - RRD	REVISED -	
PLOT SCALE =	DRAWN - SVJ	REVISED -	
PLOT DATE = 12/14/2021 4:19:44 PM	DATE - 12/14/2021	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

WALL GENERAL PLAN AND TYPICAL CROSS SECTION

SHEET OF SHEETS

F.A.U. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
3887	2018-042-CR	DUPAGE	2	2
		CONTRACT NO. 62H02		
	ILLINOIS	FED. AID PROJECT		

ATTACHMENTS

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

IL Route 31 Culvert Crossing Unnamed Ditch ■ South Elgin, Illinois
January 28, 2022 ■ Terracon Project No. MR195107 (Rev. 2)

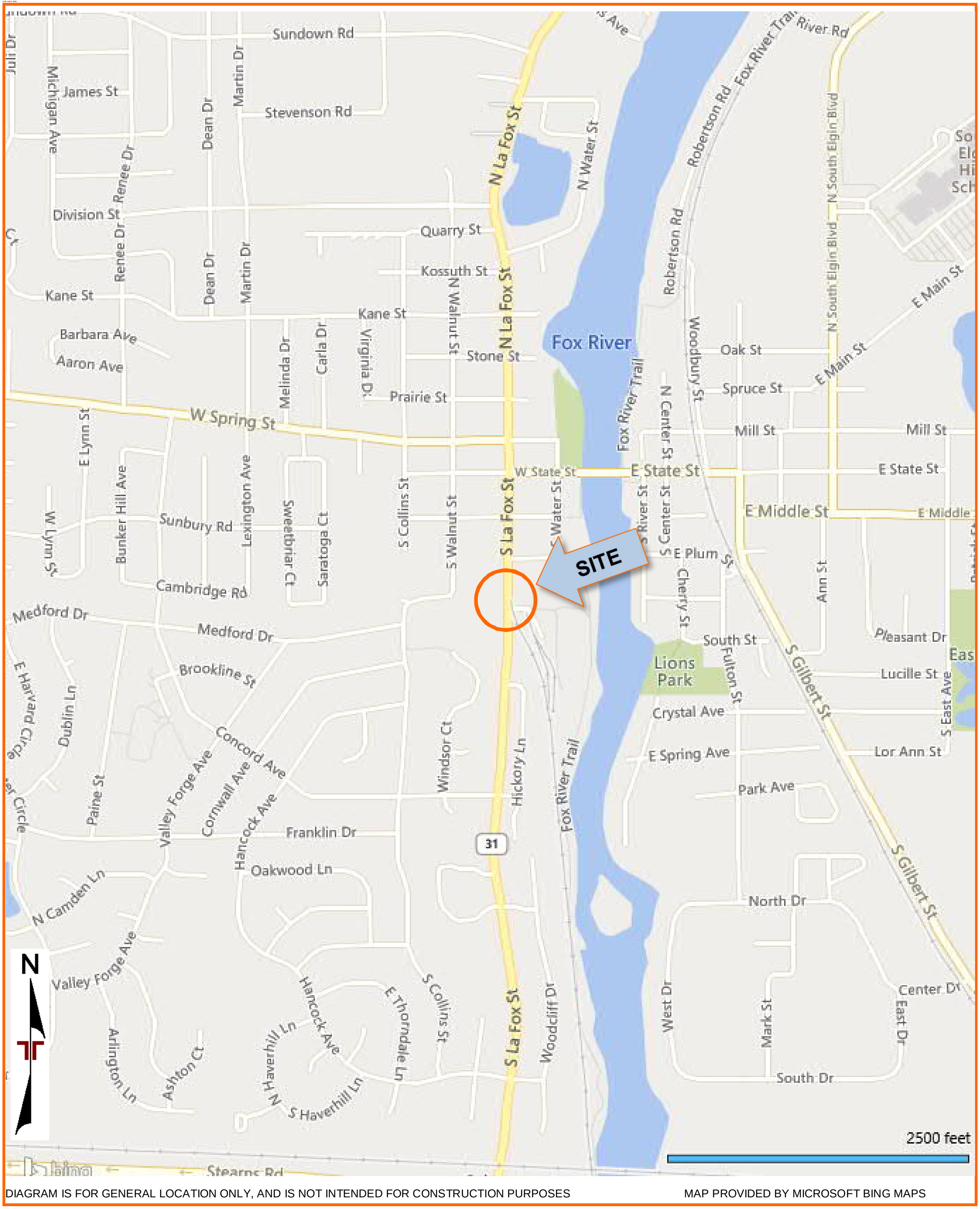


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

IL Route 31 Culvert Crossing Unnamed Ditch ■ South Elgin, Illinois
January 28, 2022 ■ Terracon Project No. MR195107 (Rev. 2)

