



Structure Foundation Exploration Report - Final
Replacement Structure No. DEL-229-2.30
Delaware County, Ohio
S&ME Project No. 23170229

PREPARED FOR:

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November 12, 2024



November 12, 2024

BG Engineering Group, LLC
5960 Wilcox Place, Suite C
Dublin, OH 43016

Attention: Mr. Ravinder Gupta, P.E.

Reference: **Structure Foundation Exploration Report - Final
Replacement Culvert No. DEL-229-0230**
Delaware County, Ohio
S&ME Project No. 23170039

Mr. Gupta:

In accordance with our proposal dated March 14, 2023, and the BG Engineering Group, LLC (BG) "Subconsultant Services Agreement Between BG Engineering Group, LLC and S&ME, Inc." which was executed on June 16, 2023, S&ME has completed a Structure Foundation Exploration for the proposed replacement of the field drain culvert passing beneath SR 229 at SLM 2.30 in northern Delaware County, Ohio. The approximate location of this project is illustrated on the Vicinity Map included as Plate 1 in the Appendix of this report.

In accordance with Section 701 of the ODOT *Specifications for Geotechnical Explorations (SGE)* and your November 7, 2024 request, S&ME is herewith submitting a "final" version of this report. Additionally, S&ME submitted final ODOT Geotechnical Profile – Culvert sheets to you on November 7, 2024.

We appreciate the opportunity to be of service. Please do not hesitate to contact us if you have any questions concerning this report.

Respectfully,

S&ME, Inc.

A blue ink signature of Brian K. Sears, consisting of a stylized 'B' followed by 'K. Sears'.

Brian K. Sears, P.E.
Senior Engineer

A blue ink signature of Richard S. Weigand, featuring a stylized 'R' and 'S' followed by 'Weigand'.

Richard S. Weigand, P.E.
Principal Engineer | Senior Reviewer

Attachments: Appendix (8 sheets)
Submitted: Email copy (rgupta@bgenggroup.com)





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1.0 Executive Summary

It is proposed to replace the existing 30-inch diameter RCP field drain which passes beneath SR 229 at SLM 2.30 in northern Delaware County. The currently proposed replacement structure is a 6-foot by 4-foot precast concrete box culvert with full-height headwalls. Based on available plan and profile information, little to no adjustment of the existing horizontal and vertical alignment of SR 229 is planned; however, the new culvert is to be 66 feet long to provide safety grading along the roadway. This length of new culvert will require widening of the existing SR 229 embankment.

Initially, ODOT District 6 requested two (2) Type E2b culvert borings be performed at this site in accordance with the ODOT *Specifications for Geotechnical Explorations (SGE)*. However, because of the small size of the proposed replacement culvert and the presence of overhead wires which would require work outside the existing right-of-way, District 6 indicated that one boring would be sufficient at this site.

Boring B-001-0-23 was drilled to a depth of 30 feet through the existing roadway embankment and pavement, with Standard Penetration Test (SPT) sampling performed at 2.5-foot intervals. Beneath 6 inches of asphalt and 6 inches of granular base, the boring encountered 2.0 feet of existing embankment fill consisting of very stiff brown and gray SILT AND CLAY (A-6a). Below the fill, the boring encountered natural soils consisting of 5.0 feet of stiff to very stiff brown mottled with gray and dark-gray CLAY (A-7-6) and 2.5 feet of very-stiff brown mottled with gray SILT AND CLAY (A-6a) over 19.5 feet of hard gray SANDY SILT (A-4a). A few cobbles were noted within this gray glacial till.

During drilling, no groundwater seepage was noted in this boring.

Based on plan and profile drawings provided by BG, S&ME understands the following proposed elevations are planned for the replacement box culvert:

	Culvert Inlet	Culvert Outlet
Flow Line	EL. 944.50	EL. 944.30
Bottom of Box Culvert	~ EL. 943.8	~ EL. 943.6
Bearing Elevation of Full-Height Wingwalls/Headwalls	~ EL. 942.3	~ EL. 942.1
Bottom of Cut-off Wall	EL. 939.83	EL. 939.63

The results of Boring B-001-0-23 indicate that the natural cohesive soil between approximate Elevations 943 and 946.5 do not meet the minimum requirements for undrained shear strength (S_{uf}) of 1,500 psf required by the standard ODOT Culvert Design Data Sheets (HWDD-1) for the design of box culverts with full-height headwalls. Therefore, in accordance with Section 1402 of the ODOT Geotechnical Design Manual, S&ME recommends that all cohesive soil of insufficient strength ($S_{uf} < 1,500$ psf) be overexcavated and replaced with a compacted granular material. The results of Boring B-001-0-23 indicate the presence of sufficiently strong soil at and below approximate Elevation 943. See Section 5.0 for additional recommendations

This site has a Seismic Site Classification of "D". See Plates 5 through 7 of the Appendix for these calculations.



2.0 Introduction

S&ME understands that the existing 30-inch diameter RCP field drain which passes beneath SR 229 at SLM 2.30 in northern Delaware County is to be replaced with a 6-foot by 4-foot precast concrete box culvert with full-height concrete headwalls. The new box culvert is to be roughly 66 feet long to provide safety grading zones along SR 229. This approximate 25-foot lengthening of the new culvert will require widening of the existing highway embankment. The proposed plans also indicate that little to no adjustment of the existing horizontal and vertical alignment of SR 229 is planned.

This exploration was originally planned to be performed in accordance with the ODOT *Specifications for Geotechnical Explorations (SGE)* and the ODOT *Geotechnical Design Manual (GDM)*, with two (2) Type E2b culvert borings being performed. However, because of the small size of the proposed replacement culvert and the presence of overhead wires which would require work outside the existing right-of-way, ODOT District 6 determined that performing only one boring would be sufficient at this site.

3.0 Exploration

3.1 Available Information

No historic geotechnical exploration information was located for this project.

3.2 Geology

The project site is in a glaciated portion of state designated as the Central Ohio Clayey Till Plain physiographic region of Ohio. The soil overburden consists of thin to thick deposits of ground and end moraine deposits of predominantly cohesive Wisconsinan-age glacial till. The uppermost bedrock consists primarily of Ohio formation shale, and ODNR bedrock mapping and water well logs indicate the top of bedrock is located 40 to 70 feet below the ground surface in the vicinity of this site.

