REPORT

Geotechnical Design Report (GDR)

Lewis Bridge No. 5396, West Cathance Stream, Bowdoin, Maine (WIN 026160.00)

Submitted to:

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Bridge Program
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Submitted by:

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WIN 026160.00 / WSP US0047101.4297

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1.0 INTRODUCTION

This Geotechnical Design Report (GDR) summarizes the results of WSP USA Inc.'s (WSP's) geotechnical investigation and recommendations for the replacement of the culvert carrying Route (RT) 125 over West Cathance Stream in Bowdoin, Maine. The location of this culvert is shown in Figure 1 (attached). The purpose of this report is to present soils and bedrock information for the culvert replacement site obtained from subsurface investigations and laboratory tests; present recommended geotechnical parameters for design and construction; and provide preliminary geotechnical design recommendations for the replacement culvert.

2.0 PROJECT BACKGROUND

We understand that MaineDOT intends to replace the existing bridge (Bridge No. 5396) which was constructed in 1920 and consists of a concrete slab bridge. The replacement design will be a box culvert based on the West Cathance Stream measured bank full width of 18.2 feet.

3.0 GEOLOGIC SETTING

3.1 Regional Surficial Geology

The surficial geology of the bridge site is mapped as Holocene (recent) alluvium, described as sand, silt, gravel, and organic material deposited by streams onto flood plains in thicknesses of up to ten feet. These sediments overlie Pleistocene-aged glaciomarine deposits. In some areas near the bridge site, the glaciomarine deposits are mapped as late-glacial fine-grained sea-floor deposits of the Presumpscot Formation, described as silt and clay with local sandy beds. In other areas near the bridge site, the glaciomarine deposits are mapped as submarine fans of sand and gravel deposited on the sea floor at the glacial margin, locally including sediments reworked by marine nearshore processes during regression of the sea. These deposits overlie older Pleistocene glacial till, present as a thin blanket covering bedrock. The till is described as a predominantly sandy and gravelly mixture of non-sorted to poorly-sorted clay, silt, sand, pebbles, cobbles, and boulders, deposited directly from glacial ice.[1,2,3] Regional mapping indicates a total overburden thickness of 50 feet.[4]

3.2 Bedrock Geology

The bedrock beneath the bridge site is mapped as the Silurian-aged Vassalboro Formation of the Central Maine Sequence. The lithology is described as medium gray to purplish-gray, fine-grained to medium-grained, quartz-plagioclase-biotite granofels and schist, interlayered with greenish-gray, fine-grained, plagioclase-quartz-actinolite-diopside granofels. Relict bedding layers are described as ranging in thickness from one to ten inches, with the calc-silicate layers being subordinate and commonly thinner and discontinuous along strike. The formation is interpreted to have been initially deposited as interlayered calcareous and non-calcareous turbidite

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[1] Hildreth, Carol T., 2003, Surficial geology of the Bowdoinham quadrangle, Maine: Maine Geological Survey, Open-File Map 03-52, map, scale 1:24,000. Maine Geological Survey Maps. 1680. http://digitalmaine.com/mgs_maps/1680

[2] Hildreth, Carol T., 2003, Surficial geology of the Bowdoinham 7.5-minute quadrangle, Kennebec and Sagadahoc Counties, Maine: Maine Geological Survey, Open-File Report 03-54, 5 p. Maine Geological Survey Publications. 285. http://digitalmaine.com/mgs_publications/285

[3] Tolman, Susan S. (compiler), 2009, Surficial geology of the western half of the Augusta 1:100,000 quadrangle, Maine: Maine Geological Survey, Open-File Map 09-40, map, scale 1:100,000. Maine Geological Survey Maps. 1832. http://digitalmaine.com/mgs_maps/1832

[4] Locke, Daniel B., and Hildreth, Carol T., 2004, Surficial materials of the Bowdoinham quadrangle, Maine: Maine Geological Survey, Open-File Map 04-44, map, scale 1:24,000. Maine Geological Survey Maps. 1172. http://digitalmaine.com/mgs_maps/1172

deposits, then buried by tectonic processes of the Acadian orogeny. Interpretations indicate the formation was metamorphosed to the amphibolite facies and experienced penetrative ductile deformation during Devonian time.[5]

4.0 SUBSURFACE INVESTIGATIONS

WSP completed three (3) test borings (BB-BWCS-101 through BB-BWCS-103) within the paved roadway of RT 125 on either side of West Cathance Stream between March 30 and April 6, 2023. MaineDOT surveyed the as-drilled boring locations following completion of the drilling program. Boring location coordinates and ground surface elevations are summarized in Table 1 (attached) and boring locations with respect to existing site features are illustrated in Figure 2 (attached). The field program included Standard Penetration Testing (SPT) of predominantly coarse-grained soils. A WSP geologist monitored drilling activities, selected sampling intervals, logged subsurface conditions encountered, and obtained soil samples for use in visual descriptions and subsequent laboratory testing and classification.

WSP subcontracted Seaboard Drilling, LLC (Seaboard, formerly S.W. Cole Explorations, LLC) of Somersworth, New Hampshire to complete the borings. Seaboard used a Mobile B-48 truck-mounted drill rig and cased wash boring methods. Boreholes were advanced using a 4-inch or 3-inch inside diameter casing in 5-foot lengths using an automatic safety hammer. Soil in the casing was washed out using a roller bit and water to the depth where samples were subsequently collected. Bedrock was encountered in BB-BWCS-101 at a depth of 56.5 feet below ground surface (bgs) and BB-BWCS-102 at a depth of 65.0 feet bgs. BB-BWCS-103 was terminated at a depth of 44.0 feet bgs and bedrock was not encountered.

Seaboard performed SPT in each boring using a calibrated automatic hammer system and standard 2-inch split spoon sampler in general accordance with American Society for Testing and Materials (ASTM) D1586. Sampling of overburden materials was conducted at approximately 5-foot intervals. Seaboard drove the split spoon sampler 24 inches with a 140-pound hammer dropped 30 inches, and WSP recorded the number of hammer blows required to advance the sampler through each 6-inch increment. Measured, uncorrected N-values, calculated as the sum of the hammer blows to advance the sampler during the 6-inch to 18-inch interval, are provided in the boring logs in Appendix A. WSP used a hammer energy transfer ratio of 91% (for the Mobile Drill rig provided by Seaboard[6]) to covert the measured N-values to N_{60} values for further calculations. WSP collected and stored soil samples in sealed glass jars for later evaluation and laboratory testing.

Seaboard collected 10 feet of rock core using NQ/NX size (1-7/8-inch diameter) diamond tipped core barrels in BB-BWCS-101 and BB-BWCS-102 following either refusal of casing, split spoon sampler, or roller bit to advance. Rock core was placed in wooden boxes and transported to the WSP office. WSP recorded the lithology, Total Core Recovery (TCR), Rock Quality Designation (RQD), and coring rates for each core run in the boring logs provided in Appendix A. A detailed summary of the rock core quality parameters for the recovered rock core is presented in Table 2 (attached) and photographs of the rock core are presented in Appendix B.

The boring logs provided in Appendix A present details of the sampling methods used, field data obtained, and soil and rock conditions encountered during the investigation. Soils were field categorized in general accordance with ASTM D2488. WSP field characterized the bedrock lithology, and the descriptions were revised in the office.

[5] West, David P., Jr., and Cubley, Joel F., 2010, Bedrock geology of the Bowdoinham quadrangle, Maine: Maine Geological Survey, Open-File Map 10-20, color map and 17 p. report, scale 1:24,000. Maine Geological Survey Maps. 46. http://digitalmaine.com/mgs_maps/46

[6] Standard Penetration Test Energy Measurement Calibration, Tracked Rig-Mobile Drill B-48 with Automatic Hammer (S/N-2021021), prepared by GTR Engineering for S.W. Cole Explorations, LLC dated 11/04/2022.

A description of the boring log symbols and terms used for the soil and rock descriptions precedes the boring logs in Appendix A.

5.0 LABORATORY TESTING PROGRAM

After reviewing the collected samples in the office, WSP transferred select samples to GeoTesting Express (GTX) of Acton, Massachusetts for geotechnical laboratory testing in accordance with applicable AASHTO and ASTM testing procedures. WSP selected representative SPT split spoon soil samples from the borings for geotechnical laboratory testing to assist in soil classification. The types and numbers of each of the laboratory tests conducted on soil samples are presented in Table 5-1. Measured index and classification test results from soil samples are summarized in Table 3 (attached) and include AASHTO and ASTM Unified Soil Classification System (USCS) classifications. Soil testing results are included on the boring logs in Appendix A. Complete laboratory testing results are provided in Appendix C.

Table 5-1: Summary of Laboratory Testing Performed

Laboratory Test	Test Standard	No. Tests Completed
Moisture content	ASTM D 2216, AASHTO T267	11
Grain size analysis (coarse)	ASTM D 6913, AASHTO T88	11
Grainsize (fines)	ASTM D 7928, AASHTO T88	2
Atterberg Limits	ASTM D 4318, AASHTO T89	2
Organic Content	ASTM D 2974	2

6.0 SUBSURFACE CONDITIONS

The soils WSP encountered in the three (3) test borings (BB-BWCS-101 through BB-BWCS-103) within the paved roadway of RT 125 on either side of West Cathance Stream shown in Figure 2 (attached) generally include: fill materials placed during construction of the culvert and roadway; naturally occurring silt and sand interpreted as stream alluvium; naturally occurring sand and gravel interpreted as glaciomarine fan deposits, and; naturally occurring sand and gravel interpreted as glacial till. Figure 3 (attached) provides WSP's Interpretive Subsurface Profile (ISP) along the centerline of RT 125 and illustrates that the bottom of the culvert will be located at the interpreted interface between the upper silt and sand stream alluvium and lower glaciomarine fan deposit comprised of sands and gravels.

The following descriptions summarize the major stratigraphic units from the existing ground surface to depth. The boring logs in Appendix A provide detailed descriptions of the soil conditions encountered in the borings.

Asphalt Pavement: Asphalt pavement thickness ranged from approximately 6 inches in BB-BWCS-101 and BB-BWCS-102B to 8 inches in BB-BWCS-103.

Fill: Fill materials associated with the existing roadway were encountered in all borings. The fill layer ranged in thickness from approximately 4.1 feet to 4.4 feet. The fill generally consisted of brown, dense to very dense, fine to coarse sand with trace to some gravel and little silt. A laboratory classification described the fill as SW-SM

(USCS) and A-1-b (AASHTO). SPT N_{60} values ranged from 42 to 71 (dense to very dense). The fill layer transitioned to the stream alluvium layer at approximately 5 feet bgs in each boring.

Stream Alluvium: A layer of silt and sand, interpreted as stream alluvium, was encountered in all borings. The alluvium layer ranged in thickness from approximately 5 feet to 7 feet. The alluvium generally consisted of brown to grey, very soft, non-plastic silt, or brown to grey, very loose to medium dense, fine to medium sand with trace gravel and trace to some silt. Laboratory testing indicated that samples from the alluvium layer contained organic matter of 2.2% to 2.5% and moisture content of 24% to 36%. Laboratory classifications described the alluvium sand as SM or SP-SM (USCS) and A-3 (AASHTO). SPT N_{60} values ranged from WOH to 11 (very soft/loose to medium dense). The alluvium layer transitioned to the glaciomarine fan deposit at approximately 10 feet to 12 feet bgs in each boring.

Glaciomarine Fan Deposits: A layer of sand and gravel, interpreted as glaciomarine fan deposits, was encountered in all borings. The glaciomarine fan deposits ranged in thickness from approximately 40 feet to 48 feet. The glaciomarine fan deposits generally consisted of brown to grey, medium dense to very dense, fine to coarse sand with trace to some gravel and trace to little silt. A zone of medium dense gravel with some sand and trace silt was encountered in BB-BWCS-101. Laboratory classifications described the glaciomarine fan deposits as SW-SM, SP-SM, or GP-GM (USCS) and A-1-b, A-2-4, A-3, or A-1-a (AASHTO). SPT N_{60} values ranged from 14 to 86 (medium dense to very dense), where values generally increased with depth. The glaciomarine fan deposits transitioned to the glacial till layer at approximately 50 feet bgs in BB-BWCS-101 and approximately 60 feet bgs in BB-BWCS-102. Boring BB-BWCS-103 terminated within the glaciomarine fan deposits.

Glacial Till: A layer of sand and gravel, interpreted as glacial till, was encountered in borings BB-BWCS-101 and BB-BWCS-102. The glacial till layer ranged in thickness from approximately 5 feet to 6.5 feet. The glacial till generally consisted of brown to grey, very dense, fine to coarse sandy gravel, or grey, dense, fine to coarse sand with some gravel and some silt. A laboratory classification described the glacial till sand as SM (USCS) and A-1-b (AASHTO). SPT N_{60} values ranged from 47 to 102 (dense to very dense). The glacial till layer transitioned to bedrock at approximately 56.5 feet bgs in BB-BWCS-101 and approximately 65 feet bgs in BB-BWCS-102.

Bedrock: The bedrock surface was encountered in borings BB-BWCS-101 and BB-BWCS-102 and varied in elevation by approximately 7.7 feet across the site. In general, the bedrock elevation trended deeper from west to east, with bedrock elevations of approximately Elev. 70.7 feet in BB-BWCS-101 and Elev. 63.0 feet in BB-BWCS-102. The bedrock lithology consisted of light grey, fine to medium grained, medium strong (R3) to very strong (R5)[7], slightly weathered to fresh, biotite schist, interpreted as the Vassalboro Formation. The Rock Quality Designation ranged from poor (RQD = 27%) to excellent (RQD = 95%) and the estimated Rock Mass Rating ranged from 44 to 64. Table 2 (attached) provides detailed information about the recovery, RQD, RMR, and descriptions of lithology, rock mass, and discontinuities.

Groundwater: Groundwater level measurements were made in all borings during drilling and upon completion of the boreholes before the removal of the casing. Measured groundwater elevations ranged between Elev. 111.2 feet and Elev. 122.1 feet. Groundwater levels shown on the subsurface profiles were interpreted based on these water level measurements.

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[7] Wyllie, D.C., 2018. Rock Slope Engineering, 5th ed., CRC Press; see p. 501, Appendix II, Table II.3 for relative description of rock strengths based on field identification methods, which is based on the International Society for Rock Mechanics (ISRM) scale.

7.0 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

The base elevation of the proposed box culvert as specified in the project plans[8] and used in these evaluations will be founded within the glaciomarine fan deposit layer. The culvert is proposed to be 64 feet long including the sloped wingwalls and could range from 24 feet to 24.3 feet wide. Figure 2 (attached) shows the culvert location in plan and Figure 3 (attached) shows the culvert location with respect to the interpreted stratigraphic profile. Installation of the proposed box culvert will require excavation of site soils at and adjacent to RT 125. The culvert base will be located between EL 116.8 feet and EL 117.0 feet at the interpreted interface between the upper stream alluvium comprised of silt and sand and the lower glaciomarine fan deposit comprised of sands and gravels. The precast toe walls are located between EL. 114.8 feet and 115.0 feet. An additional 1 foot of excavation below the base of the culvert may be required to accommodate to facilitate fine grading and dewatering below the culvert. The approximate depth of excavation is 11 feet to 12 feet below the existing ground surface at the location investigated.

7.1 Design Parameters

WSP evaluated the subsurface geotechnical data collected and developed geotechnical material design parameters. Table 7-1 provides a summary of design parameters for each in situ soil layer encountered (refer to Figure 3, attached), as well as material properties for fills as identified in the MaineDOT Standard Specifications.[9] These design parameters served as a basis for calculations, analyses, and evaluations discussed herein. For a non-yielding, stiff structure like the box culvert and wingwall system proposed for this project, an at-rest lateral earth pressure coefficient of 0.47 is recommended for design, as the culvert will be backfilled with Granular Borrow.

Table 7-1: Recommended Geotechnical Design Parameters for In Situ Soils and Construction Fills

Soil Layer		γ (pcf)	ϕ (°)	Lateral Earth Pressure Coefficients[1]		
				K_0	K_a	K_p
In Situ Materials	Existing Fill	125	32	0.47	0.31	3.25
	Alluvium	115	29	0.52	0.35	2.88
	Glaciomarine Fan Deposit	125	36	0.41	0.26	3.85
	Glacial Till	135	42	0.33	0.20	5.04
Construction Materials	Asphalt	140	N/A	N/A	N/A	N/A
	Granular Borrow (Section 703.19)	125	32	0.47	0.31	3.25
	Gravel Borrow (Section 703.20)	135	36	0.41	0.26	3.85

8 State of Maine Department of Transportation, Bowdoin, Sagadahoc County, Lewis Bridge over West Cathance Stream, Main Street, Final PIC November 5, 2024, 19 pp. Note, no substantive changes were made to the culvert geometry, depth, and location between PIC and contract plans that would impact geotechnical design and recommendations in this report.