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

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

Illinois Department of Transportation
Division of Highways
Terracon

SOIL BORING LOG

Page 1 **of** 1

Date 8/1/19

ROUTE ____ **DESCRIPTION** IL Route 31 Culvert Replacement **LOGGED BY** NH

SECTION ____ **LOCATION** , **SEC.** , **TWP.** , **RNG.** ,
Latitude 41.991626, **Longitude** -88.297175

COUNTY Kane **DRILLING METHOD** Power auger **HAMMER TYPE** Automatic

STRUCT. NO. ____
Station ____

BORING NO. SB-1
Station 50+9
Offset 5' LT
Ground Surface Elev. 723.00 **ft**

Surface Water Elev. ____ **ft**
Stream Bed Elev. ____ **ft**

Groundwater Elev.:
First Encounter 709.0 **ft** ▼
Upon Completion ____ **ft**
After ____ **Hrs.** ____ **ft**

	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
6¼" Asphalt	722.50				
8" Portland Cement Concrete	721.80				
FILL - CRUSHED STONE, about 22 inches	720.00		6 4 3		4
FILL - SILTY CLAY LOAM: trace gravel, brown (USCS - Lean clay with sand)		-5	2 3 3	1.8 P	15
	715.00		2 3 3	1.0 P	19
SILTY CLAY: trace sand and roots/organics, dark brown and dark gray, stiff (USCS - Lean to silty clay, CL-ML)		-10	2 2 3	1.3 P	24
	711.50		3 6 6	1.8 P	32 17
SANDY CLAY: with gravel and limestone fragments, brown and reddish brown, stiff (USCS - Sandy lean clay, CL)	▼ 708.50	-15	3 11 21	2.0 P	12 7
FINE TO MEDIUM CLAYEY GRAVEL: with sand (residual weathered bedrock), light brown, moist (USCS - Clayey gravel, GC)	707.50		50		14
End of Boring		-20			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
Terracon

SOIL BORING LOG

Page 1 **of** 1

Date 8/1/19

ROUTE

DESCRIPTION IL Route 31 Culvert Replacement

LOGGED BY NH

SECTION

LOCATION , **SEC.** , **TWP.** , **RNG.** ,
Latitude 41.991628, **Longitude** -88.297123

COUNTY Kane

DRILLING METHOD Hollow stem auger

HAMMER TYPE Automatic

STRUCT. NO.
Station

BORING NO. SB-2
Station 50+11
Offset 9' RT
Ground Surface Elev. 723.00 **ft**

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 709.0 **ft** ▼
Upon Completion ft
After Hrs. ft

		DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
12½" Asphalt	722.00				
FILL - CRUSHED STONE, about 3 inches	721.70		4 5 5	1.3 P	13
FILL - SANDY CLAY: with gravel, brown (USCS - Sandy lean clay)	716.50	-5	6 3 3	1.0 P	25
SILTY CLAY: trace sand and roots/organics, dark brown and brown, stiff (USCS - Lean to silty clay, CL-ML)	713.50		4 3 2	2.0 P	9 29
SILTY CLAY LOAM: trace gravel and organics, gray and grayish brown, stiff (USCS - Lean clay with sand, CL)	711.50	-10	4 5 6	2.0 P	19 25
SANDY CLAY: with gravel and limestone fragments (residual weathered bedrock), reddish brown and dark brown, stiff (USCS - Sandy lean clay, CL)			5 3 5	1.5 P	14 17
	▼ 707.00	-15	4 7 15		16
LIMESTONE, weathered and broken, light gray	705.60		50		9
End of Boring		-20			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

Illinois Department of Transportation

Division of Highways
Terracon

SOIL BORING LOG

Page 1 **of** 1

Date 8/1/19

ROUTE ______ **DESCRIPTION** IL Route 31 Culvert Replacement **LOGGED BY** NH

SECTION ______ **LOCATION** , **SEC.** , **TWP.** , **RNG.** ,
Latitude 41.991578, **Longitude** -88.297168

COUNTY Kane **DRILLING METHOD** Power auger **HAMMER TYPE** Automatic

STRUCT. NO. ______
Station ______

BORING NO. SB-3
Station 49+89
Offset 4' LT
Ground Surface Elev. 723.00 **ft**

Surface Water Elev. ______ **ft**
Stream Bed Elev. ______ **ft**

Groundwater Elev.:
First Encounter 710.5 **ft** ▼
Upon Completion ______ **ft**
After ______ **Hrs.** ______ **ft**

	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
5" Asphalt	722.60				
7" Portland Cement Concrete	722.00				
FILL - SILTY CLAY LOAM: with gravel, brown and dark brown (USCS - Lean clay with sand)			4 3 2	1.0 P	21
		-5	2 3 3	2.5 P	23
	715.00		2 3 3	2.5 P	25
SILTY CLAY: trace sand and gravel, brown and reddish brown, stiff (USCS - Lean clay, CL)	711.50	-10	2 2 2	1.0 P	16
SILTY CLAY LOAM: trace roots/organics, dark brown, stiff (USCS - Lean clay with sand, CL) ▼	709.50		2 7 3	1.3 P	12 13
FINE TO MEDIUM CLAYEY GRAVEL: with sand and limestone fragments (residual weathered bedrock), brownish gray, moist, medium dense (USCS - Clayey gravel, GC)	706.00	-15	11 10 7		13
LIMESTONE: weathered and broken, light gray	705.90		50		12
End of Boring		-20			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
Terracon