3.3 Reconnaissance

On July 14, 2023, S&ME visited the project site to observe current site conditions, look for potential utility conflicts, select and mark the boring location, and assess traffic control requirements at the site. The inlet and outlet of the existing culvert were partially covered with grass and weeds, and some standing water was present at the outlet. The existing pavement appeared to be in generally good condition with a few longitudinal cracks noted near the outer edges of the existing pavement.

3.4 Field Exploration

On October 13, 2023, S&ME drilled Boring B-001-0-23 (hereafter referred to as B-001) through the existing pavement of SR 229 as neither proposed full-height headwall location could be accessed without crossing private property outside the existing right-of-way. The location (latitude/longitude) of this exploration was obtained by S&ME using a sub-meter GPS unit. These coordinates were provided to BG, who provided S&ME with the existing ground surface elevation and proposed station/offset at the boring location. The approximate location of Boring B-001 is shown on the Plan of Borings included as Plate 2 in the Appendix.



The boring was performed by an ATV-mounted drill rig using a 3¼-inch I.D. hollow-stem auger to advance the boring between sampling attempts. SPT soil sampling was performed at 2½-foot intervals throughout the entire boring using a 2-inch O.D. split-barrel sampler driven by blows from a 140-pound hammer freely falling 30 inches (AASHTO T206 - Standard Penetration Test, SPT). The drill rig used for this exploration was calibrated on August 29, 2023, in accordance with ASTM D4633, with a drill rod energy of 87.5%. At the completion of drilling, the boring was backfilled with soil cuttings mixed with bentonite gravel and the existing pavement was repaired with an approximate equivalent thickness of cold patch asphalt.

In the field, experienced S&ME personnel performed the following: 1) examined all samples recovered from the boring; 2) preserved representative portions of soil samples in airtight glass jars; 3) prepared a log of each boring; 4) made seepage and groundwater observations; 5) made hand-penetrometer measurements in soil specimens exhibiting cohesion; and, 6) provided liaison between the field work and the Project Manager so that the exploration program could be modified in the event unusual or unexpected subsurface conditions were encountered. The recovered samples were transported to S&ME's laboratory for further identification and testing.

3.5 Laboratory Testing Program

In the laboratory, all soil samples were visually identified and tested for natural moisture content, with liquid/plastic limit determinations and grain-size analyses performed on select, representative samples of the soils encountered. The results of all tests are reported numerically on the boring log.

Based on the results of the laboratory testing program, soil descriptions on the field boring log were modified, if necessary, and a laboratory-corrected log is included on Plate 4 in the Appendix. Shown on the log are: descriptions of the soil stratigraphy encountered; depths from which samples were preserved; sampling efforts (blow-counts) required to obtain the soil specimens; calculated N_{60} values; laboratory test results; seepage and groundwater observations; and, values of hand-penetrometer measurements made in soil samples exhibiting cohesion. For your reference, hand-penetrometer values are roughly equivalent to the unconfined compressive strength of the cohesive fraction of the soil sample.

Soils have been classified in general accordance with Section 603 of the ODOT *SGE* and described in general accordance with Section 602. An explanation of the symbols and terms used on the boring log, definitions of the special adjectives used to denote the minor soil components, and information pertaining to sampling and identification are presented on Plate 3 of the Appendix. Group Indices determined from the results of the laboratory testing program are also provided on the boring log.

4.0 Findings

4.1 General Subsurface Conditions

Boring B-001 was drilled through the existing roadway embankment and pavement to a depth of 30 feet below the roadway surface. Beneath 6 inches of asphalt and 6 inches of granular base, the following general stratigraphy, described in descending order, was encountered:

- 2.0 feet of existing embankment fill described as very stiff brown and gray SILT AND CLAY (A-6a) containing a few asphalt fragments
- 5.0 feet of natural stiff to very stiff brown mottled with gray and dark-gray CLAY (A-7-6)



- 2.5 feet of very stiff brown mottled with gray SILT AND CLAY (A-6a)
- 19.5 feet of hard gray SANDY SILT (A-4a) containing a few cobbles. The N_{60} values obtained during SPT sampling in this soil ranged from 16 to 36 blows per foot. Boring B-001 was terminated in this stratum at a depth of 30 feet.

Please refer to the individual boring log on Plate 4 in the Appendix for more detailed information. Inferences should not be made to the subsurface conditions away from the boring location without performance of additional borings or other field verifications.

4.2 Groundwater Observations

During drilling, no groundwater seepage was noted in this boring, and the boring was dry at completion, meaning no measurable groundwater had accumulated at the bottom of the borehole. No long-term groundwater measurements were obtained in the boring.

5.0 Analyses and Recommendations

5.1 General Discussion

S&ME understands that the existing 30-inch diameter pipe culvert carrying drainage from an agricultural field beneath SR 229 is to be replaced with a 66-foot-long and 6-foot-wide precast box culvert with a 4-foot rise and full-height concrete headwalls. Although the horizontal and vertical alignment of SR 229 will remain relatively unchanged, the width of the existing SR 229 embankment will need to be widened at this location to accommodate safety grading.

5.2 Roadway Embankment Widening

Plan information provided by BG indicates the proposed safety grading will require the existing SR 229 embankment to be widened approximately 20 feet on both sides of the roadway. Profile information indicates that roughly 4 vertical feet of new embankment fill may be needed in the vicinity of the culvert.

5.2.1 Embankment Foundation Preparation

Prior to the commencement of earthwork operations, it is recommended that all existing pavement, granular base, grass, topsoil, vegetation, and other miscellaneous materials be completely removed from the entire footprint of the proposed roadway subgrade and embankment realignment/widening areas. After the removal of these materials, and prior to commencing fill placement in the embankment widening areas, S&ME recommends that the entire exposed embankment foundation surface be examined by the Geotechnical Engineer of Record or their designated representative to identify any weak, wet, organic, or otherwise unsuitable soils that were not encountered during the subsurface exploration. Any such materials identified should be removed and replaced with suitable compacted fill (ODOT *Construction and Material Specifications (CMS)* Item 203, or Item 204 when within 12 inches of the proposed subgrade) prior to commencing placement of new embankment fill in the widening areas.