9 MaineDOT Standard Specifications, March 2020. https://www.maine.gov/mdot/contractors/publications/standardspec/docs/2020/2020%20Standard%20Specification.pdf

				Lateral Earth Pressure Coefficients[1]		
Soil Layer		γ (pcf)	ϕ (°)	K_0	K_a	K_p
	Special Fill (Stream Bed) (Section 203.33)	135	N/A	N/A	N/A	N/A
	Stream Channel Rock	140	N/A	N/A	N/A	N/A
	Riprap (Section 703.26)	140	42	N/A	N/A	N/A

Notes: [1]Lateral earth pressure coefficients determined using Rankine method for fully active and fully passive conditions. The term N/A indicates these parameters are not used in design.

7.2 Bearing Capacity and Subgrade Modulus

We recommend a strength limit state bearing resistance factor of 0.45 and a strength limit state factored bearing resistance of 7.7 ksf (kips [kilo-pounds] per square foot) be used for design. We recommend a service limit state bearing resistance factor of 1.0, and a factored presumptive bearing resistance of 6 ksf for the service limit state that limits settlement to 1 inch. Based on the corrected N_{60}-values encountered for the glaciomarine fan deposit layer and FB-Multipier Soil parameter Table[10], a modulus of subgrade reaction for a 1-foot x 1-foot steel plate (k_1) equal to 89 tcf (tons per cubic foot) or 103 pci (pounds per cubic inch) should be used for structural design of the proposed culvert. Calculations, references, and assumptions are provided in Appendix D.

7.3 Settlement

WSP estimates a net increase in effective stress will exist below the proposed culvert following installation and roadway reconstruction compared to present conditions following excavation of existing soils. We evaluated settlement of the glaciomarine fan deposit below the culvert elevation at the edge of the roadway where the stress changes will be greatest and at the midpoint of the roadway where the stress changes will be least. We considered only immediate settlement as fine-grained silts and clays that would experience consolidation settlement were not encountered on site. The loads imposed by the proposed culvert and roadway fills were distributed through the subsurface soils using Boussinesq stress distribution theory for the given geometry. The subsurface soils were then discretized into layers less than 10 feet thick, and the effective stress, imposed stresses, and other soil parameters were used to evaluate settlement within each layer using the Hough method and correlations to N_{60}-values. We estimated less than one (1) inch of immediate settlement below the culvert centerline at the roadway edge and a negligible amount of settlement below the center of the culvert. Calculations, references, and assumptions are provided in Appendix D.

7.4 Global Stability Analyses

WSP evaluated global stability at one (1) cross-section transverse to RT 125 with the greatest change in embankment geometry, for existing and proposed conditions at Station 103+75, southeast of the proposed box culvert. Both northeastern and southwestern slopes were analyzed in the transverse cross-section. We performed the analyses using the two-dimensional limit equilibrium modeling software *Slide2* by Rocscience[11] for existing

[10] Bride Software Institute (BSI) FB-Multipier Soil Parameter Table https://bsi.ce.ufl.edu/downloads/files/MultiPier_Soil_Table

[11] Rocscience Inc. Slide2 software package, Version 9.027, build date February 13, 2023.

and post-construction static conditions. Embankment geometry was created using the proposed and existing grades from PIC[8] plans. We interpreted the subsurface stratigraphy from Figure 3 (attached).

We analyzed the models using the Spencer method with auto refined search for circular failure surfaces, and the Spencer Method with a Cuckoo search plus surface altering optimization for non-circular failure surfaces. The search algorithm that produced a lower factor of safety was selected; analyses show that non-circular surfaces govern potential slope failures. Per the MaineDOT Bridge Design Guide[12] Section 5.9.2, a minimum allowable design factor of safety (FS) of 1.3 for embankments was used to assess satisfactory global stability conditions.

Based on our stability analyses, the existing embankment geometry at the northeastern slope produced FS values less than the minimum allowable design FS, the existing embankment geometry at the southwestern slope produced adequate FS values. The proposed embankment geometry for both the northeastern and the southwestern slopes produced FS values that meet the minimum allowable design FS. Each of the analyses indicates that the lowest FS potential failure surfaces are within the roadway embankment and do no extend below the roadway. The analysis results are shown in Appendix D and summarized in Table 7-2.

Table 7-2: Summary of Global Stability Factors of Safety for Embankment at Sta. 103+75

Surface Type	Location	Condition	Static Factor of Safety
Non-Circular	Northeast Slope	Existing	1.14
Non-Circular	Southwest Slope	Existing	1.80
Non-Circular	Northeast Slope	Proposed	1.41
Non-Circular	Southwest Slope	Proposed	1.32

7.5 Scour and Riprap

Both the inlet and outlet of the culvert will be armored with riprap in accordance with MaineDOT Standard Details[13] and Standard Specifications.[9] The inlet and outlet should include a 3-foot thick by 10-foot long Plain Riprap Apron (Detail 610(04)) comprised of Plain Riprap (Section 703.26) capped with a 2-foot-thick layer of Special Fill (Item No. 203.33, which will be specified in a Special Provision later in the project). The riprap slope will be underlain by a Class 1 non-woven erosion control geotextile meeting the requirements of Section 722.03.

8.0 CONSTRUCTION CONSIDERATIONS

At the writing of this report, the sequence of the work and considerations for water diversion are unknown. However, construction activities will require soil excavation to below both the water table encountered during the geotechnical site investigation and the stream water level. Construction may require cofferdams and earth support systems to support culvert and stream bed excavations, and to control water flow. Design of all temporary earth support systems should comply with Section 511 Cofferdams of the MaineDOT Standard Specifications[9] and

[12] Maine Department of Transportation, Bridge Design Guide, 2003 updated 2018. https://www.maine.gov/mdot/bdg/docs/BDGupdateJune2018.pdf

[13] Maine DOT Standard Details, March 2020. https://www.maine.gov/mdot/contractors/publications/standarddetail/docs/2020/2020-STANDARD_DETAILS.pdf

OSHA requirements. Temporary dewatering of the stream and excavation may be required and should be performed to limit disturbance to the culvert bearing surfaces. Dewatering activities should comply with Section 656 Temporary Soil Erosion and Water Pollution Control of the MaineDOT Standard Specifications.[9] The contractor should additionally control groundwater and surface water infiltration so that construction can be completed under dry conditions.

Fills should be placed systematically in horizontal layers not more than 12 inches in thickness, prior to compaction. Cobbles larger than 8 inches should be removed from the fill prior to placement. Compaction equipment should preferably consist of large, self-propelled vibratory rollers. Where hand-guided equipment is used, such as a small vibratory plate compactor, the loose lift thickness shall not exceed 6 inches and cobbles larger than 4 inches should be removed from the fill prior to placement.

Embankment fills should be compacted to a dry density of no less than 95% of the maximum dry density determined in accordance with AASHTO T-99, Method C. Granular Borrow, or other select materials, placed within the roadway base section shall be compacted to a dry density equal to 95% of the maximum dry density as determined in accordance with AASHTO T-99.

Prior to placing the box culvert and wingwalls, we recommend undercutting the foundation 12 inches and placing a separation geotextile (Section 722.04) and 12 inches of Granular Borrow for Underwater Backfill (Section 703.19) to facilitate fine grading and dewatering for the installation of the culvert.

9.0 REPORT AND EXPLORATION LIMITATIONS

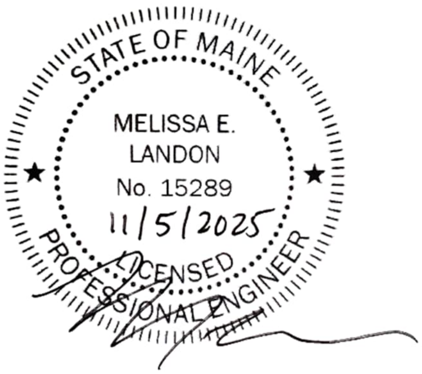
This Geotechnical Design Report was prepared for the use of MaineDOT for specific application to the proposed replacement of the culvert that passes RT 125 over West Cathance Stream in Bowdoin, Maine. We conducted our evaluations and compiled our recommendations in accordance with generally accepted soil and foundation engineering practices in this geographical area and under similar time and financial constraints. WSP makes no other warranty, either express or implied. If changes in the nature, design, or location of the proposed project are planned, WSP should be notified to review the appropriateness of our conclusions and recommendations, and to modify the recommendations as appropriate to reflect the changes in design. In addition, WSP should review the final plans and specifications to evaluate compliance with these recommendations.

Our analyses and recommendations are based, in part, on information obtained from the referenced subsurface explorations completed at the discrete locations described in the report. Variations in the nature and extent of subsurface conditions between explorations should be expected. WSP should be notified if conditions encountered during construction vary from those described in this report so that we may re-evaluate, and if necessary, revise the recommendations made in this report.

The professional services provided by WSP for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been investigated or addressed.

Signature Page

WSP USA, Inc.



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TABLES

Table 1: Subsurface Exploration Locations
Geotechnical Design Report
West Cathance Stream Bridge #5396 Replacement, Augusta, Maine
MaineDOT WIN 026160.00

Boring Designation[1,2,3]	As-Drilled Locations[4]		Existing Ground Surface Elevation[4] (feet)	Maximum Depth of Investigation (feet bgs[5])
	Northing	Easting		
BB-BWCS-101	438427.0471	1092714.1300	127.2	66.5
BB-BWCS-102	438394.0438	1092752.8460	128.0	76.8
BB-BWCS-102A	438396.2995	1092748.8070	127.9	25.0
BB-BWCS-102B	438398.4363	1092744.8420	127.8	10.0
BB-BWCS-103	438422.5168	1092697.6900	127.4	44.0

Notes:

1. Test boring locations are shown in Figure 2 - Boring Location Plan of the Preliminary Geotechnical Design Report.
2. Borings BWCS-101, BWCS-102, and BWCS-103 were performed by Seaboard Drilling, LLC in April 2023.
3. Boring logs are presented in Appendix A of the Preliminary Geotechnical Design Report.
4. As-drilled locations and elevations for borings BWCS-101 through BWCS-103 are derived from the elctronic file "CORRECTED BORINGS 17 AUG 23" recieved by WSP on August 17th, 2023.
5. Depth below ground surface.

Prepared By: KMB
Checked By: ATM
Reviewed By: MEL

Table 2: Summary of Rock Core Quality
Preliminary Geotechnical Design Report
Lewis Bridge #5396, West Cathance Stream, Bowdoin, Maine
MaineDOT WIN 026160.00

Test Boring Designation	Core Size	Existing Ground Surface Elevation[1]	Run						TCR [2]		RQD [3]			Physical Rock Parameters			Lithologic, Rock Mass and Discontinuity Description
			No.	Midpoint Depth Below Bedrock Surface	Depth Below Ground Surface [ft]			Length	Length	%	Length	%	Designation	Weathering[4]	Estimated Field Strength[4]	Rock Mass Rating [RMR][5]	
	[in]	[ft]		[ft]	Start	End	Midpoint	[ft]	[ft]		[ft]						
BB-BWCS-101	NQ [1.875"]	127.2	R1	1.3	57.0	58.5	57.8	1.5	1.3	87%	0.4	27%	Poor	Slightly Weathered (W2)	Medium Strong (R3)	44	57.0 ft - 58.5 ft: Light grey, fine to very fine grained, medium strong (R3), biotite SCHIST, slightly weathered (W2), discontinuities steeply dipping and closely spaced, average 3.8 fractures per foot. [VASSALBORO FORMATION].
			R2	3.8	58.5	62.0	60.3	3.5	3.5	100%	1.3	37%	Poor	Fresh (W1)	Medium Strong (R3)	51	58.5 ft - 62.0 ft: Light grey, fine to very fine grained, medium strong (R3), biotite SCHIST, fresh (W1), discontinuities steeply dipping and closely spaced, average 4 fractures per foot.. Broken core zone from 61.2 ft - 61.5 ft bgs. [VASSALBORO FORMATION]
			R3	7.8	62.0	66.5	64.3	4.5	4.5	100%	2.2	49%	Poor	Slightly Weathered (W2)	Medium Strong (R3)	48	62 ft - 66.5 ft: Light grey, fine to very fine grained, medium strong (R3), biotite SCHIST, slightly weathered (W2), dicontinuities moderately dipping and closely spaced. White calcite infilling on fracture surfaces, average 2.4 fractures per foot. [VASSALBORO FORMATION]
BB-BWCS-102	NQ [1.875"]	128.0	R1	4.3	66.8	71.8	69.3	5.0	4.7	94%	4.3	86%	Good	Fresh (W1)	Medium Strong (R3)	61	66.8 ft - 71.8 ft: Light grey, fine to medium grained, medium strong (R3), biotite SCHIST, fresh (W1), little to moderately fractured, dicontinuities shallowly dipping, tightly spaced, and rough, average 1.5 fracture per foot. [VASSALBORO FORMATION]
			R2	9.3	71.8	76.8	74.3	5.0	4.9	98%	4.8	95%	Excellent	Fresh (W1) to Slightly Weathered (W2)	Medium Strong (R3) to Very Strong (R5)	64	71.8 ft - 76.8 ft: Light grey, fine to medium grained, medium strong (R3) to very strong (R5), biotite SCHIST with frequent granitic intrusions, fresh (W1) to slightly weathered (W2), discontinuities shallowly dipping, widely spaced and smooth to rough, average 0.6 fracture per foot. [VASSALBORO FORMATION]

Notes:

1. As-drilled surface elevations were surveyed by MaineDOT on May 3, 2023 and provided to WSP.
2. TCR = total core recovery. Total core recovery is the length of core recovered divided by the length of the run.
3. RQD = rock quality designation. RQD is the total length of intact, full diameter core pieces recovered with a length greater than or equal to twice the core diameter (i.e., length of 4 inches) measured along the core axis. The percent RQD is the total length of RQD measured versus the run length. Note that vertical discontinuities are not included in determination of RQD.
4. Weathering and Estimated Field Strength based on Tables II.4 and II.3 (respectively) in Willey, 2004 (based on ISRM, 1981).
5. Rock Mass Rating System (RMR; Bieniawski, 1989) assigns numerical ratings to six parameters, including the strength of the intact rock, the RQD, the discontinuity spacing, discontinuity conditions, groundwater conditions, and orientation of discontinuities. These ratings are summed to give the RMR value. As proposed foundations or tie-back designs are not complete, the rating adjustment for joint orientation was assigned a value of 0.
6. ft = feet, in = inches

Prepared by: KAR
Checked by: ATM
Reviewed by: JRS

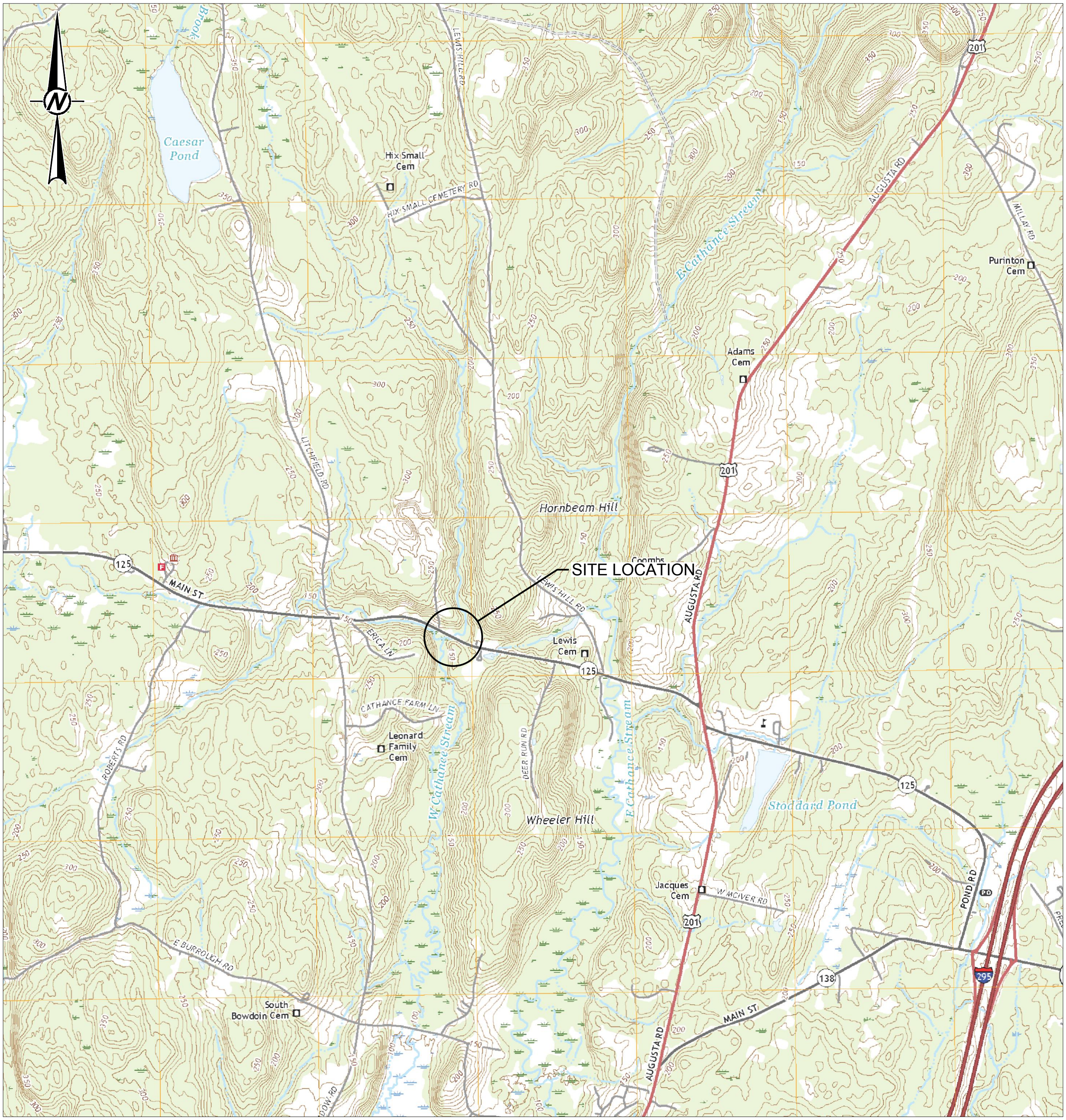
Table 3: Summary of Soil Index and Classification Laboratory Testing Results
Preliminary Geotechnical Design Report
Lewis Bridge #5396, West Cathance Stream, Bowdoin, Maine
MaineDOT WIN 026160.00