SOIL BORING LOG

Page 1 of 1

Date 8/1/19

ROUTE

DESCRIPTION IL Route 31 Culvert Replacement

LOGGED BY NH

SECTION

LOCATION , SEC. , TWP. , RNG. ,
Latitude 41.991566, **Longitude** -88.297120

COUNTY Kane

DRILLING METHOD Hollow stem auger

HAMMER TYPE Automatic

STRUCT. NO.
Station

BORING NO. SB-4
Station 49+90
Offset 9' RT
Ground Surface Elev. 723.00 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 709.0 ft ▼
Upon Completion ft
After Hrs. ft

	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
3½" Asphalt 722.60				
FILL - CRUSHED STONE, about 9 inches 722.00		7		
FILL - SANDY CLAY: with gravel, dark brown, brown, and gray (USCS - Sandy lean clay)		4		8
		5		11
		2		
		3	3.3	23
	-5	5	P	
		3		
		3		16
		3		
		4		
		3	1.8	14
	-10	11	P	
711.50		2		
SILTY CLAY: trace sand and roots/organics, dark brown, stiff (USCS - Lean to silty clay, CL-ML)		3	1.5	13
		6	P	26
710.00				
SILTY CLAY LOAM: trace gravel, gray and reddish brown, medium stiff (USCS - Lean clay with sand, CL)	▼	5		
		6	0.5	19
	-15	4	P	
705.00				
SANDY CLAY: with gravel and limestone fragments (residual weathered bedrock), gray and brown 704.00		50		13
	-20			
(USCS - Sandy lean clay with gravel, CL)				
End of Boring				
	-25			
	-30			
	-35			
	-40			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

IL Route 31 Culvert Replacement ■ South Elgin, IL

September 13, 2019 ■ Terracon Project No. MR195107

Terracon GeoReport

SAMPLING

☒ Standard Penetration Test

WATER LEVEL

▽ **Water Initially Encountered**

⊽ **Water Level After a Specified Period of Time**

▼ **Water Level After a Specified Period of Time**

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 is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. 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

RELATIVE PROPORTIONS OF SAND AND GRAVEL		**RELATIVE PROPORTIONS OF FINES**	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		**PLASTICITY DESCRIPTION**	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

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]	Cu ≥ 4 and 1 ≤ Cc ≤ 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 ≥ 6 and 1 ≤ Cc ≤ 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”		CL	Lean clay[K, L, M]
			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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

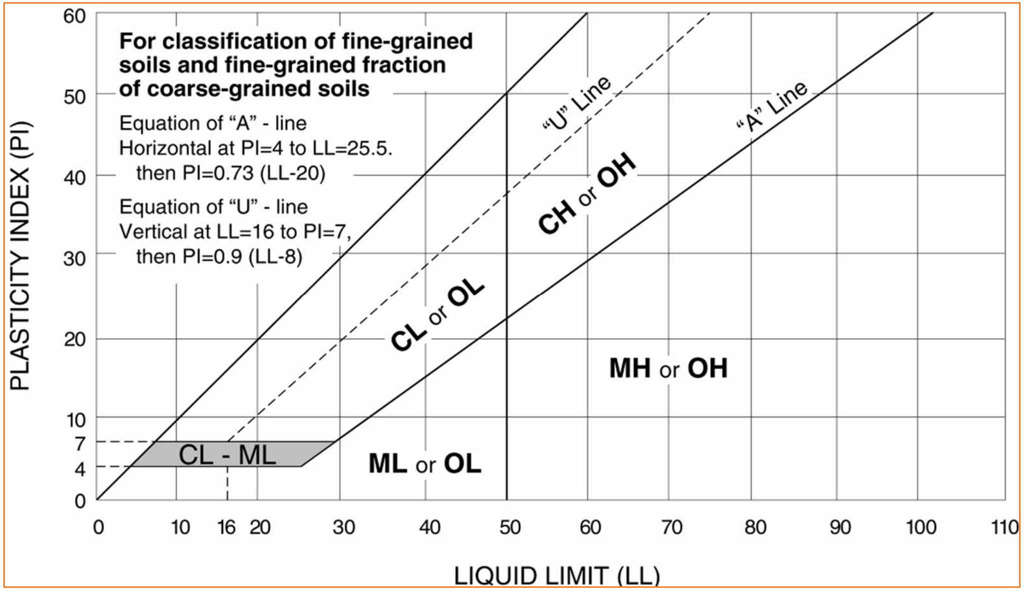
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ≥ 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

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