S&ME also recommends that consideration be given to performing Item 206.04 Test Rolling of all exposed embankment foundation areas beneath proposed these new fill embankment areas. Test rolling, performed in accordance with Item 204.06 of the ODOT *CMS* and Section 204 of the ODOT Construction Administration,



Manual of Procedures (MOP), would assist in identifying soft, wet, or weak zones, or areas of unsuitable, organic, or highly plastic soil that may be present in ditches, swales, or wetland areas. If any such zones of soft, wet, or weak soils are present, the materials contained in these zones should be scarified, dried, and thoroughly recompacted in place in accordance with ODOT *CMS* Item 203.07. If unsuitable or organic soils are encountered, these materials should be completely removed and the overexcavation filled in a controlled manner with compacted, suitable embankment material (*CMS* Item 203.02).

Soft, weak, wet, or unsuitable soils that are not removed from beneath a thin layer of fill may result in difficulties achieving the compaction percentages required for the new fill (ODOT *CMS* Items 203.07 or 204.03) such that final subgrade acceptance proofrolling may require overexcavation of the new fill where weak soils were “bridged” by a minimal thickness of new fill. Although ODOT *CMS* Item 203.05 permits the use of a “bridge lift” to aid in spanning soft or wet foundation areas, S&ME recommends that this practice not be permitted unless more than 3 feet of new embankment fill placement is required. Additionally, S&ME does not recommend that a bridge lift be permitted in widening areas over existing roadway ditches, even if more than 3 feet of new fill is required, because of the potential for soft organic soil to be present in these ditch areas. Long term settlement within any organic soil left in the embankment areas may result in the development of a depression in the pavement surface.

Existing underground utility lines may be present beneath the existing roadway and/or beneath the proposed embankment widening areas. The type of material used and the relative compactness of backfill placed within utility trenches is unknown. Some instability of utility trench backfill may occur during earthwork operations and/or proofrolling, and some recompaction of the utility trench backfill may become necessary. Additionally, if water has accumulated within the existing utility backfill, the subgrade soil above any saturated utility trenches may have become sufficiently weak, soft, and/or wet that proofrolling may identify these additional areas as requiring overexcavation and replacement. In any case, care should be taken not to disturb any shallow utilities or damage the culverts during proofrolling or overexcavation activities.

5.2.2 Benching of Embankment Slopes

It is recommended that horizontal benches be cut into all existing sloping surfaces to permit placement and compaction of new fill in horizontal lifts. Where new fill for embankment widening is to be placed immediately adjacent to an existing roadway embankment slide slope which is sloping more steeply than 8(H):1(V), S&ME recommends that benching of the existing ground be performed in accordance with ODOT *CMS* Item 203.05.

However, at locations where the sides of the existing embankment/ground surface is steeper than 4(H):1(V), S&ME recommends “Special Benching” procedures as outlined in Section 800, “Special Benching and Sidehill Embankment Fills” of the ODOT *GDM* and the ODOT *MOP* should be performed. Sketches illustrating several “typical” Special Benching configurations for sidehill fills on various slopes are included in Figures 800-1, 800-3, and 800-4 of the ODOT *GDM*.

During any required Special Benching procedures, S&ME also recommends the following: 1) only one bench be exposed at any given time and that excavation of the next bench should not be permitted until embankment fill placement and compaction has been completed to the top of the backslope of the previous bench; and, 2) the length of any given bench that is exposed should not exceed the quantity of embankment fill which may be properly placed and compacted in one day. Additionally, S&ME recommends that the final, completed side slopes of new embankments be constructed no steeper than 2(H):1(V).



As stated in Section 800 of the ODOT *GDM*, wherever “Special Benching” is used, Plan Note G109 from the ODOT *L&D*, Vol. 3, should be included in the General Notes

5.2.3 Borrow Requirements and Compaction Criteria

Soil used as borrow for embankment widening should consist of inorganic soil free of all miscellaneous materials, cobbles, and boulders, which is placed in uniform, thin layers and then compacted in accordance with either ODOT *CMS* Item 203 or, when within 12 inches of the proposed SR 229 subgrade, *CMS* Item 204. Borrow materials should not be placed in a frozen condition or upon a frozen surface, and any sloping surfaces on which new fill is to be placed should first be benched in accordance with the recommendations in Section 5.2.2.

Compaction requirements in the *CMS* for the construction of earthen embankments specify a minimum percent compaction based on the dry unit weight of the type of soil fill being placed as borrow. S&ME recommends that once the source of borrow for this project is determined, sampling and testing of this borrow material be performed prior to construction to verify that the borrow soils are suitable for the planned construction.

5.2.4 Compaction/Moisture Conditioning Concerns

Cohesive soils, if exposed to inclement weather or rainfall, may rapidly absorb additional moisture, and weaken. It is imperative that these soil types not be exposed to rainfall while in a loosened state, such as during embankment foundation preparation (Section 5.2.1), or when discing and drying for moisture conditioning during fill placement. Should these materials become sufficiently saturated that additional moisture conditioning is impractical, the material should be wasted. Therefore, it is recommended that embankment foundation preparation and moisture conditioning only be performed when extended periods of suitable weather are anticipated, and that only the amount of borrow soil be exposed that may be moisture conditioned and properly compacted during suitable weather periods.

5.3 Replacement Box Culvert

5.3.1 Proposed Culvert Information

Preliminary plan information provided to S&ME indicates the proposed replacement culvert is to be precast concrete box culvert with a 6-foot span, a 4-foot rise, and full-height concrete headwalls. The new box culvert is to be roughly 66 feet long to provide safety grading zones along SR 229. The available plans indicate the new culvert will be constructed at the following elevations:

	Culvert Inlet	Culvert Outlet
Flow Line	EL. 944.50	EL. 944.30
Bottom of Box Culvert	~ EL. 943.8	~ EL. 943.6
Bearing Elevation of Full-Height Wingwalls/Headwalls	~ EL. 942.3	~ EL. 942.1
Bottom of Cut-off Wall	EL. 939.83	EL. 939.63



5.3.2 Box Culvert and Headwall/Wingwall Support

Based on the ODOT design data sheet "Concrete Headwalls for Precast Box Culverts" (HWDD-1), a standard headwall design may be used for concrete box culverts provided the following criteria are met:

- Internal angle of friction of backfill soil, $\phi_{bf} = 30^\circ$
- Total unit weight of backfill soil = 120 pcf
- Internal angle of friction (drained), foundation soil, $\phi_f = 28^\circ$
- Undrained shear strength (cohesive), foundation soil, $S_{uf} = 1,500$ psf
- Unit weight of headwall concrete = 150 pcf
- Slope of backfill = 2H:1V (for Type A & B headwalls)
- Height of live load surcharge = 2 ft (for Type C headwalls)
- Concrete class QC1 is used with compressive strength of 4,000 psi
- Grade 60 reinforcing steel is used

The findings from Boring B-001 indicate that the natural cohesive soil between approximate Elevations 943 and 946.5 does not meet the minimum requirements for undrained shear strength (S_{uf}) of 1,500 psf required by the standard ODOT Culvert Design Data Sheets (HWDD-1) for the design of box culverts with full-height headwalls. Therefore, in accordance with Section 1402 of the ODOT *Geotechnical Design Manual*, S&ME recommends that all cohesive soil of insufficient strength ($S_{uf} < 1,500$ psf) be overexcavated and replaced with a compacted granular material. The results of Boring B-001 indicate the presence of soil meeting the above requirements below approximate Elevation 943.