Test Boring Designation[1]	Ground Surface Elevation[2] (feet)	Sample Number	Sample Depth Below Ground Surface (feet)	Approximate Sample Elevation (feet)[2]	Laboratory Testing[3]: Sieve Minus No. 200[4] (%)	Moisture Content[5] (%)	Liquid Limit[6]	Plastic Limit[6]	Plasticity Index[6]	Liquidity Index[6]	Organic Content[7] (%)	Soil Classification: AASHTO[8]	USCS[8]
BB-BWCS-101	127.2	S-1	0.9 - 2.9	126.3 - 124.3	11.0	5.4	-	-	-	-	-	A-1-b (0)	SW-SM
		S-2	5.0 - 7.0	122.2 - 120.2	N/A	36	NP				2.2	-	-
		S-3	10.0 - 12.0	117.2 - 115.2	10.2	12.2	-	-	-	-	-	A-1-a (0)	GP-GM
		S-5	15.0 - 17.0	112.2 - 110.2	6.5	22.6	-	-	-	-	-	A-3 (1)	SP-SM
		S-6	20.0 - 22.0	107.2 - 105.2	10.6	16.3	-	-	-	-	-	A-2-4 (0)	SP-SM
		S-7	25.0 - 27.0	102.2 - 100.2	10.7	12.8	-	-	-	-	-	A-1-b (0)	SW-SM
		S-9	35.0 - 37.0	92.2 - 90.2	8.6	14.6	-	-	-	-	-	A-1-b (1)	SW-SM
BB-BWCS-102	128.0	S-13	60.0 - 62.0	68.0 - 66.0	23.4	9.2	-	-	-	-	-	A-1-b (0)	SM
BB-BWCS-103	127.4	S-2	5.0 - 7.0	122.4 - 120.4	N/A	36	26	23	3	4.3	2.5	-	SM
		S-3	10.0 - 12.0	117.4 - 115.4	5.5	24.1	-	-	-	-	-	A-3 (1)	SP-SM
		S-5	20.0 - 22.0	107.4 - 105.4	7.8	18.6	-	-	-	-	-	A-3 (1)	SP-SM
		S-8	35.0 - 37.0	92.4 - 90.4	9.0	11.1	-	-	-	-	-	A-1-b (1)	SP-SM
		S-10	42.0 - 44.0	85.4 - 83.4	8.5	11.5	-	-	-	-	-	A-1-b (1)	SP-SM

Notes:
1. Test boring locations are illustrated in Figure 2 - Boring Location Plan of the Preliminary Geotechnical Design Report.
2. As-drilled elevations for borings BB-BWCS-101, BB-BWCS-102, and BB-BWCS-103 are derived from the electronic file "CORRECTED BORINGS 17 AUG 23" received by WSP on August 17, 2023.
3. Laboratory testing was performed by Geotesting Express of Acton, MA.
4. Particle size testing was performed in accordance with ASTM D6913, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
5. Moisture content testing was performed in accordance with ASTM D2216, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
6. Atterberg Limits testing was performed in accordance with ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
7. Organic content testing was performed in accordance with ASTM D2974, Standard Test Methods for Determining the Water (Moisture) Content, Ash Content, and Organic Material of Peat and Other Organic Soils.
8. AASHTO and USCS symbols were assigned based on interpreted laboratory test results provided by Geotesting Express on May 2nd, 2023.
9. Complete laboratory test results for soil testing are provided in Appendix C of the Preliminary Geotechnical Design Report.

Prepared By: KMB
Checked By: ATM
Reviewed By: MEL

FIGURES



REFERENCE(S)

BASE MAP TAKEN FROM U.S.G.S. 7.5 MINUTE QUADRANGLE OF BOWDOINHAM, MAINE DATED 2021.

NOT FOR CONSTRUCTION

0 1500 3000

1" = 3000' FEET

CLIENT MAINE DEPARTMENT OF TRANSPORTATION 16 STATE HOUSE STATION AUGUSTA, MAINE 04333-0016	PROJECT LEWIS BRIDGE No. 5396, WEST CATHANCE STREAM BOWDOIN, MAINE (WIN 026160.00)
CONSULTANT	TITLE **SITE LOCATION MAP**

YYYY-MM-DD	2023-11-31
DESIGNED	DB
PREPARED	AM
REVIEWED	MEL
APPROVED	

PROJECT NO.	CONTROL	REV.	SHEET
US0047101.4297	0001-001	0	1

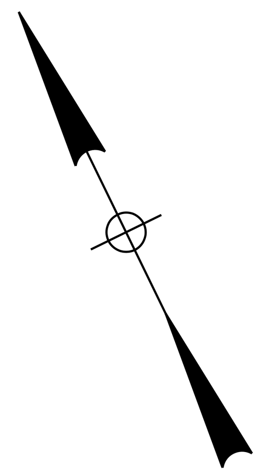
Last Edited By: amorales Date: 2023-10-31 Time:11:56:44 AM | Printed By: AMorales Date: 2023-10-31 Time:12:08:21 PM
Path: \\golder.gds\complexdata\office\Manchester\SIM\MEDOT\MainRd\99_PROJ\30900914.002_MainRd\0001_PrelimDesignGeotechReport\40_PROD\ | File Name: 30900914.002-0001-001.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

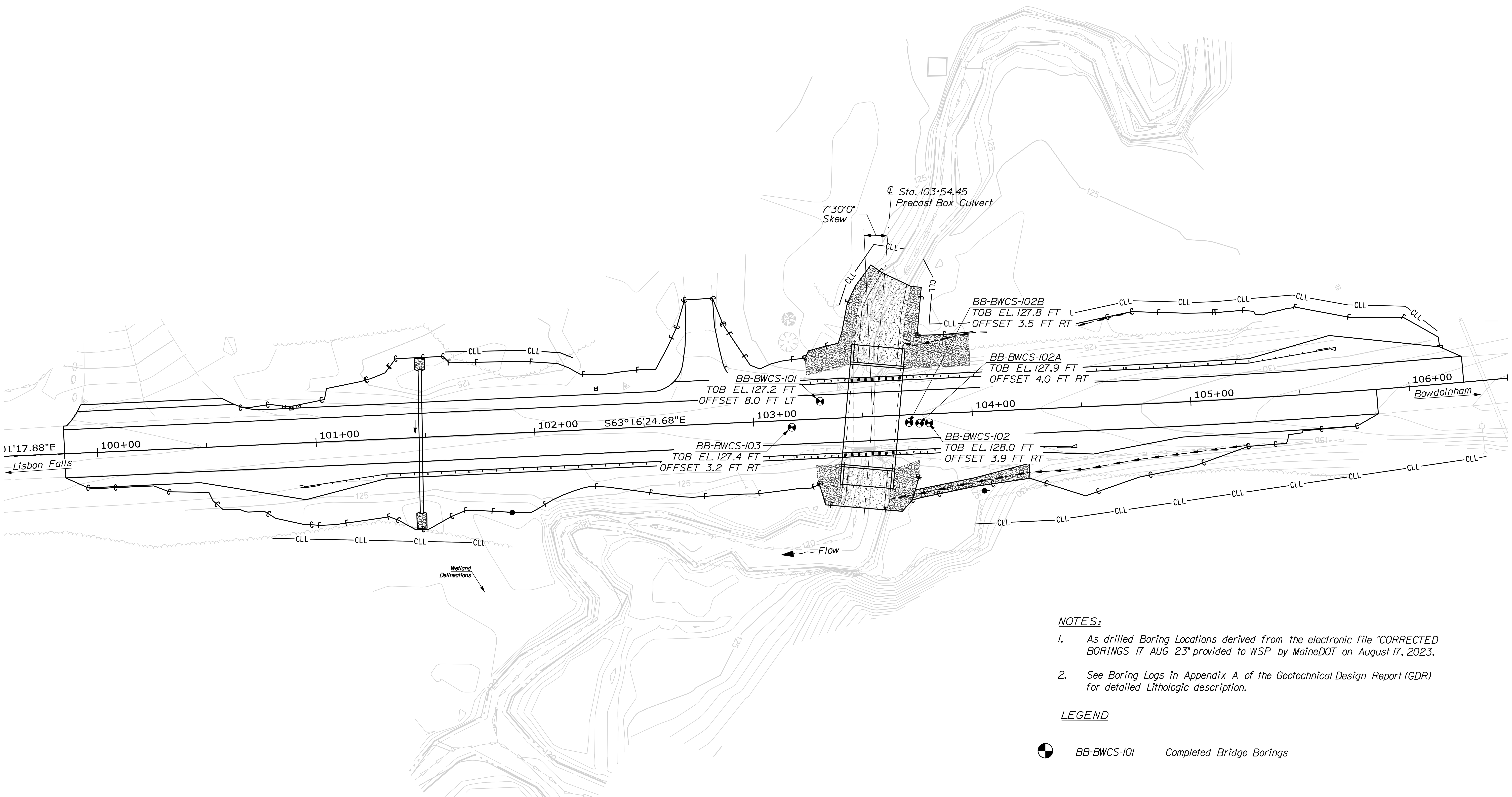
1 in

0

Date:11/4/2025 Username: Division: BRIDGE Filename: ...\005_Boring LocationPlan.dgn



CURVE DATA #1
PI = 105+57.67
D = 1°32'12.5"
Δ = 2°41'16.9" Lt.
R = 3728.25'
L = 174.91'
T = 87.47'
E = 1.03'
N = 438317.74
E = 1092913.11



BORING LOCATION PLAN

25 0 25 50
Scale of Feet

NOTES:

1. As drilled Boring Locations derived from the electronic file "CORRECTED BORINGS 17 AUG 23" provided to WSP by MaineDOT on August 17, 2023.
2. See Boring Logs in Appendix A of the Geotechnical Design Report (GDR) for detailed Lithologic description.

LEGEND

BB-BWCS-101 Completed Bridge Borings

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2616000

WIN 26160.00

BRIDGE PLANS

BRIDGE NO. 5396

	BY	DATE
PROJ. MANAGER	B. NICHOLS	
DESIGN-DETAILED	E. CARON	11/2025
CHECKED-REVIEWED	E. CARON	11/2025
DESIGN2-DETAILED2	D. BURGESS	
DESIGN3-DETAILED3	M. LANDON	
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

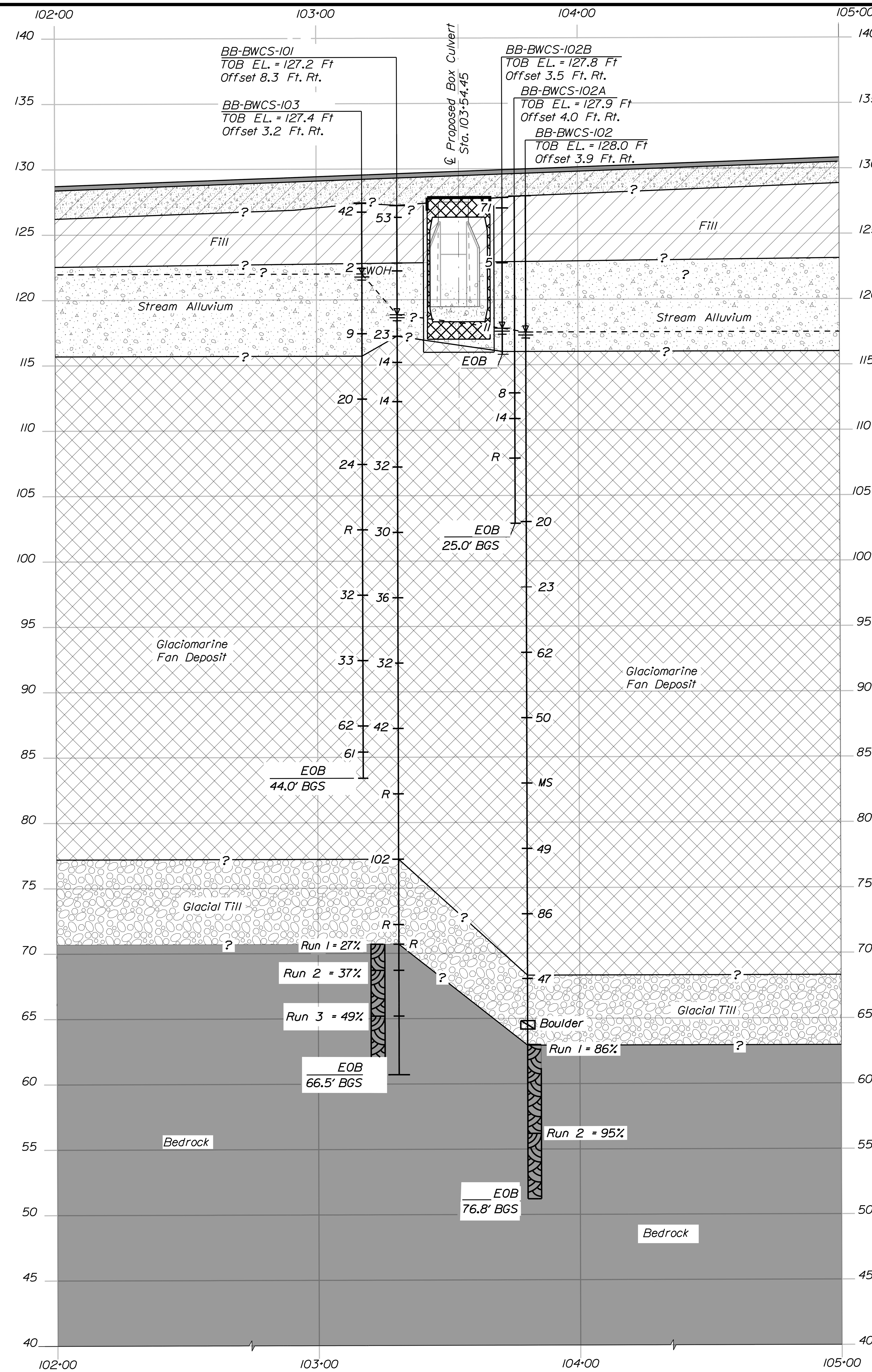
DATE

LEWIS BRIDGE
WEST CATHANCE STREAM
BOWDOIN SAGADAHOC COUNTY

BORING LOCATION PLAN

wsp

SHEET NUMBER
2
OF 3



LEGEND

- Asphalt
- Light Brown To Brown, Dry, Dense, To Very Dense, Fine To Coarse Sand, Trace To Some Gravel, Little Silt (Fill)
- Light Brown To Grey, Moist To Wet, Very Loose To Loose, Fine To Medium Sand, Trace To Some Silt, Non Plastic (Stream Alluvium)
- Grey, Brown, Tan, Moist to Wet, Medium Dense to Very Dense, Fine to Coarse Sand, Trace to some Gravel, Trace to Little Silt (Glaciomarine Fan Deposit)
- Grey, Brown, Moist To Wet, Dense To Very Dense, Fine To Coarse Sand, Some Gravel, Some Silt (Glacial Till)
- Light Grey, Very Fine To Medium-Grained Biotist Schist, Medium Strong, Slightly Weathered To Fresh (Bedrock)
- Existing Ground Surface
- Existing Groundwater Elevations
- Interpreted Ground Water Surface

Boring Location I.D.
Elevation
Offset (Ft.) From ℄ of Roadway

Top of Boring
30 SPT: N60 - Value (Corrected for Hammer Efficiency)
WOH Weight Of Hammer
MS Missed Sample
R Refusal
Boulder
—? Strata Interface
Run 1 = 92% Rock Core Number and Rock Quality Designation (RQD)
EOB End of Boring Depth Below Ground Surface (BGS)

NOTES:

1. As Drilled Boring Locations Derived from the Electronic file "CORRECTED BORINGS 17 AUG 23" Provided to WSP by MaineDOT on August 17, 2023.
2. For Detailed Lithologic Descriptions see Boring Logs in Appendix A of the Geotechnical Design Report (GDR).
3. For Complete Laboratory Data, see Laboratory Results in Appendix C of the Geotechnical Design Report (GDR).
4. Groundwater Surface is Interpreted from Localized Water Levels and Measurements Taken During the Subsurface Exploration Program, see the Geotechnical Design Report (GDR) and Boring Logs in Appendix A.
5. This Generalized Subsurface Profile is Intended to Convey Trends in Subsurface conditions. The Boundaries between Strata are Approximate and Idealized and have been Developed based on Interpretations of Widely Spaced Explorations. Actual Soil and Rock Transitions may vary and may be Erratic.

INTERPRETIVE SUBSURFACE PROFILE

Horiz. 25 0 25 50
Vert. 5 0 5 10
SCALE

wsp

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2616000

WIN 26160.00

BRIDGE PLANS

BRIDGE NO. 5396

	BY	DATE
PROJ. MANAGER	B. NICHOLS	
DESIGN-DETAILED	E. CARON	E. CARON	11/2025
CHECKED-REVIEWED	D. BURGESS	M. LANDON	11/2025
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE
P.E. NUMBER
DATE

BOWDOIN SAGADAHOC COUNTY
LEWIS BRIDGE
WEST CATHANCE STREAM

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3
OF 3

APPENDIX A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, Gravelly sands, little or no fines
			SP	Poorly-graded sands, Gravelly sand, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve size)	SILTS AND CLAYS (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, Silty or Clayey fine sands, or Clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, Gravelly clays, Sandy clays, Silty clays, lean clays.
			OL	Organic silts and organic Silty clays of low plasticity.
	SILTS AND CLAYS (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine Sandy or Silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.

Desired Soil Observations (in this order, if applicable):
Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
Name (Sand, Silty Sand, Clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc.,)
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

Maine Department of Transportation
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

MODIFIED BURMISTER SYSTEM

Descriptive Term	Portion of Total (%)
trace	0 - 10
little	11 - 20
some	21 - 35
adjective (e.g. Sandy, Clayey)	36 - 50

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) Silty or Clayey gravels; and (3) Silty, Clayey or Gravelly sands. Density is rated according to standard penetration resistance (N-value).

Density of Cohesionless Soils	Standard Penetration Resistance N_{60}-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) Gravelly, Sandy or Silty clays; and (3) Clayey silts. Consistency is rated according to undrained shear strength as indicated.

Consistency of Cohesive soils	SPT N_{60}-Value (blows per foot)	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnail
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$\text{RQD (\%)} = \frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Rock Quality Based on RQD

Rock Quality	RQD (%)
Very Poor	≤25
Poor	26 - 50
Fair	51 - 75
Good	76 - 90
Excellent	91 - 100

Desired Rock Observations (in this order, if applicable):
Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
- -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
- -tightness (tight, open, or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Sample Container Labeling Requirements:

WIN	Blow Counts
Bridge Name / Town	Sample Recovery
Boring Number	Date
Sample Number	Personnel Initials
Sample Depth	

Table A-2

Classification of Rock Material Strengths[1]

Grade	Description	Field Identification	Approx. Range of Uniaxial Compressive Strength	
			MPa	psi
S1	Very soft clay	Easily penetrated several inches by fist	<0.025	<4
S2	Soft clay	Easily penetrated several inches by thumb	0.025-0.05	4-7
S3	Firm clay	Can be penetrated several inches by thumb with moderate effort	0.05-0.10	7-15
S4	Stiff clay	Readily indented by thumb but penetrated only with great effort	0.10-0.25	15-35
S5	Very stiff clay	Readily indented by thumbnail	0.25-0.50	35-70
S6	Hard clay	Indented with difficulty by thumbnail	>0.50	>70
R0	Extremely weak rock	Indented by thumbnail	0.25-1.0	35-150
R1	Very weak rock	Crumbles under firm blows with point of geological hammer; can be peeled by a pocket knife	1-5	150-725
R2	Weak rock	Can be peeled by a pocket knife with difficulty; shallow indentations made by firm blow with point of geological hammer	5-25	725-3,500
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife; specimen can be fractured with single firm blow of geological hammer	25-50	3,500-7,000
R4	Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50-100	7,000-15,000
R5	Very strong rock	Specimen requires many blows of geological hammer to fracture it	100-250	15,000-36,000
R6	Extremely strong rock	Specimen can only be chipped with geological hammer	>250	>36,000

Note: Grades S1 to S6 apply to cohesive soils, for example clays, silty clays, and combinations of silts and clays with sand, generally slow draining. Discontinuity wall strength will generally be characterized by grades R0-R6 (rock) while S1-S6 (clay) will generally apply to filled discontinuities. Rock material strength descriptions are included in the rock core descriptions in the boring logs. Rock material strength grades (R0-R6) are not included in the rock core descriptions to avoid confusion with the numbering of the rock core runs.

[1] International Society for Rock Mechanics (ISRM), Commission on standardization of laboratory and field tests (1978): Suggested methods for the quantitative description of discontinuities in rock masses. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr., Vol. 15, No. 6, pp. 319-368.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream		**Boring No.:**	BB-BWCS-101
Location: Bowdoin, Maine		**WIN:**	026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.2	**Auger ID/OD:**	N/A
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Berube	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	3/30/2023-4/3/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438427.047, E: 1092714.130	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒	Hydraulic ☐	Rope & Cathead ☐

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/18	0.90 - 2.90	16-16-19-14	35	53	40	126.7		ASPHALT (6 inches) 0.5	
							58	126.5		TOPSOIL (3 inches) 0.8	WC = 5.4% Fines = 11% A-1-b(0), SW-SM
							53			Light brown, dry, very dense, fine to coarse SAND, some gravel, little silt, well-graded [FILL].	
							42				
							30				
5	2D	24/24	5.00 - 7.00	WOH(24")	- -		42	122.2		5.0 Light brown to grey, moist, very soft, SILT, non-plastic [ALLUVIUM].	WC = 36% OC = 2.2%
							34				
							29				
							26				
							24				
10	3D	24/7	10.00 - 12.00	2-5-10-7	15	23	39	117.2		10.0 Dark grey, moist, medium dense, GRAVEL, some sand, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	WC = 12.2% Fines = 10.2% A-1-a(0), GP-GM
							26				
	4D	24/0	12.00 - 14.00	6-5-4-5	9	14	42			No recovery, cobble lodged in tip of spoon.	
							38				
							52				
15	5D	24/11	15.00 - 17.00	3-4-5-5	9	14	60			Light brown, wet, medium dense, fine to medium SAND, trace gravel, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	WC = 22.6% Fines = 6.5% A-3(1), SP-SM
							38				
							46				
							49				
							58				
20	6D	24/12	20.00 - 22.00	4-5-16-26	21	32	54			Light brown to tan, moist, dense, fine to coarse SAND, little silt, trace gravel, poorly-graded [GLACIOMARINE FAN DEPOSIT].	WC = 16.3 Fines = 10.6% A-2-4(0), SP-SM
							54				
							49				
							56				
25							60				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Water level measured at 7.70 ft bgs at 8:59 on 3/31/2023 and 8.35 ft bgs at 9:12 on 4/3/2023. 4. Boring Station 103+30.96, Offset 8.0 feet L

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-101
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.2	**Auger ID/OD:**	N/A
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Berube	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	3/30/2023-4/3/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438427.047, E: 1092714.130	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	7D	24/12	25.00 - 27.00	14-11-9-8	20	30	51			Light brown to reddish brown, moist, medium dense, fine to coarse SAND, little gravel, little silt, well-graded [GLACIOMARINE FAN DEPOSIT].	WC = 12.8% Fines = 10.7% A-1-b(0), SW-SM
							38				
							52				
							63				
							62				
30	8D	24/11	30.00 - 32.00	10-12-12-11	24	36	69			Reddish brown, moist to wet, dense, fine to coarse SAND, little gravel, little silt, well-graded [GLACIOMARINE FAN DEPOSIT] .	
							68				
							71				
							64				
							74				
35	9D	24/5	35.00 - 37.00	9-11-10-10	21	32	72			Light brown, moist to wet, dense, fine to coarse SAND, little gravel, trace silt, well-graded [GLACIOMARINE FAN DEPOSIT].	WC = 14.6% Fines = 8.6% A-1-b(1), SW-SM
							69				
							63				
							72				
							79				
40	10D	24/5	40.00 - 42.00	12-12-16-27	28	42	74			Light brown, moist to wet, dense, fine to coarse SAND, some gravel, well-graded [GLACIOMARINE FAN DEPOSIT].	
							84				
							88				
							90				
							91				
45	11D	5/0	45.00 - 45.42	50/5"	R		64			No recovery in sampler, possible boulder encountered from 45.5-46.0 ft bgs.	
							66				
							117				
							161			Blow-in material encountered at 48 ft bgs.	
50							178				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Water level measured at 7.70 ft bgs at 8:59 on 3/31/2023 and 8.35 ft bgs at 9:12 on 4/3/2023. 4. Boring Station 103+30.96, Offset 8.0 feet L

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-101
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.2	**Auger ID/OD:**	N/A
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Berube	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	3/30/2023-4/3/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438427.047, E: 1092714.130	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50	12D	23/7	50.00 - 51.92	39-37-30-50/5"	67	102	150	77.2		50.0 Reddish brown, moist to wet, very dense, fine to coarse Sandy GRAVEL, well-graded [GLACIAL TILL].	
							164				
							211				
							207				
							272				
55	13D	6/2	55.00 - 55.50	50/6"			OPEN			Grey, moist, very dense, fine to coarse Sandy GRAVEL, poorly-graded [GLACIAL TILL].	
								70.7		56.5 Top of Bedrock at Elev. 70.7 ft.	
	R1	18/15.6	57.00 - 58.50	RQD = 27%			NQ			R1: Light grey, fine to very fine grained, medium strong (R3), biotite SCHIST, slightly weathered (W2), discontinuities steeply dipping and closely spaced, average 3.8 fractures per foot [VASSALBORO FORMATION]. Rock Mass Quality = Poor Rock Core Rate (min:sec) 57.0-58.5 ft (4:23) 87% Recovery	
	R2	42/42	58.50 - 62.00	RQD = 37%							
60											
	R3	54/54	62.00 - 66.50	RQD = 49%						R2: Light grey, fine to very fine grained, medium strong (R3), biotite SCHIST, fresh (W1), discontinuities steeply dipping and closely spaced, average 4.0 fractures per foot. Broken core zone from 61.2-61.5 ft bgs. [VASSALBORO FORMATION]. Rock Mass Quality = Poor Rock Core Rate (min:sec) 58.5-59.5 ft (2:40) 59.5-60.5 ft (5:16) 60.5-61.5 ft (5:08) 61.5-62.0 ft (5:47) 100% Recovery	
65											
								60.7			
										R3: Light grey, fine to very fine grained, medium strong (R3), biotite SCHIST, slightly weathered (W2), discontinuities moderately dipping and closely spaced, white calcite infilling on fracture surfaces, average 2.4 fractures per foot [VASSALBORO FORMATION]. Rock Mass Quality = Poor Rock Core Rate (min:sec) 62.0-63.0 ft (3:48) 63.0-64.0 ft (2:24) 64.0-65.0 ft (3:47) 65.0-66.0 ft (4:46)	
70											
75											

Remarks:

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Boring No.: BB-BWCS-101

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-101
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.2	**Auger ID/OD:**	N/A
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Berube	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	3/30/2023-4/3/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438427.047, E: 1092714.130	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
75										66.0-66.5 ft (5:13) 100% Recovery	
										66.5	
										Bottom of Exploration at 66.5 feet below ground surface. Boring backfilled with bentonite chips and capped with cold patch to ground surface.	
80											
85											
90											
95											
100											

Remarks:

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Bowdoin Lewis Bridge #5396 over West Cathance Stream **Location:** Bowdoin, Maine	**Boring No.:** BB-BWCS-102 **WIN:** 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	128.0	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/4/2023-4/6/2023	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438394.044, E: 1092752.846	**Casing ID/OD:**	4 in / 4.5 in, telescope 3 in / 3.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
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S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Advanced solid-stem auger to 12 ft bgs with no sampling. See BB-BWCS-102A and BB-BWCS-102B for stratigraphy.	
5											
10											
							20			Advanced casing to 25 ft bgs with no sampling. See BB-BWCS-102A and BB-BWCS 102B for stratigraphy.	
							20				
							20				
15							18				
							20				
							24				
							28				
							60				
20							32				
							22				
							47				
							67				
							NR				
25											

Remarks:

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream Location: Bowdoin, Maine	Boring No.: BB-BWCS-102 WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	128.0	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/4/2023-4/6/2023	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438394.044, E: 1092752.846	**Casing ID/OD:**	4 in / 4.5 in, telescope 3 in / 3.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	7D	24/5	25.00 - 27.00	11-6-7-7	13	20	53	103.0		25.0 Brown, wet, medium dense, fine to coarse SAND, some fine gravel, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	
							42				
							63				
							74				
							80				
30	8D	24/4	30.00 - 32.00	7-7-8-9	15	23	79			Brown, wet, medium dense, fine to coarse SAND, some fine gravel, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	
							75				
							90				
							124				
							141				
35	9D	24/7	35.00 - 37.00	18-17-24-22	41	62	102			Brown, wet, very dense, fine to coarse SAND, little fine gravel, trace silt, well-graded [GLACIOMARINE FAN DEPOSIT].	
							192				
							157				
							135				
							177				
40	10D	24/3	40.00 - 42.00	26-20-13-19	33	50	184			Brown, wet, dense, fine to coarse SAND, little fine to coarse gravel, trace silt, well-graded [GLACIOMARINE FAN DEPOSIT].	
							176				
							170				
							189				
							220				
45							79				
							91				
							129				
							145				
50							163				

Remarks:

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream Location: Bowdoin, Maine	Boring No.: BB-BWCS-102 WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	128.0	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/4/2023-4/6/2023	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438394.044, E: 1092752.846	**Casing ID/OD:**	4 in / 4.5 in, telescope 3 in / 3.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50	11D	24/0	50.00 - 52.00	18-13-19-26	32	49	191			No sample recovery, rock lodged in tip of spoon.	
							187				
							221				
							234				
							234				
55	12D	22/7	55.00 - 56.83	21-20-37-50/4"	57	86	162			Brown, wet, very dense, fine to coarse SAND, little fine to coarse gravel, trace silt, well-graded [GLACIOMARINE FAN DEPOSIT].	
							203				
							220				
							236				
							229				
60	13D	24/5	60.00 - 62.00	18-18-13-19	31	47	166	68.0		60.0 Grey, wet, dense, fine to coarse SAND, some gravel, some silt, poorly-graded [GLACIAL TILL].	WC = 9.2% Fines = 23.4% A-1-b(0), SM
							160				
							183				
							154			Boulder encountered from 63.5 to 64.5 feet bgs.	
							151				
65							NW	63.0		65.0 Top of Bedrock at Elev. 63.0 ft. Weathered rock encountered at 65 ft bgs.	
	R1	60/56.4	66.80 - 71.80	RQD = 86%			NQ			R1: Light grey, fine to medium grained, medium strong (R3), biotite SCHIST, fresh (W1), little to moderately fractured, discontinuities shallowly dipping, tightly spaced, and rough, average 1.5 fractures per foot [VASSALBORO FORMATION]. Rock Mass Quality = Good Rock Core Rate (min:sec) 66.8-67.8 ft (4:59) 67.8-68.8 ft (2:16) 68.8-69.8 ft (2:17) 69.8-70.8 ft (2:27) 70.8-71.8 ft (1:48) 94% Recovery	
70											
	R2	60/58.8	71.80 - 76.80	RQD = 95%							
										R2: Light grey, fine to medium grained, medium strong (R3) to very	
75											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Water level measured at 10.12 ft bgs at 15:30 on 4/4/2023; 10.55 ft bgs at 9:08 on 4/5/2023; 15.8 ft bgs at 15:25 on 4/5/2023; 16.81 ft bgs at 8:20 on 4/6/2023; and 6.35 ft bgs at 12:18 on 4/6/2023. 4. Boring Station 103+75.83, Offset 3.9 feet R

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-102
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	128.0	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/4/2023-4/6/2023	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	1 7/8 in - NQ
Boring Location:	N: 438394.044, E: 1092752.846	**Casing ID/OD:**	4 in / 4.5 in, telescope 3 in / 3.5 in	**Water Level*:**	See Remarks
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
75								51.2		strong (R5), biotite SCHIST with frequent granitic intrusions, fresh (W1) to slightly weathered (W2), discontinuities shallowly dipping, widely spaced, and smooth to rough, average 0.6 fractures per foot [VASSALBORO FORMATION]. Rock Mass Quality = Excellent Rock Core Rate (min:sec) 71.8-72.8 ft (2:30) 72.8-73.8 ft (2:36) 73.8-74.8 ft (2:45) 74.8-75.8 ft (3:15) 75.8-76.8 ft (4:02) 98% Recovery	
80										76.8	
										Bottom of Exploration at 76.8 feet below ground surface. Boring backfilled with bentonite chips and capped with cold patch to ground surface.	
85											
90											
95											
100											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Water level measured at 10.12 ft bgs at 15:30 on 4/4/2023; 10.55 ft bgs at 9:08 on 4/5/2023; 15.8 ft bgs at 15:25 on 4/5/2023; 16.81 ft bgs at 8:20 on 4/6/2023; and 6.35 ft bgs at 12:18 on 4/6/2023. 4. Boring Station 103+75.83, Offset 3.9 feet R