Please note that the estimated quantity of overexcavation of insufficiently strong soils from beneath the culvert should not include any volume of bedding stone required beneath the box culvert.

5.3.3 Lateral Earth Pressures

Based on the soils encountered in the borings and the minimum soil properties required for standard headwalls (ODOT HWDD-1), earth pressure coefficients for use during design of the culvert headwalls/wingwalls are provided in the table below. These earth pressure coefficients consider the presence of backfill sloping upward behind the headwalls at approximately 6(H):1(V), as shown for the safety graded area on the available site plan and profile drawing for this site.

Table 1: Lateral Earth Pressure Parameters – Headwall/Wingwall Backfill

Angle of Internal Friction (degrees)	Active Coefficient (K_a)	Passive Coefficient (K_p)	Recommended Unit Weight (pcf)
30	0.34	2.77	120



5.3.4 Construction Considerations

Even though no groundwater was noted in the boring, and as this drainage channel does not continuously convey water, considerations for control of surface water runoff should be still made, as the natural cohesive soils anticipated to be present in the sidewalls and at the bottom of culvert excavations may exhibit instability in the presence of water.

It is recommended all excavations for the proposed culvert be protected from exposure to rainfall and storm water flow, as exposure of cohesive soils to water will result in a decrease in soil strength and an increase in compressibility. Even with diversion of the drainage channel, provisions should be made for the removal of water that may emanate from any granular seams or zones encountered in excavations for the culvert; however, this quantity of water is anticipated to be limited and may likely be controlled by bailing or with portable pumps. S&ME also recommends the sides and bottoms of all excavations be closely monitored by the Geotechnical Engineer of Record or their representative after exposure to rainfall or stormwater runoff during construction.

Additionally, all excavations should be either sloped back or braced in accordance with the most recent OSHA excavation guidelines.

5.3.5 Seismic Site Classification

Based on the subsurface stratigraphy encountered in the boring and an estimate of the depth to bedrock at this site, it is the opinion of S&ME that this site is best characterized by AASHTO *LRFD* Table 3.10.3.1-1 as Seismic Site Class D. The seismic site classification calculations are included as Plates 5-7 in the Appendix.

5.3.6 Scour Countermeasures

It is recommended that the inlet and outlet of the new culvert and wingwall foundations be protected from erosion of soil by scour during periods of elevated flow. It is recommended that below-grade cutoff walls be installed at both ends of the culvert to at least the anticipated scour depth so that stream flow does not pass beneath, and result in the loss of support at the base of the culvert by piping.

If rock channel protection (rip rap) is to be utilized, it is recommended that the headwall/wingwall foundations be protected from flow during the design event by using, as a minimum, rip rap of a size and layer thickness in accordance with Section 1107.3 "Bridge RCP", of the ODOT *L&D*, Vol. 2. The rip rap should be placed across the entire channel bottom from the ends of the culvert to at least 10 feet beyond (downstream) the ends of any wingwalls. Additionally, rip rap should be placed in a continuous manner so that no portions of the foundations or creek banks below the design storm water surface are exposed to elevated water flow.

Rip rap is not a permanent or absolute countermeasure against, nor does it totally eliminate, the potential for scour. Therefore, specifications which include the use of rip rap must also contain provisions for routine maintenance of the rip rap blanket so that the design blanket thickness is preserved over the design life of the structure. Additionally, in all cases where rip rap is used for scour protection, the structure should be monitored during and inspected after periods of high flow.



5.3.7 Temporary Excavation Considerations

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P". This document was issued to better ensure the safety of workers entering trenches or excavations. It is mandated by this federal regulation that excavations be constructed in accordance with the OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR, Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. If an excavation, including a trench is extended to a depth of more than twenty (20) feet, it will be necessary to have the side slopes designed by a professional engineer registered in the state where the construction is occurring.

We are providing this information solely as a service to our client. S&ME does not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations.

6.0 Considerations and Report Limitations

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other representation or warranty, either expressed or implied, is made.

We relied on preliminary project information given to us to develop our conclusions and recommendations. If project information described in this report is not accurate, or if it changes during project development, we should be notified of the changes so that we can modify our recommendations based on this information, if necessary.

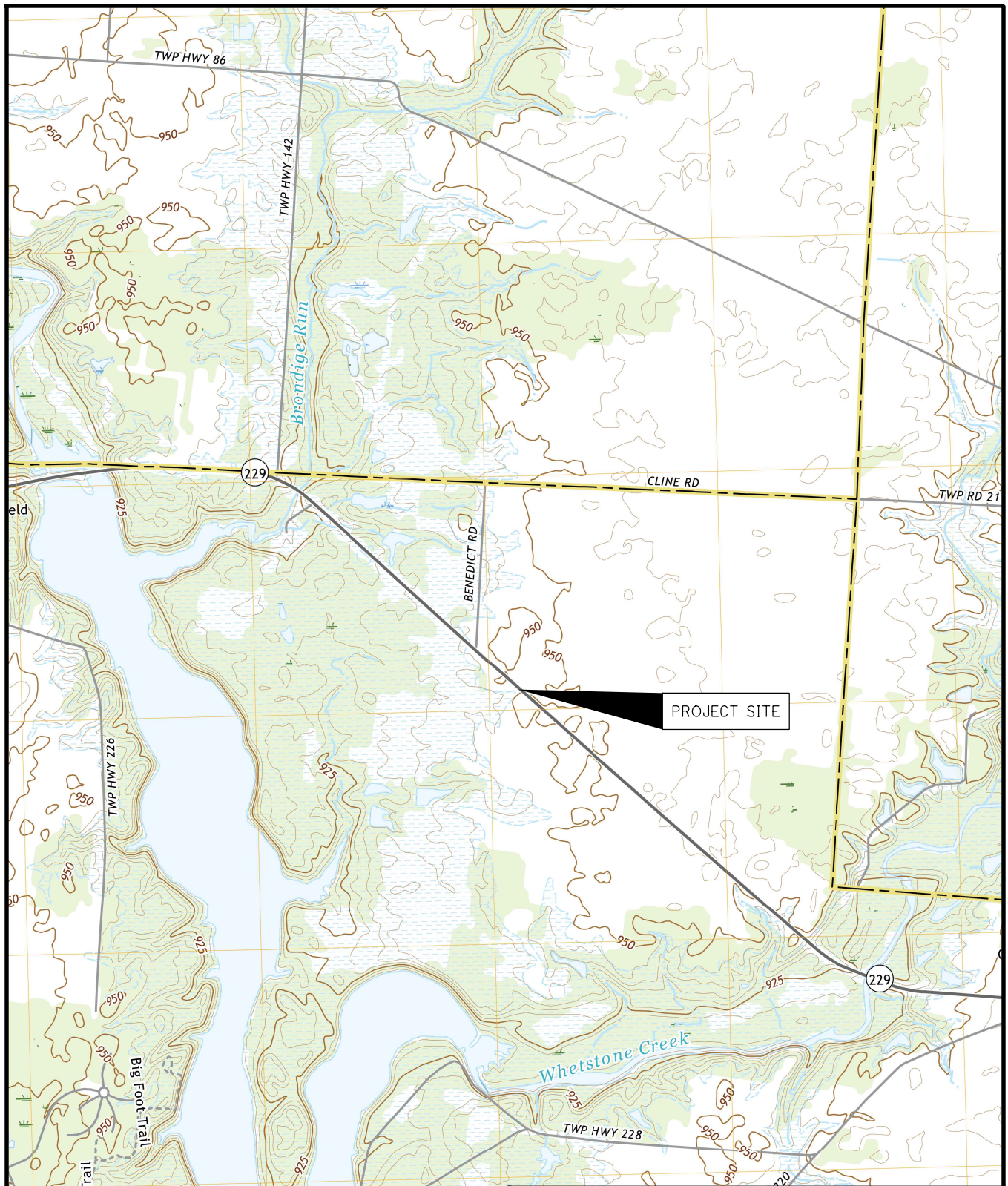
Our conclusions and recommendations are based on limited data from a field exploration program. Subsurface conditions can vary widely between explored areas. Some variations may not become evident until construction. If conditions are encountered which appear different than those described in our report, we should be notified. This report should not be construed to represent subsurface conditions for the entire site.

Unless specifically noted otherwise, our field exploration program did not include an assessment of regulatory compliance, environmental conditions or pollutants or presence of any biological materials (mold, fungi, bacteria). If there is a concern about these items, other studies should be performed.

S&ME should be retained to review the final plans and specifications to confirm that earthwork, foundation, and other recommendations are properly interpreted and implemented. The recommendations in this report are contingent on S&ME's review of final plans and specifications followed by our observation and monitoring of earthwork and foundation construction activities.