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-102A
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.9	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/3/2023-4/4/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	N: 438396.300, E: 1092748.807	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	5.77 ft bgs at 8:55 4/4/2023
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							HSA			Advanced hollow-stem auger to 10 ft bgs with no sampling. See BB-BWCS-102B for stratigraphy.	
5											
10							6			Advanced casing to 15 ft bgs with no sampling. See BB-BWCS-102B for stratigraphy.	
							12			Wood encountered at 11.5 ft bgs.	
							27				
							17				
							NR				
15	4D	24/0	15.00 - 17.00	8-3-2-2	5	8	8			No recovery	
							11				
	5D	24/7	17.00 - 19.00	5-4-5-7	9	14	11	110.9		17.0 Light grey, wet, medium dense, fine to coarse SAND, trace gravel, trace silt, well-graded [GLACIOMARINE FAN DEPOSIT].	
							80				
							40/6"				
20	6D	3/1	20.00 - 20.25	50/3"	R		195			Grey, wet, very dense, coarse SAND, some gravel, trace silt [GLACIOMARINE FAN DEPOSIT]. Cobble in tip of spoon.	
							78				
							14				
							36				
25							48				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Boring Station 103+80.30, Offset 4.0 feet R

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-102A
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.9	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/3/2023-4/4/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	N: 438396.300, E: 1092748.807	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	5.77 ft bgs at 8:55 4/4/2023
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25								102.9		Casing bent at 25 ft bgs and drive shoe broke off in hole. 25.0	
										Bottom of Exploration at 25.0 feet below ground surface. Boring terminated due to casing damage. Backfilled with bentonite chips and capped with cold patch to ground surface. Offset 5 feet southeast to BB-BWCS-102.	
30											
35											
40											
45											
50											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Boring Station 103+80.30, Offset 4.0 feet R

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-102B
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.8	**Auger ID/OD:**	N/A
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Berube	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/3/2023-4/3/2023	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	N: 438398.436, E: 1092744.842	**Casing ID/OD:**	4 in / 4.5 in	**Water Level*:**	10 ft bgs at 15:40 4/3/2023
Hammer Efficiency Factor: 0.91		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/12	0.90 - 2.90	15-25-22-27	47	71	3	127.3		ASPHALT (6 inches) — 0.5	
							2	126.9		TOPSOIL (5 inches) — 0.9	
							4			Light brown, dry, very dense, fine to coarse SAND, trace gravel, well-graded [FILL].	
							6				
							4				
5	2D	24/18	5.00 - 7.00	2-3-WOH(6")-3	3	5	17	122.8		5.0 — Light brown to grey, moist, loose, fine to medium SAND, trace silt, trace gravel, poorly-graded [ALLUVIUM].	
							15				
							18				
							40				
							OPEN			Casing refusal at 9 ft bgs.	
10	3D	24/24	10.00 - 12.00	WOH(6")-3-4-3	7	11				Light grey, wet, medium dense, fine to coarse SAND, trace gravel, trace wood fragments, well-graded [ALLUVIUM].	
								115.8		12.0 — **Bottom of Exploration at 12.0 feet below ground surface.** Boring terminated due to casing refusal. Backfilled with bentonite chips and capped with cold patch to ground surface. Offset 5 feet southeast to BB-BWCS-102A.	
15											
20											
25											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Boring Station 103+71.05, Offset 3.5 feet R

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-103

WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.4	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/6/2023-4/6/2023	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	N: 438422.517, E: 1092697.690	**Casing ID/OD:**	3 in / 3.5 in	**Water Level*:**	5.43 ft bgs at 16:15 4/6/2023
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt

R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person

S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected

T_V = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/10	0.60 - 2.60	11-11-17-25	28	42	SSA	126.8		ASPHALT (8 inches) 0.6 Brown, dry, dense, fine to coarse SAND, little fine to coarse gravel, little silt, well-graded [FILL]. Asphalt fragments at 2 ft bgs.	
5	2D	24/20	5.00 - 7.00	2-1(6")-1(12")	1	2		122.4		5.0 Grey, wet, very loose, fine to medium SAND, some silt [ALLUVIUM].	WC = 36% LL = 26 PL = 23 PI = 3 LI = 4.2 OC = 2.5% SM
10	3D	24/14	10.00 - 12.00	4-3-3-4	6	9	19			Grey, wet, loose, fine to medium SAND, trace silt, poorly-graded [ALLUVIUM].	WC = 24.1% Fines = 5.5% A-3(1), SP-SM
							13				
							19	115.4		12.0	
							20				
							NR				
15	4D	24/7	15.00 - 17.00	5-6-7-7	13	20	10			Grey, wet, medium dense, fine to coarse SAND, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	
							22				
							31				
							40				
							34				
20	5D	24/7	20.00 - 22.00	8-7-9-11	16	24	12			Grey to brown, wet, medium dense, fine to coarse SAND, trace gravel, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	WC = 18.6% Fines = 7.8% A-3(1), SP-SM
							24				
							75				
							106				
25							131				

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Boring Station 103+17.42, Offset 3.2 feet R

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Bowdoin Lewis Bridge #5396 over West Cathance Stream
Location: Bowdoin, Maine

Boring No.: BB-BWCS-103
WIN: 026160.00

Driller:	S.W. Cole Explorations	**Elevation (ft.)**	127.4	**Auger ID/OD:**	2 1/4 in (ID)
Operator:	M. Bussey	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	D. Burgess	**Rig Type:**	B-48 Mobile Drill	**Hammer Wt./Fall:**	140 lbs / 30 in
Date Start/Finish:	4/6/2023-4/6/2023	**Drilling Method:**	Cased Wash / Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	N: 438422.517, E: 1092697.690	**Casing ID/OD:**	3 in / 3.5 in	**Water Level*:**	5.43 ft bgs at 16:15 4/6/2023
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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MU = Unsuccessful Thin Wall Tube Sample Attempt
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MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D	6/2	25.00 - 25.50	50/6"	R		158			Light brown, wet, very dense, fine to medium SAND, little fine to coarse gravel, little silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	
							135				
							95				
							89				
							73				
30	7D	24/3	30.00 - 32.00	12-10-11-12	21	32	57			Brown, wet, dense, fine to coarse SAND, trace fine to coarse gravel, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	
							68				
							106				
							103				
							102				
35	8D	24/10	35.00 - 37.00	19-10-12-13	22	33	55			Brown, wet, dense, gravelly fine to coarse SAND, trace silt, poorly-graded [GLACIOMARINE FAN DEPOSIT].	WC = 11.1% Fines = 9.0% A-1-b(1), SP-SM
							75				
							75				
							130				
							115				
40	9D	24/0	40.00 - 42.00	31-21-20-21	41	62	OPEN			No recovery, rock lodged in tip of spoon.	
	10D	24/16	42.00 - 44.00	16-16-24-31	40	61				Brown, wet, very dense, fine to coarse SAND, some gravel, trace silt, poorly- graded [GLACIOMARINE FAN DEPOSIT]. Interbedded 2-inch lenses of fine to medium sand.	WC = 11.5% Fines = 8.5% A-1-b(1), SP-SM
								83.4		44.0 **Bottom of Exploration at 44.0 feet below ground surface.** Boring backfilled with bentonite chips and capped with cold patch to ground surface.	
45											
50											

Remarks:

1. Hammer efficiency factor provided by S.W. Cole and taken from "Standard Penetration Test Energy Measurement Calibration: Tracked Rig - Mobile Drill B-48 with Automatic Hammer (S/N 2021021)" by Geosciences Testing and Research, Inc., dated 11/4/2022. 2. As-drilled boring locations and ground surface elevations were provided by MaineDOT in electronic file "CORRECTED BORINGS 17 AUG 23.csv". 3. Boring Station 103+17.42, Offset 3.2 feet R

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

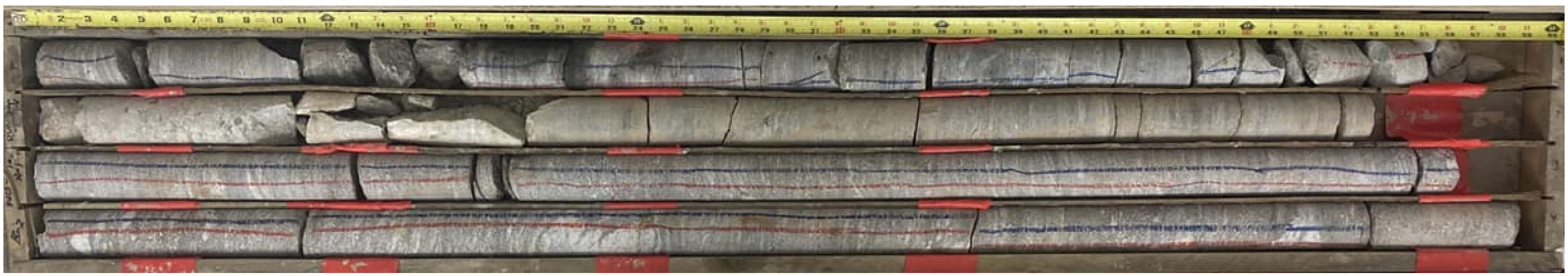
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

APPENDIX B

Rock Core Photographs

APPENDIX B
ROCK CORE PHOTOGRAPHS
WEST CATHANCE STREAM CULVERT REPLACEMENT, LEWIS BRIDGE #5396, AUGUSTA, MAINE
MAINEDOT WIN 026161.00

Boring	Run	Depth Below Surface Feet			Recovery Feet			Recovery %	RQD Feet			RQD %	Rock Type	Box Row	Date Cored
BB-ATB-101	R1	57.0	-	58.5	1.3	/	1.5	87	0.4	/	1.5	27	SCHIST	1	4/8/2023
	R2	58.5	-	62.0	3.5	/	3.5	100	1.3	/	3.5	37	SCHIST	1	4/8/2023
	R3	62.0	-	66.5	4.5	/	4.5	100	2.2	/	4.5	49	SCHIST	2	4/8/2023
BB-ATB-102	R1	66.0	-	71.8	4.7	/	5.0	94	4.3	/	5.0	86	SCHIST	3	4/6/2023
	R2	71.8	-	76.8	4.9	/	5.0	98	4.8	/	5.0	95	SCHIST	4	4/6/2023



Notes:
1. "Box row" indicates the section of the box where the core is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.

Prepared By: KMB
Checked By: ATM
Reviewed By: JRS

APPENDIX C

Laboratory Test Results

Client:	WSP USA, Inc.			
Project:	ME DOT Bowdoin W. Cathance Stream			
Location:	Bowdoin, ME		Project No:	GTX-317119
Boring ID:	---	Sample Type: ---	Tested By:	ckg
Sample ID:	---	Test Date: 05/02/23	Checked By:	ank
Depth :	---	Test Id: 713520		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-BWCS-101	S- 1	0.9'-2.9'	Moist, brown sand with silt and gravel	5.4
BB-BWCS-101	S- 3	10'-12'	Moist, dark gray gravel with silt and sand	12.2
BB-BWCS-101	S- 5	15'-17'	Moist, olive brown sand with silt	22.6
BB-BWCS-101	S- 6	20'-22'	Moist, light olive brown sand with silt	16.3
BB-BWCS-101	S- 7	25'-27'	Moist, brown sand with silt and gravel	12.8
BB-BWCS-101	S- 9	35'-37'	Moist, brown sand with silt	14.6
BB-BWCS-102	S- 12	60'-62'	Moist, dark gray silty sand with gravel	9.2

Notes: Temperature of Drying : 110º Celsius

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Client:	WSP USA, Inc.				
Project:	ME DOT Bowdoin W. Cathance Stream				
Location:	Bowdoin, ME			Project No:	GTX-317119
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	05/02/23	Checked By:	ank
Depth :	---	Test Id:	713524		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-BWCS-103	S- 3	10'-12'	Moist, gray sand with silt	24.1
BB-BWCS-103	S- 5	20'-22'	Moist, light olive brown sand with silt	18.6
BB-BWCS-103	S- 8	35'-37'	Moist, olive brown sand with silt and gravel	11.1
BB-BWCS-103	S- 10	42'-44'	Moist, olive brown sand with silt and gravel	11.5

Notes: Temperature of Drying : 110º Celsius

printed 5/2/2023 11:19:29 AM

Client: WSP USA, Inc.			
Project: ME DOT Bowdoin W. Cathance Stream			
Location: Bowdoin, ME		Project No: GTX-317119	
Boring ID: ---	Sample Type: ---	Tested By: cam	
Sample ID: ---	Test Date: 05/01/23	Checked By: ank	
Depth : ---	Test Id: 713526		

Moisture, Ash, and Organic Matter - ASTM D2974

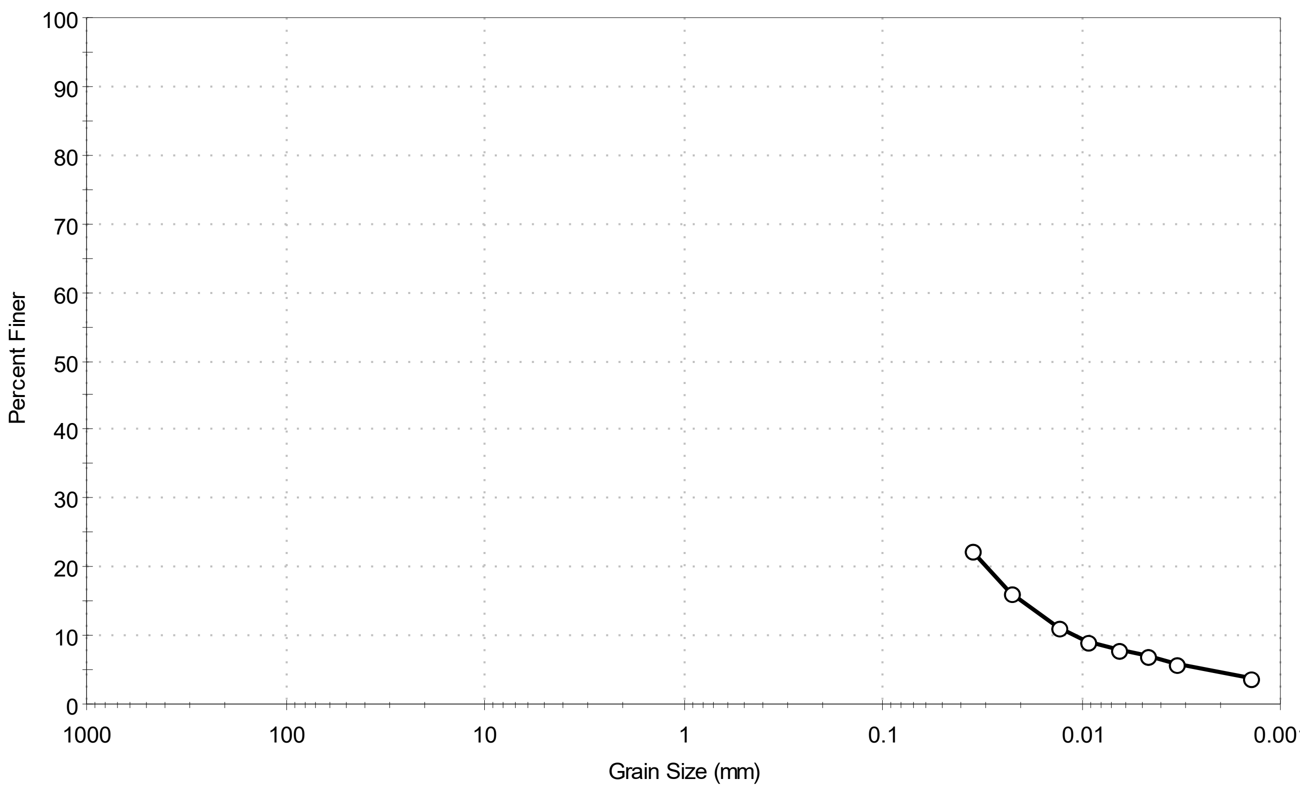
Boring ID	Sample ID	Depth	Description	Moisture Content,%	Ash Content,%	Organic Matter,%
BB-BWCS-101	S-2	5'-7'	Moist, very dark brown silty sand	36	97.8	2.2
BB-BWCS-103	S-2	5'-7'	Wet, dark grayish brown silty sand	36	97.5	2.5

Notes: Moisture content determined by Method A and reported as a percentage of oven-dried mass; dried to a constant mass at temperature of 105º C
Ash content and organic matter determined by Method C; dried to constant mass at temperature 440º C