Appendix



Project Location
Delaware County, Ohio



0 2000 4000
SCALE IN FEET

Vicinity Map

DEL-229-2.30 Culvert Replacement
Delaware County, Ohio

Project: 23-17-0039

Drawing Date: 4-12-2024

Revision Date: 4-12-2024

Drawn By: KAH

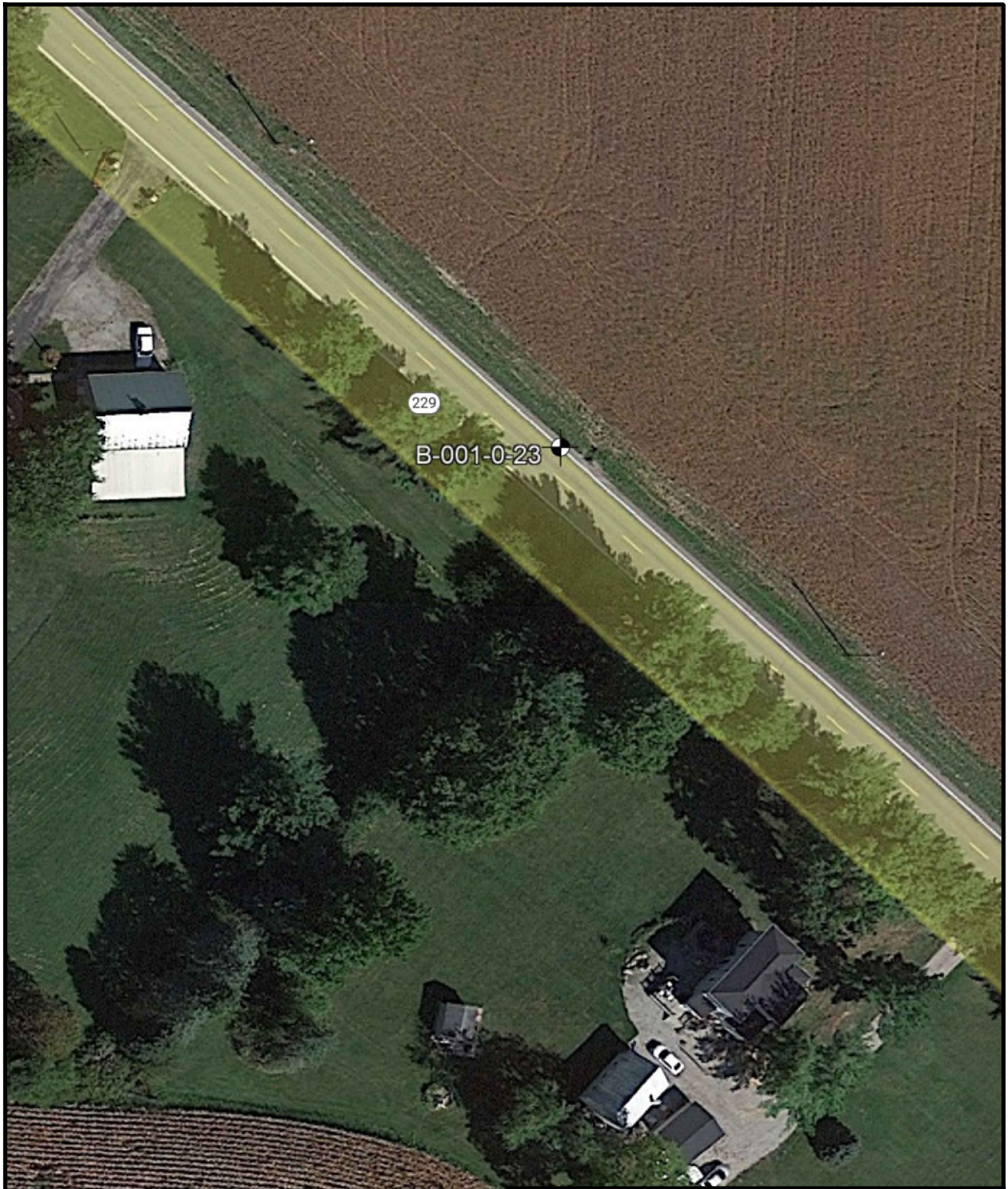
Approved By: RSW

Scale: GRAPHIC



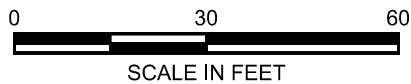
WWW.SMEINC.COM

ENGINEERING LICENSE NO: F-0176



LEGEND

BORING NUMBER
AND LOCATION



Plan of Borings

DEL-229-2.30 Culvert Replacement
Delaware County, Ohio

Project: 23-17-0039

Drawing Date: 4-12-2024

Revision Date: 4-12-2024

Drawn By: KAH

Approved By: RSW

Scale: GRAPHIC



WWW.SMEINC.COM

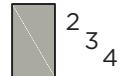
ENGINEERING LICENSE NO: F-0176

ODOT SOIL LOG

LEGEND



The **STANDARD PENETRATION TEST (SPT)** as defined by AASHTO T206 (or ASTM D1586) is a method to obtain a disturbed soil sample for examination and testing and to obtain relative density and consistency information. A standard 1.4-inch I.D./2-inch O.D. split-barrel sampler is driven three 6-inch increments (see graphic at right) with a 140 lb. hammer freely falling 30 inches. The hammer can either be of a trip, free-fall design, or actuated by a rope and cathead. The SPT N Value is determined by adding the number of blows from the 2nd and 3rd 6-inch increments.



SPT BLOWCOUNT CORRECTION FOR HAMMER EFFICIENCY (N_{60}) is determined by the following equation: $N_{60} = N * [\text{Drill Rod Energy Ratio (\%)} / 60]$, and where the drill rod energy ratio is determined in accordance with ASTM D4633. If the drill rod energy ratio exceeds 90%, it is limited to 90% to determine the N_{60} value and is shown on the log as 90*.

SHELBY TUBE (ST) samples are obtained by hydraulically pushing a thin-walled tube (typically 3-inches in diameter) to obtain a relatively undisturbed sample for testing of fine-grained soils to determine engineering properties such as strength, compressibility, permeability, and density. Shelby tubes are sampled in general accordance with ASTM D1587 (AASHTO T207).



DESCRIPTIVE ORDER OF SOIL STRATA: Consistency/Density, color, ODOT soil classification description, minor soil constituents with percentage modifiers, organic content, miscellaneous constituents or descriptions, relative moisture condition.

ODOT SOIL CLASSIFICATION DESCRIPTION AND SYMBOL

	GRAVEL (A-1-a)		SILT (A-4-b)		ORGANIC CLAY (A-8-b)
	GRAVEL WITH SAND (A-1-b)		ELASTIC SILT AND CLAY (A-5)		PEAT
	FINE SAND (A-3)		SILT AND CLAY (A-6-a)		UNCONTROLLED FILL
	COARSE AND FINE SAND (A-3-a)		SILTY CLAY (A-6-b)		BOULDERLY ZONE
	GRAVEL WITH SAND AND SILT (A-2-4 OR A-2-5)		ELASTIC CLAY (A-7-5)		SOD/ROOTMAT/TOPSOIL
	GRAVEL WITH SAND, SILT AND CLAY (A-2-6 OR A-2-7)		CLAY (A-7-6)		PAVEMENT OR BASE
	SANDY SILT (A-4-a)		ORGANIC SILT (A-8-a)		CONCRETE

SOIL LOG SYMBOLS

SS - Split-Spoon Sample	Qu - Unconfined Compressive Strength	FS - Fine Sand Content, %
ST - Shelby Tube Sample	γ_d - Dry Unit Weight, pcf	SI - Silt Content, %
TR - Top of Rock	γ_m - Moist Unit Weight, pcf	CL - Clay Content, %
REC - Sample Recovery, %	GR - Gravel Content, %	LL - Liquid Limit
HP - Hand Penetrometer Value, tsf	CS - Coarse Sand Content, %	PL - Plastic Limit
LOI - Loss on Ignition Test, %		PI - Plasticity Index
		WC - Natural Water Content, %

NOTE: Particle size contents are expressed % by weight.

PARTICLE SIZE

Particle	Size	US Sieve Size
Boulder	>300 mm (12 in.)	12 in.
Cobble	75 - 300 mm (3 - 12 in.)	3 - 12 in.
Coarse gravel	19 - 75 mm (3/4 - 3 in.)	3/4 - 3 in.
Fine gravel	2 - 19 mm (0.08 - 3/4 in.)	#10 - 3/4 in.
Coarse sand	0.42 - 2.0 mm	#40 - #10
Fine sand	0.074 - 0.42 mm	#200 - #40
Silt	0.005 - 0.074 mm	NA
Clay	< 0.005 mm	NA

FINE-GRAINED SOIL (Relative Consistency)

	N_{60}	HP
Very soft	< 2 bpf	< 0.25 tsf
Soft	2 - 4 bpf	> 0.25 - 0.5 tsf
Medium stiff	5 - 8 bpf	> 0.5 - 1.0 tsf
Stiff	9 - 15 bpf	> 1.0 - 2.0 tsf
Very stiff	16 - 30 bpf	> 2.0 - 4.0 tsf
Hard	> 30 bpf	> 4.0 tsf

COARSE-GRAINED SOIL (Relative Density)

	N_{60}
Very loose	< 5 bpf
Loose	5 - 10 bpf
Medium dense	11 - 30 bpf
Dense	31 - 50 bpf
Very dense	> 50 bpf

MINOR CONSTITUENTS (% By Weight)

	Percentage
Trace	0% - 10%
Little	>10% - 20%
Some	>20% - 35%
"And"	≥ 35%

ORGANIC CONTENT OF SOIL (Determined by ASTM D2974 or AASHTO T267)

Classification	Percentage
Slightly organic	2% - 4%
Moderately organic	>4% - 10%
Highly organic	> 10%

RELATIVE MOISTURE CONDITION

Dry	Cohesive - Powdery, WC well below PL Granular - No moisture present	At Time of Drilling
Damp	Cohesive - Leaves very little moisture when pressed, WC < PL Granular - Internal moisture, little to no surface moisture	At end of Drilling
Moist	Cohesive - Leaves moisture when pressed, PL < WC < LL - 3 Granular - Free water on surface, shiny appearance	24 hrs After Drilling
Wet	Cohesive - Mushy, WC near or above LL Granular - Voids filled with free water	

Free water (seepage or groundwater) observation made anytime during the drilling process. Depending on time of reading and drilling methodologies, this value may be influenced by the drilling process.