Client:	WSP USA, Inc.			
Project:	ME DOT Bowdoin W. Cathance Stream			
Location:	Bowdoin, ME		Project No:	GTX-317119
Boring ID:	BB-BWCS-101	Sample Type: jar	Tested By:	ckg
Sample ID:	S-2	Test Date: 05/03/23	Checked By:	ank
Depth :	5'-7'	Test Id: 713501		

Test Comment: ---
Visual Description: Moist, very dark brown silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	—	—	—

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0361	22		
---	0.0228	16		
---	0.0133	11		
---	0.0094	9		
---	0.0067	8		
---	0.0047	7		
---	0.0033	6		
---	0.0014	4		

Coefficients

D_{85} =N/A
D_{30} =N/A
D_{60} =N/A
D_{15} =0.0201 mm
D_{50} =N/A
D_{10} =0.0110 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO ()

Sample/Test Description

Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

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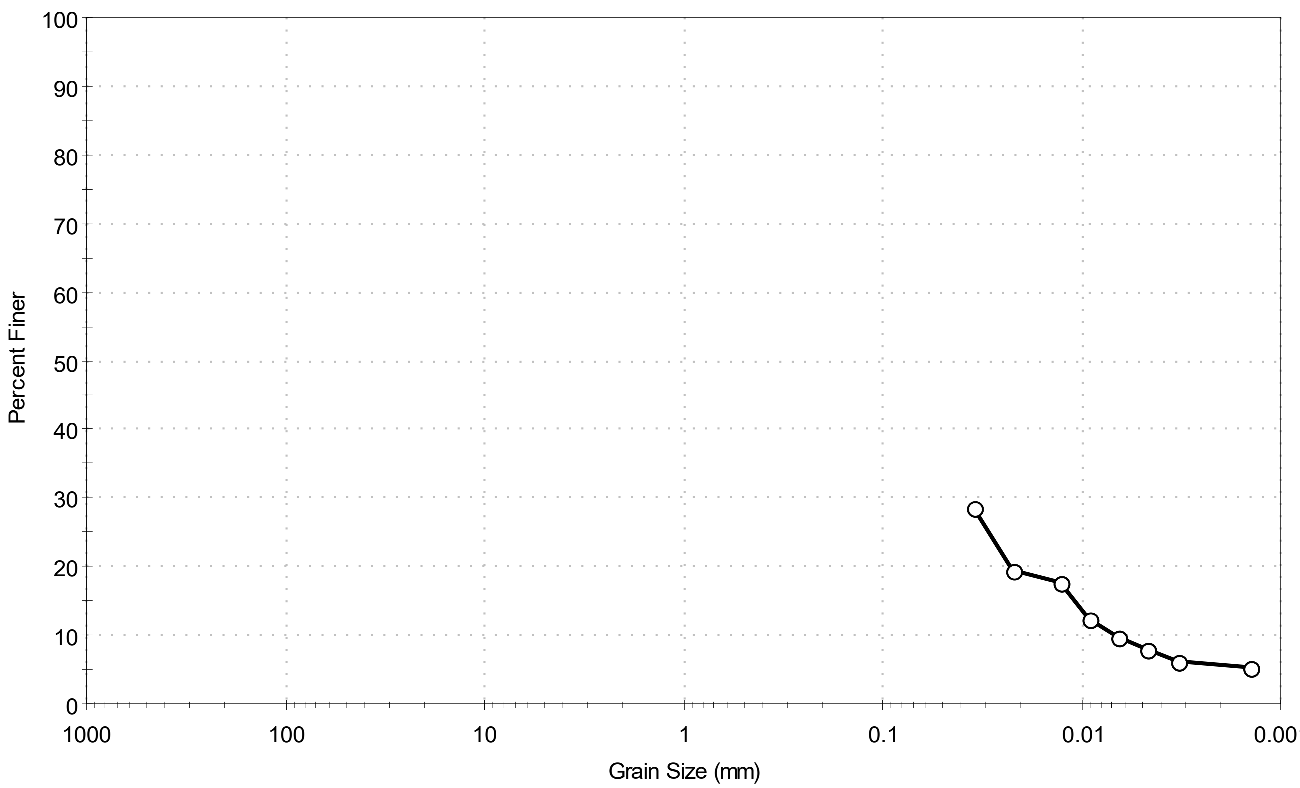
Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119
Boring ID: BB-BWCS-103	Sample Type: jar	Tested By:	ckg
Sample ID: S-2	Test Date: 05/03/23	Checked By:	ank
Depth : 5'-7'	Test Id: 713502		
Test Comment:	---		
Visual Description:	Wet, dark grayish brown silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	—	—	—

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0351	29		
---	0.0224	20		
---	0.0129	18		
---	0.0093	12		
---	0.0066	10		
---	0.0047	8		
---	0.0033	6		
---	0.0014	5		

Coefficients

D_{85} =N/A
D_{30} =N/A
D_{60} =N/A
D_{15} =0.0109 mm
D_{50} =N/A
D_{10} =0.0068 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO ()

Sample/Test Description

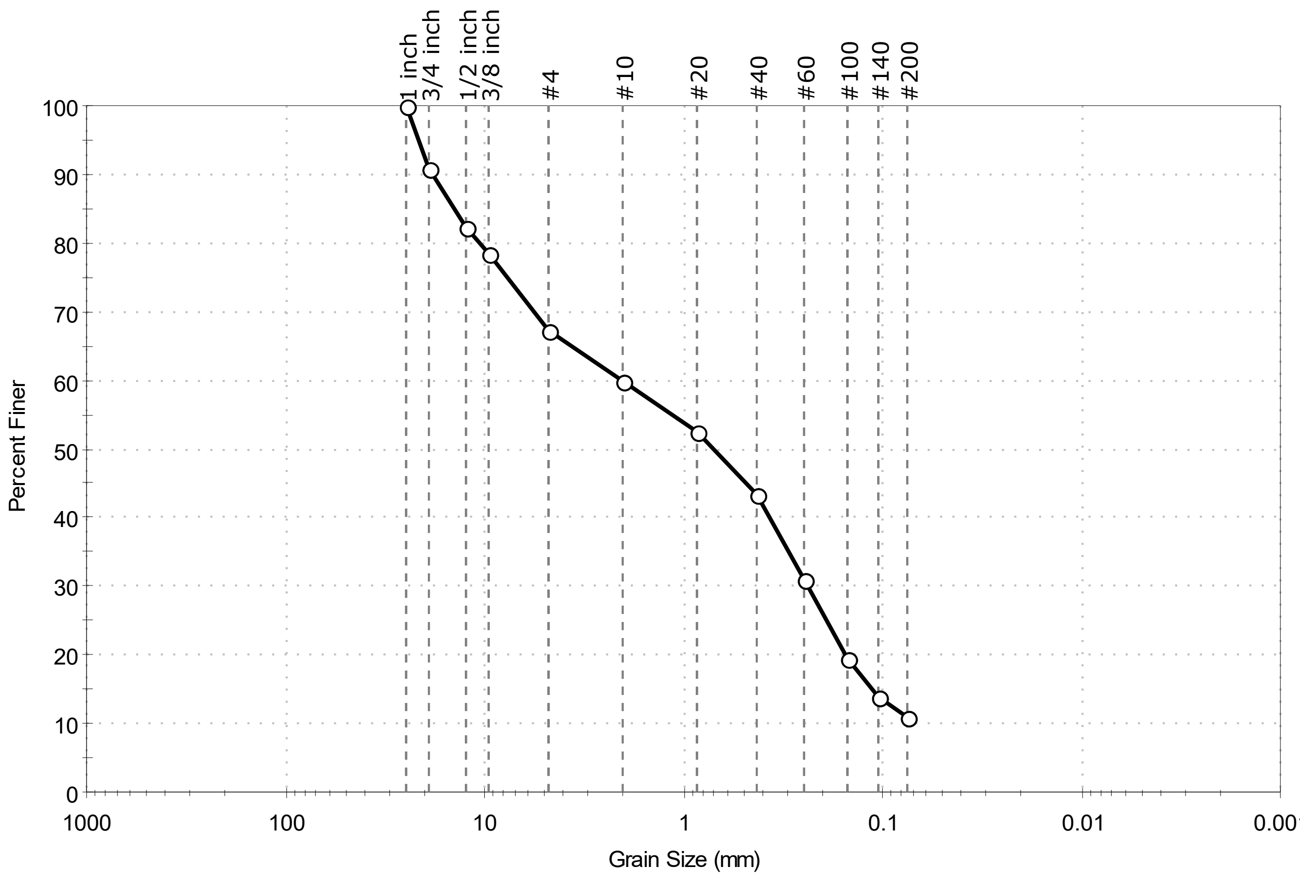
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

printed 5/3/2023 10:28:10 AM

GeoTesting EXPRESS

Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119
Boring ID: BB-BWCS-101	Sample Type: jar	Tested By:	ckg
Sample ID: S-1	Test Date: 05/01/23	Checked By:	ank
Depth : 0.9'-2.9'	Test Id: 713503		
Test Comment:	---		
Visual Description:	Moist, brown sand with silt and gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	32.6	56.4	11.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 inch	25.00	100		
3/4 inch	19.00	91		
1/2 inch	12.50	82		
3/8 inch	9.50	79		
#4	4.75	67		
#10	2.00	60		
#20	0.85	53		
#40	0.42	43		
#60	0.25	31		
#100	0.15	19		
#140	0.11	14		
#200	0.075	11		

Coefficients

D_{85} =14.2265 mm　D_{30} =0.2400 mm

D_{60} =2.0073 mm　D_{15} =0.1137 mm

D_{50} =0.7001 mm　D_{10} =N/A

C_u =N/A　C_c =N/A

Classification

ASTM　N/A

AASHTO　Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

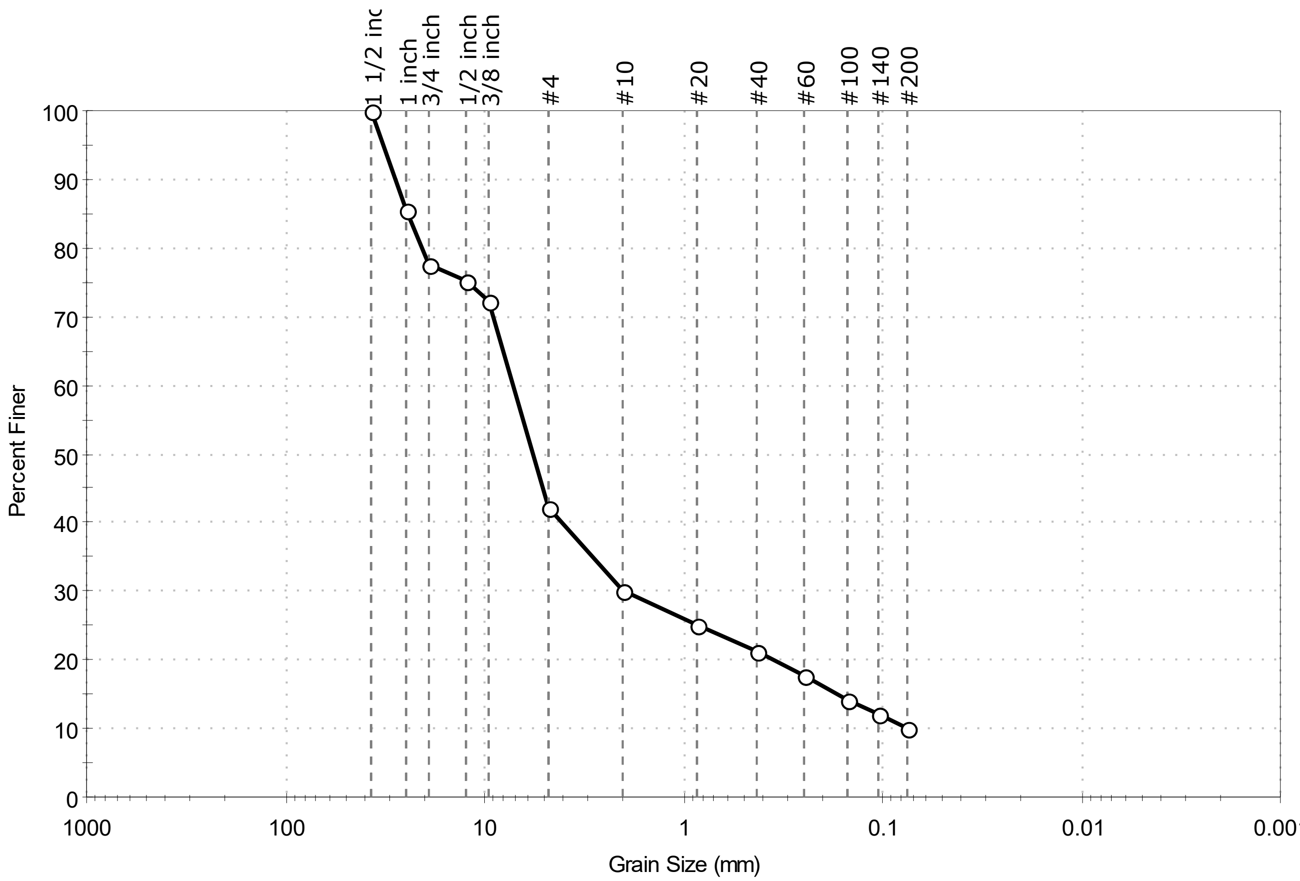
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

printed 5/2/2023 11:50:37 AM

Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119
Boring ID: BB-BWCS-101	Sample Type: jar	Tested By:	ckg
Sample ID: S-3	Test Date: 05/01/23	Checked By:	ank
Depth : 10'-12'	Test Id: 713504		
Test Comment:	---		
Visual Description:	Moist, dark gray gravel with silt and sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	57.9	31.9	10.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 1/2 inch	37.50	100		
1 inch	25.00	85		
3/4 inch	19.00	78		
1/2 inch	12.50	75		
3/8 inch	9.50	72		
#4	4.75	42		
#10	2.00	30		
#20	0.85	25		
#40	0.42	21		
#60	0.25	18		
#100	0.15	14		
#140	0.11	12		
#200	0.075	10		

Coefficients

D_{85} =24.5746 mm | D_{30} =1.9826 mm

D_{60} =7.1734 mm | D_{15} =0.1695 mm

D_{50} =5.7004 mm | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

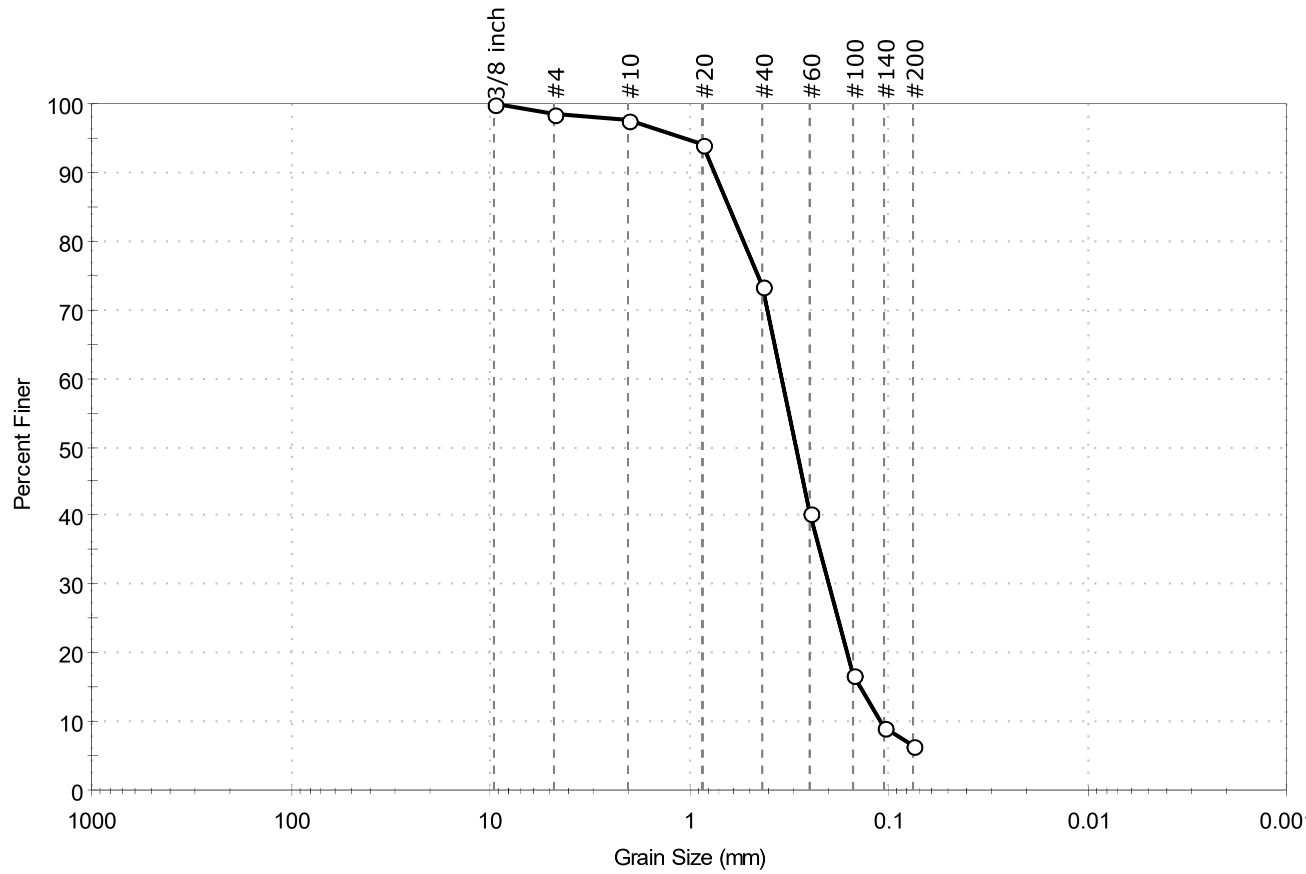
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

printed 5/2/2023 11:50:39 AM

Client:	WSP USA, Inc.				
Project:	ME DOT Bowdoin W. Cathance Stream				
Location:	Bowdoin, ME			Project No:	GTX-317119
Boring ID:	BB-BWCS-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-5	Test Date:	05/01/23	Checked By:	ank
Depth :	15'-17'	Test Id:	713505		
Test Comment:	---				
Visual Description:	Moist, olive brown sand with silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	1.4	92.1	6.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/8 inch	9.50	100		
#4	4.75	99		
#10	2.00	98		
#20	0.85	94		
#40	0.42	73		
#60	0.25	41		
#100	0.15	17		
#140	0.11	9		
#200	0.075	6.5		

Coefficients

D_{85} =0.6276 mm | D_{30} =0.1994 mm

D_{60} =0.3423 mm | D_{15} =0.1385 mm

D_{50} =0.2913 mm | D_{10} =0.1105 mm

C_u =3.098 | C_c =1.051

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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GeoTesting EXPRESS

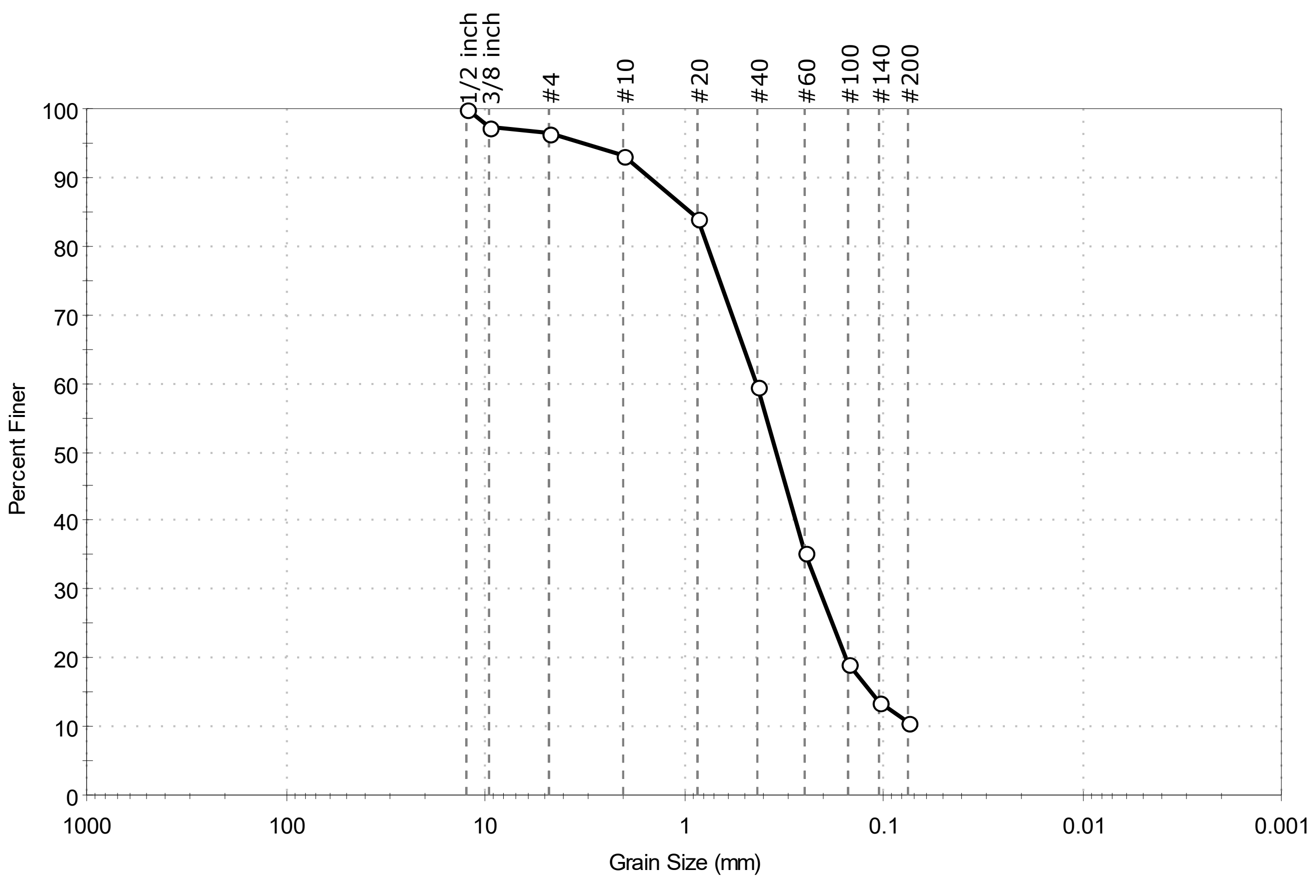
Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119
Boring ID: BB-BWCS-101	Sample Type: jar	Tested By:	ckg
Sample ID: S-6	Test Date: 05/01/23	Checked By:	ank
Depth : 20'-22'	Test Id: 713506		

Test Comment: ---

Visual Description: Moist, light olive brown sand with silt

Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	3.6	85.8	10.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 inch	12.50	100		
3/8 inch	9.50	97		
#4	4.75	96		
#10	2.00	93		
#20	0.85	84		
#40	0.42	60		
#60	0.25	35		
#100	0.15	19		
#140	0.11	14		
#200	0.075	11		

Coefficients

D_{85} =0.9203 mm	D_{30} =0.2113 mm
D_{60} =0.4302 mm	D_{15} =0.1161 mm
D_{50} =0.3446 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

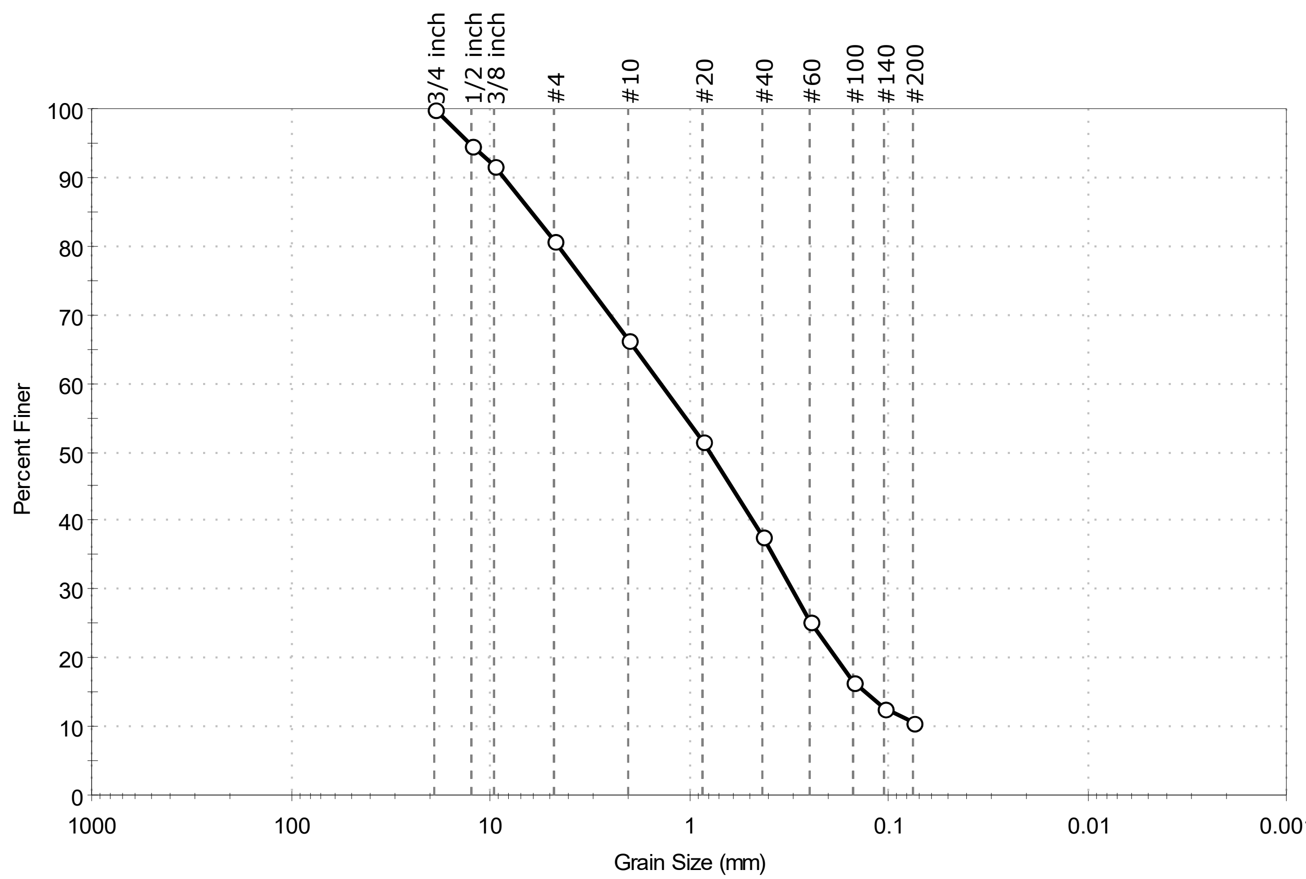
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

printed 5/2/2023 11:50:42 AM

Client:	WSP USA, Inc.			
Project:	ME DOT Bowdoin W. Cathance Stream			
Location:	Bowdoin, ME		Project No:	GTX-317119
Boring ID:	BB-BWCS-101	Sample Type: jar	Tested By:	ckg
Sample ID:	S-7	Test Date: 05/01/23	Checked By:	ank
Depth :	25'-27'	Test Id: 713507		
Test Comment:	---			
Visual Description:	Moist, brown sand with silt and gravel			
Sample Comment:	---			

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	19.0	70.3	10.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/4 inch	19.00	100		
1/2 inch	12.50	95		
3/8 inch	9.50	92		
#4	4.75	81		
#10	2.00	66		
#20	0.85	52		
#40	0.42	38		
#60	0.25	25		
#100	0.15	16		
#140	0.11	13		
#200	0.075	11		

Coefficients

D_{85} =6.1639 mm
D_{30} =0.3063 mm
D_{60} =1.3771 mm
D_{15} =0.1305 mm
D_{50} =0.7813 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

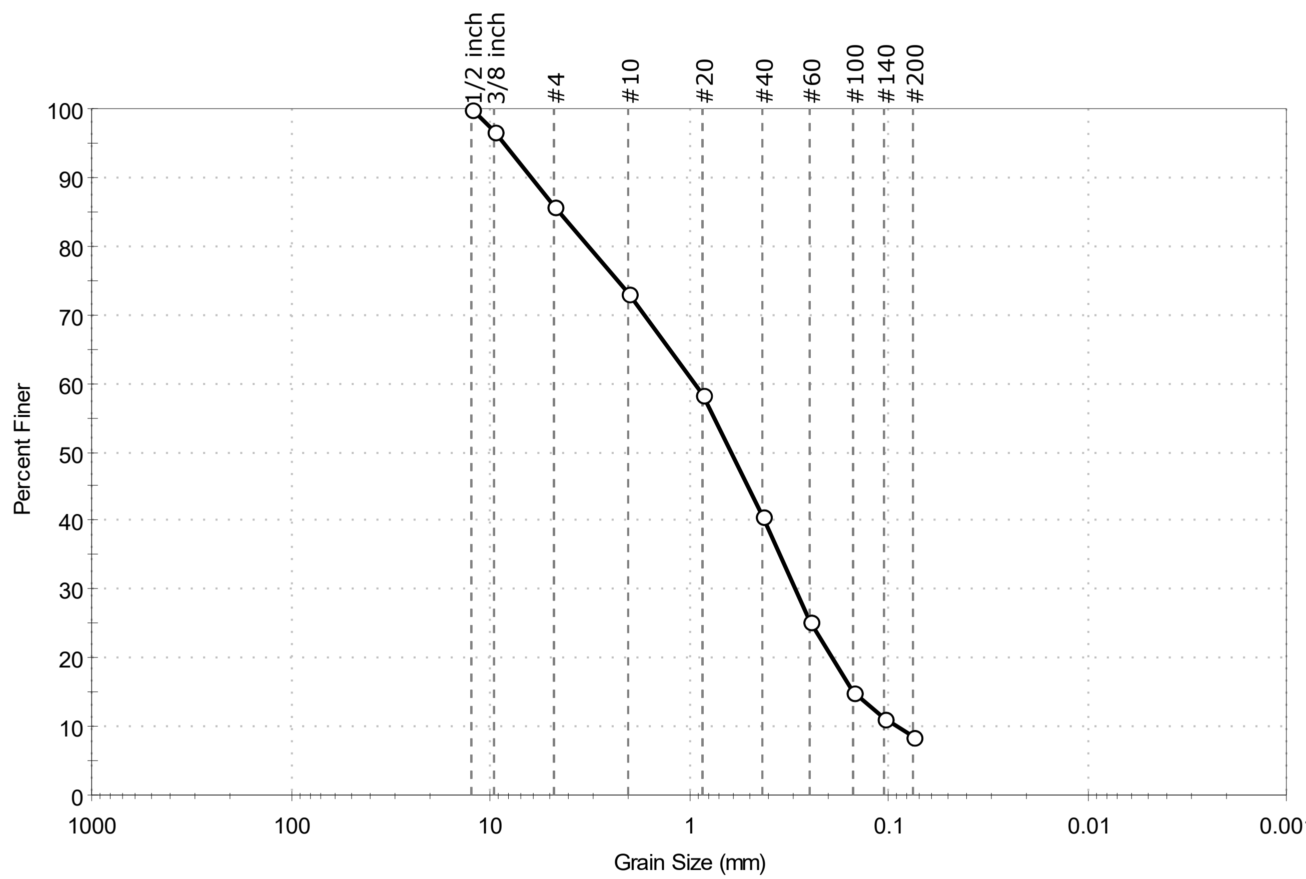
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

printed 5/2/2023 11:50:43 AM

Client: WSP USA, Inc.			
Project: ME DOT Bowdoin W. Cathance Stream			
Location: Bowdoin, ME		Project No:	GTX-317119
Boring ID: BB-BWCS-101	Sample Type: jar	Tested By:	ckg
Sample ID: S-9	Test Date: 05/01/23	Checked By:	ank
Depth : 35'-37'	Test Id: 713508		
Test Comment: ---			
Visual Description: Moist, brown sand with silt			
Sample Comment: ---			

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	14.0	77.4	8.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 inch	12.50	100		
3/8 inch	9.50	97		
#4	4.75	86		
#10	2.00	73		
#20	0.85	59		
#40	0.42	41		
#60	0.25	25		
#100	0.15	15		
#140	0.11	11		
#200	0.075	8.6		