Free water measurement soon after the drilling processes are complete, and the borehole is at final depth. Drilling fluids, if introduced during drilling, may influence this measurement.

Free water measurements made in a borehole hours to days after drilling is complete including the time elapsed (i.e., "24 hrs" as shown at left). Depending on subsurface conditions, elapsed time, drilling process, etc. this observation may reflect a stabilized level.

REFERENCES:

Ohio Department of Transportation (ODOT), Specifications for Geotechnical Explorations (SGE)



PROJECT: <u>DEL-229-2.30</u>		DRILLING FIRM / OPERATOR: <u>S&ME / T. FROST</u>		DRILL RIG: <u>S&ME ATV D50 (R61)</u>		STATION / OFFSET: <u>14+31, 9' LT</u>		EXPLORATION ID													
TYPE: <u>CULVERT REPLACEMENT</u>		SAMPLING FIRM / LOGGER: <u>S&ME / T. FROST</u>		HAMMER: <u>CME AUTOMATIC</u>		ALIGNMENT: <u>SR 229</u>		B-001-0-23													
PID: <u>107754</u> BR ID: <u>DEL-229-0230</u>		DRILLING METHOD: <u>3.25" HSA</u>		CALIBRATION DATE: <u>8/29/23</u>		ELEVATION: <u>949.3 (MSL)</u> EOB: <u>30.0 ft.</u>		PAGE													
START: <u>10/13/23</u> END: <u>10/13/23</u>		SAMPLING METHOD: <u>SPT</u>		ENERGY RATIO (%): <u>87.5</u>		LAT / LONG: <u>40.426618 N, 83.037696 W</u>		1 OF 1													
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
			949.3																		
ASPHALT - 6 INCHES			948.8																		
GRANULAR BASE - 6 INCHES			948.3																		
Fill: Very stiff brown and gray SILT AND CLAY , little fine to coarse sand, little fine gravel, few asphalt fragments, damp.																					
			946.3																		
Stiff to very stiff brown mottled with dark-gray and gray CLAY , little fine to coarse sand, trace fine gravel, damp.																					

Project Number: 231700229
 Project Name: Repl. Structure No. DEL-229-0230
 Project Location: Delaware County, OH
 Client Name: BG Engineering Group, LLC

Calculated By: RSW
 Date: 4/11/2024
 Checked By: BKS
 Date: 4/18/2024



Seismic Site Class Definitions (AASHTO 9th Ed. LRFD Table 3.10.3.1-1)

Site Class	Soil Type and Profile	$\bar{v}_s$	$\bar{N}$	$\bar{s}_u$
A	Hard rock	$> 5,000$ ft/s	N/A	N/A
B	Rock	$2,500$ ft/s $< v_s < 5,000$ ft/s	N/A	N/A
C	Very dense soil and soil rock	$1,200$ ft/s $< v_s < 2,500$ ft/s	> 50 bpf	> 2.0 ksf
D	Stiff soil	600 ft/s $< v_s < 1,200$ ft/s	15 bpf $< N < 50$ bpf	1.0 ksf $< s_u < 2.0$ ksf
E	Soil meeting the following criteria OR any profile with more than 10 feet of soft clay ($PI > 20$, $w > 40\%$ and $s_u < 0.5$ ksf)	< 600 ft/s	< 15 bpf	< 1.0 ksf
F	Soils requiring site-specific evaluations, such as: - Peats or highly organic clays (greater than 10 feet thick) - Very high plasticity clays ($PI > 75$ and greater than 25 feet thick) - Very thick soft/medium stiff clays (greater than 120 feet thick)			

Term Definitions

$\bar{v}_s$ = average shear wave velocity for the upper 100 feet of the profile
 $\bar{N}$ = average Standard Penetration Test (SPT) blow count (blows/ft, bpf) for the upper 100 feet of the profile
 $\bar{s}_u$ = average undrained shear strength in ksf for the upper 100 feet of the profile
 PI = plasticity index
 w = moisture content

Site Classification Procedure (AASHTO LRFD 9th Ed. Table C3.10.3.1-1)

- Step 1: Check for the three categories of Site Class F. If the site corresponds to any of those categories, classify as Site Class F and conduct a site-specific evaluation.
- Step 2: Check for existence of a soft layer ($s_u < 0.5$ ksf, $w > 40\%$ and $PI > 20$) with a total thickness greater than 10 feet. If these criteria are met, classify site as Site Class E.
- Step 3: Categorize the site into one of the site classes using Method B or C on the following page (NOTE: This calculation package has omitted Method A which determines the site class by calculating the average shear wave velocity).

Determine if site conditions meet criteria for Site Classes E or F

Does your site have:

- Peats or highly organic clays (greater than 10 feet thick)
- Very high plasticity clays ($PI > 75$ and greater than 25 feet thick)
- Very thick soft/medium stiff clays (greater than 120 feet thick)

Condition
Exists?
(Yes/No)

No

No

No

Does your site have:

- More than 10 feet of soft clay ($PI > 20$, $w > 40\%$ and $s_u < 0.5$ ksf)

Condition
Exists?
(Yes/No)

No

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Method B: Average SPT N Method

$$\bar{N} = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \frac{d_i}{N_i}}$$

where: n = number of soil layers in the top 100 feet
 d_i = thickness of a layer between 0 and 100 feet
 N_i = uncorrected SPT blow count of a layer (cannot exceed 100 bpf)

Method C: Average s_u Method

$$\bar{N}_{ch} = \frac{d_s}{\sum_{i=1}^m \frac{d_i}{N_{chi}}}$$

in which: $\sum_{i=1}^m d_i = d_s$

$$\bar{s}_u = \frac{d_c}{\sum_{i=1}^k \frac{d_i}{s_{ui}}}$$

in which: $\sum_{i=1}^k d_i = d_c$

where: m = number of cohesionless soil layers in the top 100 feet
 N_{chi} = uncorrected SPT blow count for a cohesionless layer (cannot exceed 100 bpf)
 d_s = total thickness of cohesionless soil layers in the top 100 feet
 k = number of cohesive soil layers in the top 100 feet
 s_{ui} = undrained shear strength for a cohesive layer (cannot exceed 5.0 ksf)
 d_c = total thickness of cohesive soil layers in the top 100 feet

Data Entry for Method B or C					Method B	Method C			
Layer Top El.	Layer Bottom El.	Layer Thickness, d_i	Uncorrected Blow Count, N_i or N_{chi}	Undrained Shear Strength, s_{ui}	$\frac{d_i}{N_i}$	$\sum_{i=1}^m d_i = d_s$	$\sum_{i=1}^m \frac{d_i}{N_{chi}}$	$\sum_{i=1}^k d_i = d_c$	$\sum_{i=1}^k \frac{d_i}{s_{ui}}$
MSL	MSL	ft	bpf	ksf	ft/bpf	ft	ft/bpf	ft	ft/ksf
949.3	946.3	3.0	11	2.5	0.27			3.0	1.20
946.3	941.3	5.0	4	1.0	1.25			5.0	5.00
941.3	938.8	2.5	8	2.5	0.31			2.5	1.00
938.8	919.3	19.5	18	4.5	1.08			19.5	4.33
919.3	909.3	10.0	18	4.5	0.56			10.0	2.22
909.3	849.3	60.0	100		0.60	60.0	0.60		
Totals		100.0	---	---	4.07	60.0	0.60	40.0	13.76

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Summary of Results and Determining Site Class

Do site conditions meet criteria for Site Class E or F?

- Peats or highly organic clays (greater than 10 feet thick)	<u>No</u>
- Very high plasticity clays ($PI > 75$ and greater than 25 feet thick)	<u>No</u>
- Very thick soft/medium stiff clays (greater than 120 feet thick)	<u>No</u>
- More than 10 feet of soft clay ($PI > 20$, $w > 40\%$ and $s_u < 0.5$ ksf)	<u>No</u>

Results from Method B (average uncorrected blowcount)

	Criteria	$\bar{N}$
Site Class C	> 50 bpf	
Site Class D	$15 \text{ bpf} < N < 50 \text{ bpf}$	24.55
Site Class E	< 15 bpf	

Results from Method C (average undrained shear strength)

	Average N Criteria	Average s_u Criteria	$\bar{N}_{ch}$	$\bar{s}_u$
Site Class C	> 50 bpf	> 2.0 ksf		
Site Class D	$15 \text{ bpf} < N < 50 \text{ bpf}$	$1.0 \text{ ksf} < s_u < 2.0 \text{ ksf}$	100.00	2.91
Site Class E	< 15 bpf	< 1.0 ksf		

Estimated Site Class: D

NOTE: When using Method C, if the site class resulting from N_{ch} and s_u differ, select the site class that gives the highest site factors and design spectral response in the period range of interest. For example, if N_{ch} was equal to 20 bpf and s_u was equal to 0.8 ksf, the site would classify as D or E in accordance with Method C and the site class definitions. In this example, for relatively low response spectral acceleration and for long-period motions, site factors are highest for Site Class E. However, for relatively high short-period spectral acceleration ($S_s > 0.75$), short period site factors, F_a , are higher for Site Class D.



Important Information About Your Geotechnical Engineering Report

Variations in subsurface conditions can be a principal cause of construction delays, cost overruns and claims. The following information is provided to assist you in understanding and managing the risk of these variations.

Geotechnical Findings Are Professional Opinions

Geotechnical engineers cannot specify material properties as other design engineers do. Geotechnical material properties have a far broader range on a given site than any manufactured construction material, and some geotechnical material properties may change over time because of exposure to air and water, or human activity.

Site exploration identifies subsurface conditions at the time of exploration and only at the points where subsurface tests are performed or samples obtained. Geotechnical engineers review field and laboratory data and then apply their judgment to render professional opinions about site subsurface conditions. Their recommendations rely upon these professional opinions. Variations in the vertical and lateral extent of subsurface materials may be encountered during construction that significantly impact construction schedules, methods and material volumes. While higher levels of subsurface exploration can mitigate the risk of encountering unanticipated subsurface conditions, no level of subsurface exploration can eliminate this risk.

Scope of Geotechnical Services

Professional geotechnical engineering judgment is required to develop a geotechnical exploration scope to obtain information necessary to support design and construction. A number of unique project factors are considered in developing the scope of geotechnical services, such as the exploration objective; the location, type, size and weight of the proposed structure; proposed site grades and improvements; the construction schedule and sequence; and the site geology.

Geotechnical engineers apply their experience with construction methods, subsurface conditions and exploration methods to develop the exploration scope. The scope of each exploration is unique based on available project and site information. Incomplete project information or constraints on the scope of exploration increases the risk of variations in subsurface conditions not being identified and addressed in the geotechnical report.

Services Are Performed for Specific Projects

Because the scope of each geotechnical exploration is unique, each geotechnical report is unique. Subsurface conditions are explored and recommendations are made for a specific project.

Subsurface information and recommendations may not be adequate for other uses. Changes in a proposed structure location, foundation loads, grades, schedule, etc. may require additional geotechnical exploration, analyses, and consultation. The geotechnical engineer should be consulted to determine if additional services are required in response to changes in proposed construction, location, loads, grades, schedule, etc.

Geo-Environmental Issues

The equipment, techniques, and personnel used to perform a geo-environmental study differ significantly from those used for a geotechnical exploration. Indications of environmental contamination may be encountered incidental to performance of a geotechnical exploration but go unrecognized. Determination of the presence, type or extent of environmental contamination is beyond the scope of a geotechnical exploration.

Geotechnical Recommendations Are Not Final

Recommendations are developed based on the geotechnical engineer's understanding of the proposed construction and professional opinion of site subsurface conditions. Observations and tests must be performed during construction to confirm subsurface conditions exposed by construction excavations are consistent with those assumed in development of recommendations. It is advisable to retain the geotechnical engineer that performed the exploration and developed the geotechnical recommendations to conduct tests and observations during construction. This may reduce the risk that variations in subsurface conditions will not be addressed as recommended in the geotechnical report.