Coefficients

D_{85} =4.4481 mm D_{30} =0.2939 mm

D_{60} =0.9274 mm D_{15} =0.1493 mm

D_{50} =0.6111 mm D_{10} =0.0902 mm

C_u =10.282 C_c =1.033

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

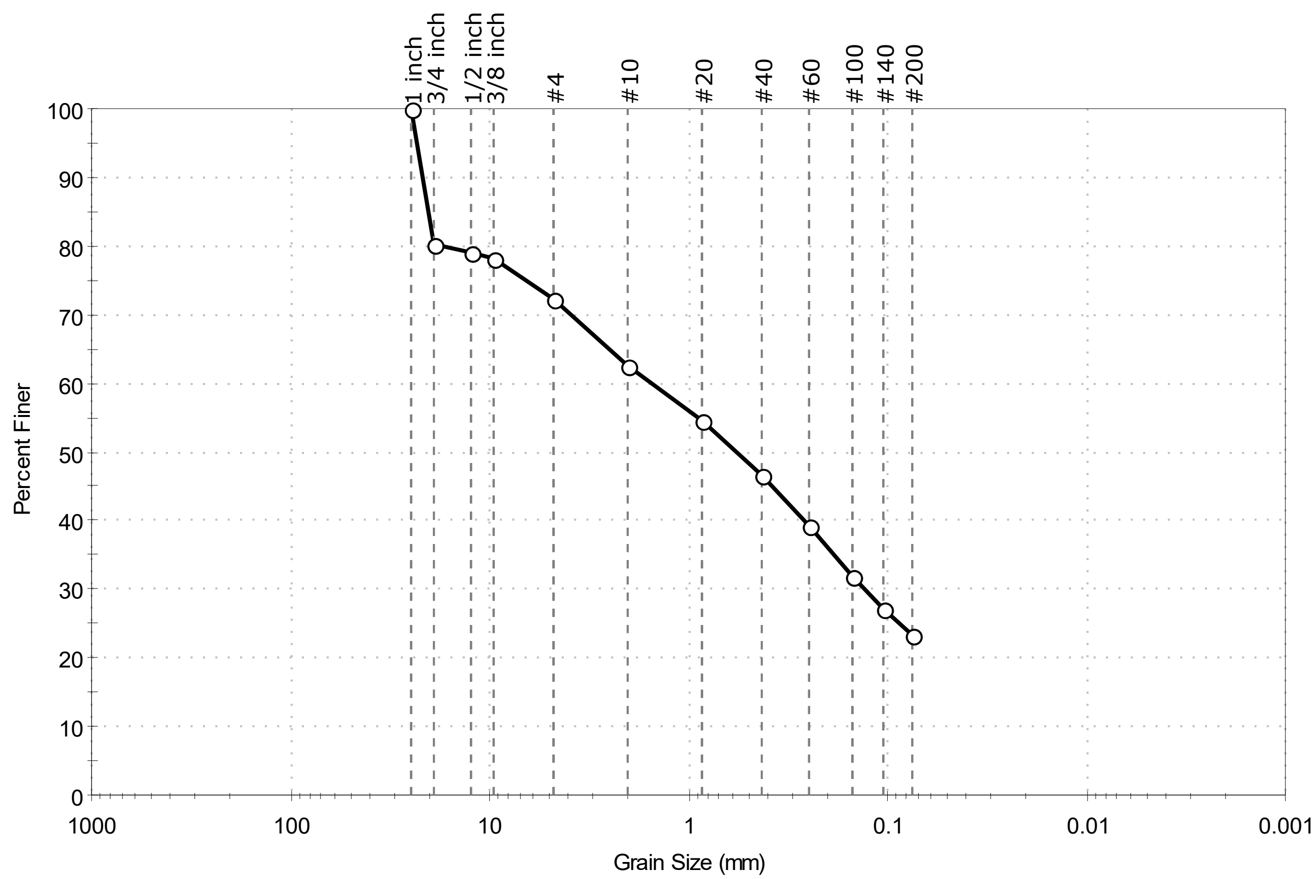
printed 5/2/2023 11:50:44 AM

Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119

Boring ID:	BB-BWCS-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-12	Test Date:	05/01/23	Checked By:	ank
Depth :	60'-62'	Test Id:	713509		

Test Comment: ---
Visual Description: Moist, dark gray silty sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	27.7	48.9	23.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 inch	25.00	100		
3/4 inch	19.00	80		
1/2 inch	12.50	79		
3/8 inch	9.50	78		
#4	4.75	72		
#10	2.00	63		
#20	0.85	55		
#40	0.42	47		
#60	0.25	39		
#100	0.15	32		
#140	0.11	27		
#200	0.075	23		

Coefficients

D_{85} =20.2834 mm D_{30} =0.1315 mm
D_{60} =1.5127 mm D_{15} =N/A
D_{50} =0.5665 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

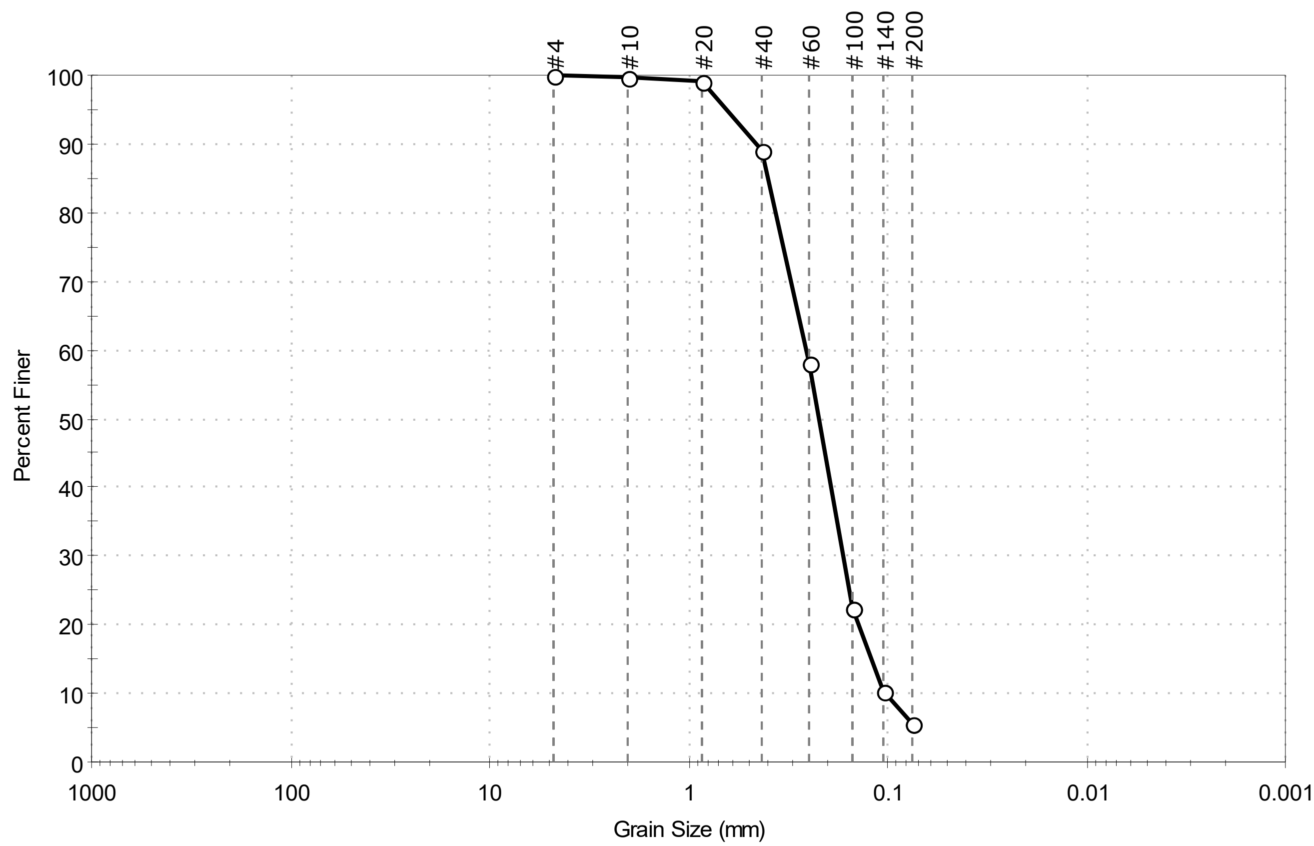
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

printed 5/2/2023 11:50:45 AM

Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119
Boring ID:	BB-BWCS-103	Sample Type: jar	Tested By: ckg
Sample ID:	S-3	Test Date: 05/01/23	Checked By: ank
Depth :	10'-12'	Test Id: 713510	
Test Comment:	---		
Visual Description:	Moist, gray sand with silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	94.5	5.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	89		
#60	0.25	58		
#100	0.15	22		
#140	0.11	10		
#200	0.075	5.5		

Coefficients

D_{85} =0.3968 mm D_{30} =0.1671 mm

D_{60} =0.2584 mm D_{15} =0.1209 mm

D_{50} =0.2226 mm D_{10} =0.1029 mm

C_u =2.511 C_c =1.050

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

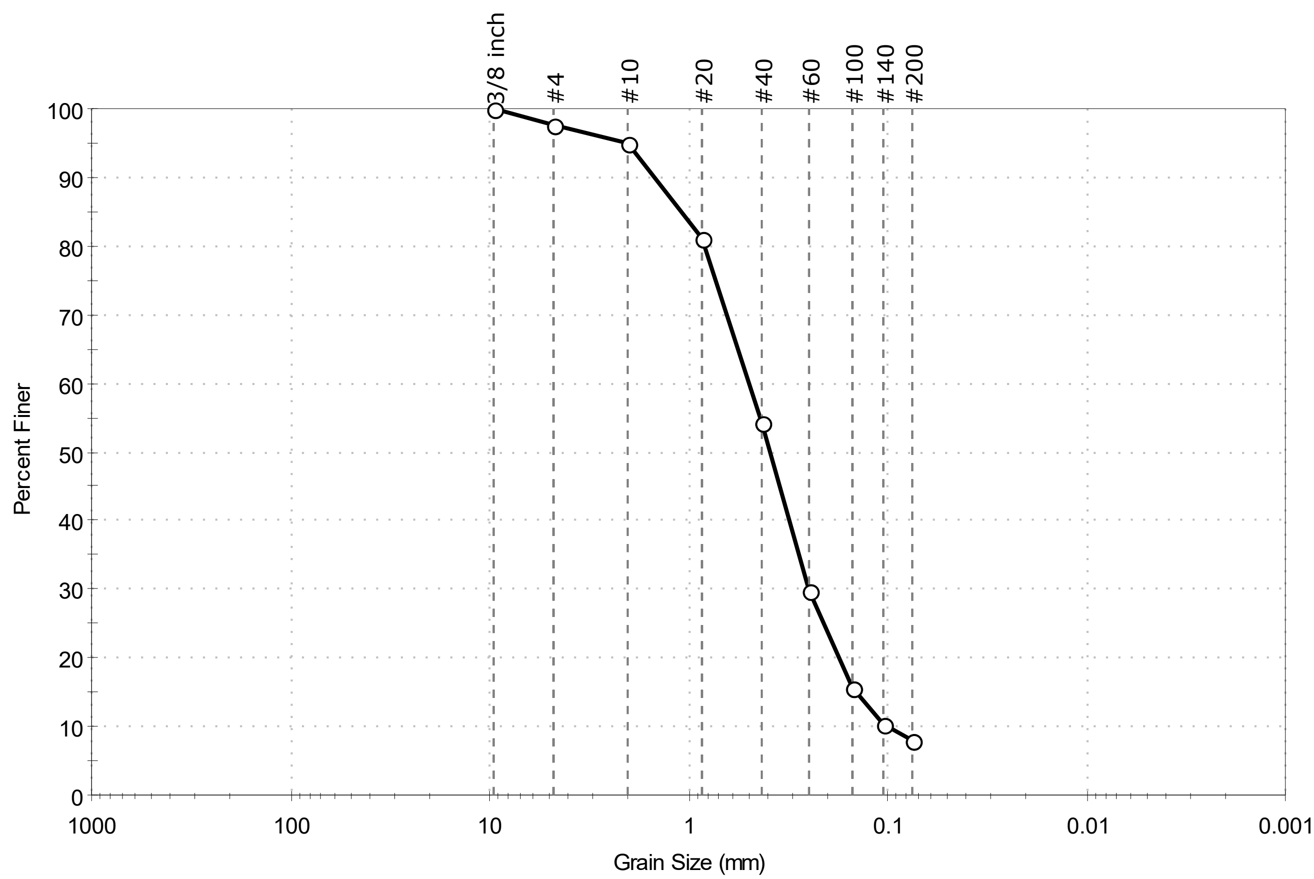
Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

printed 5/2/2023 11:50:46 AM

Client: WSP USA, Inc.			
Project: ME DOT Bowdoin W. Cathance Stream			
Location: Bowdoin, ME		Project No:	GTX-317119
Boring ID: BB-BWCS-103	Sample Type: jar	Tested By:	ckg
Sample ID: S-5	Test Date: 05/01/23	Checked By:	ank
Depth : 20'-22'	Test Id: 713511		
Test Comment: ---			
Visual Description: Moist, light olive brown sand with silt			
Sample Comment: ---			

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	2.3	89.9	7.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/8 inch	9.50	100		
#4	4.75	98		
#10	2.00	95		
#20	0.85	81		
#40	0.42	54		
#60	0.25	30		
#100	0.15	16		
#140	0.11	10		
#200	0.075	7.8		

Coefficients

D_{85} =1.0769 mm D_{30} =0.2517 mm

D_{60} =0.4932 mm D_{15} =0.1433 mm

D_{50} =0.3880 mm D_{10} =0.1002 mm

C_u =4.922 C_c =1.282

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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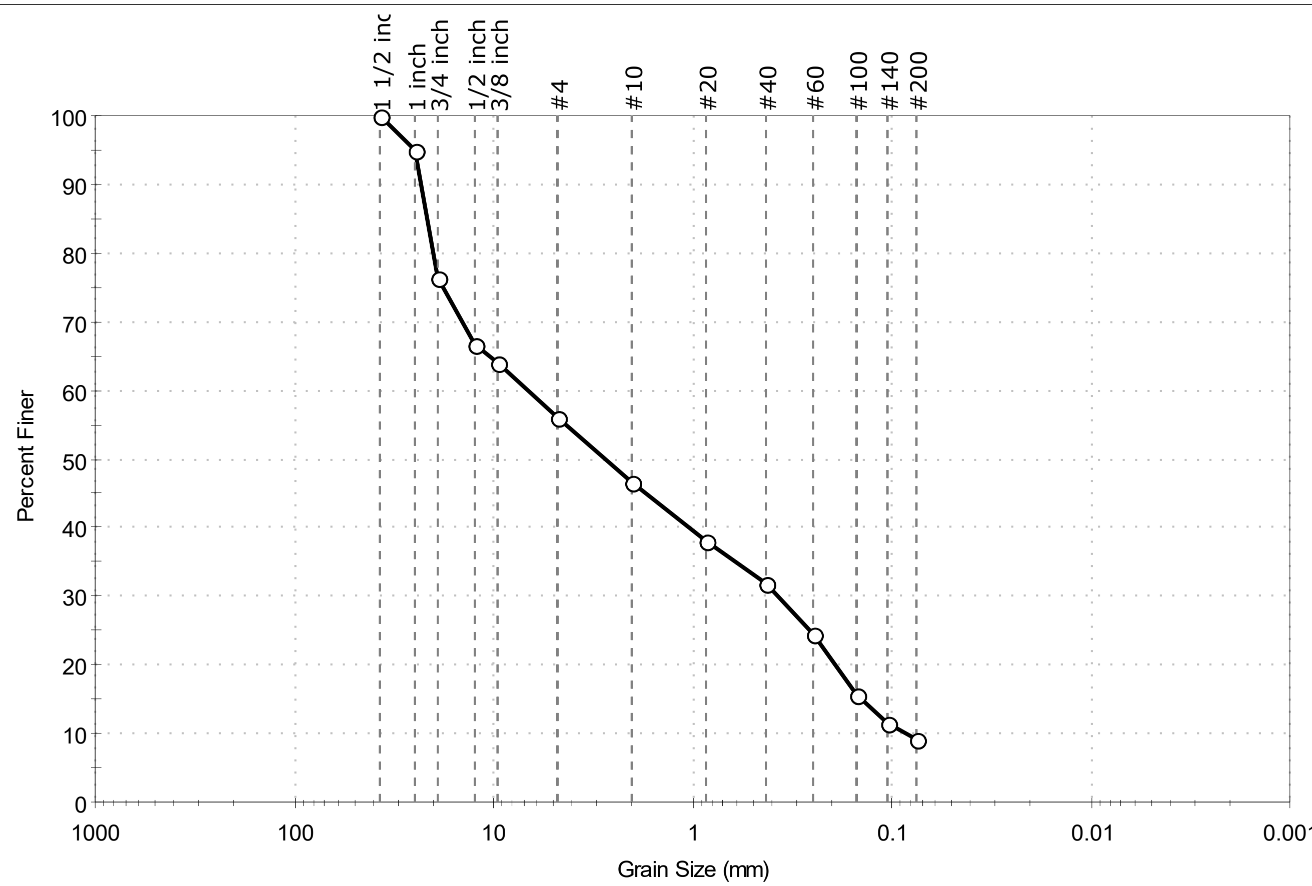
Client:	WSP USA, Inc.				
Project:	ME DOT Bowdoin W. Cathance Stream				
Location:	Bowdoin, ME			Project No:	GTX-317119
Boring ID:	BB-BWCS-103	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-8	Test Date:	05/01/23	Checked By:	ank
Depth :	35'-37'	Test Id:	713512		
Test Comment:	---				
Visual Description:	Moist, olive brown sand with silt and gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	44.0	47.0	9.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 1/2 inch	37.50	100		
1 inch	25.00	95		
3/4 inch	19.00	76		
1/2 inch	12.50	67		
3/8 inch	9.50	64		
#4	4.75	56		
#10	2.00	47		
#20	0.85	38		
#40	0.42	32		
#60	0.25	24		
#100	0.15	16		
#140	0.11	12		
#200	0.075	9.0		

Coefficients

D_{85} =21.5937 mm
D_{30} =0.3740 mm
D_{60} =6.7418 mm
D_{15} =0.1424 mm
D_{50} =2.7354 mm
D_{10} =0.0855 mm
C_u =78.851
C_c =0.243

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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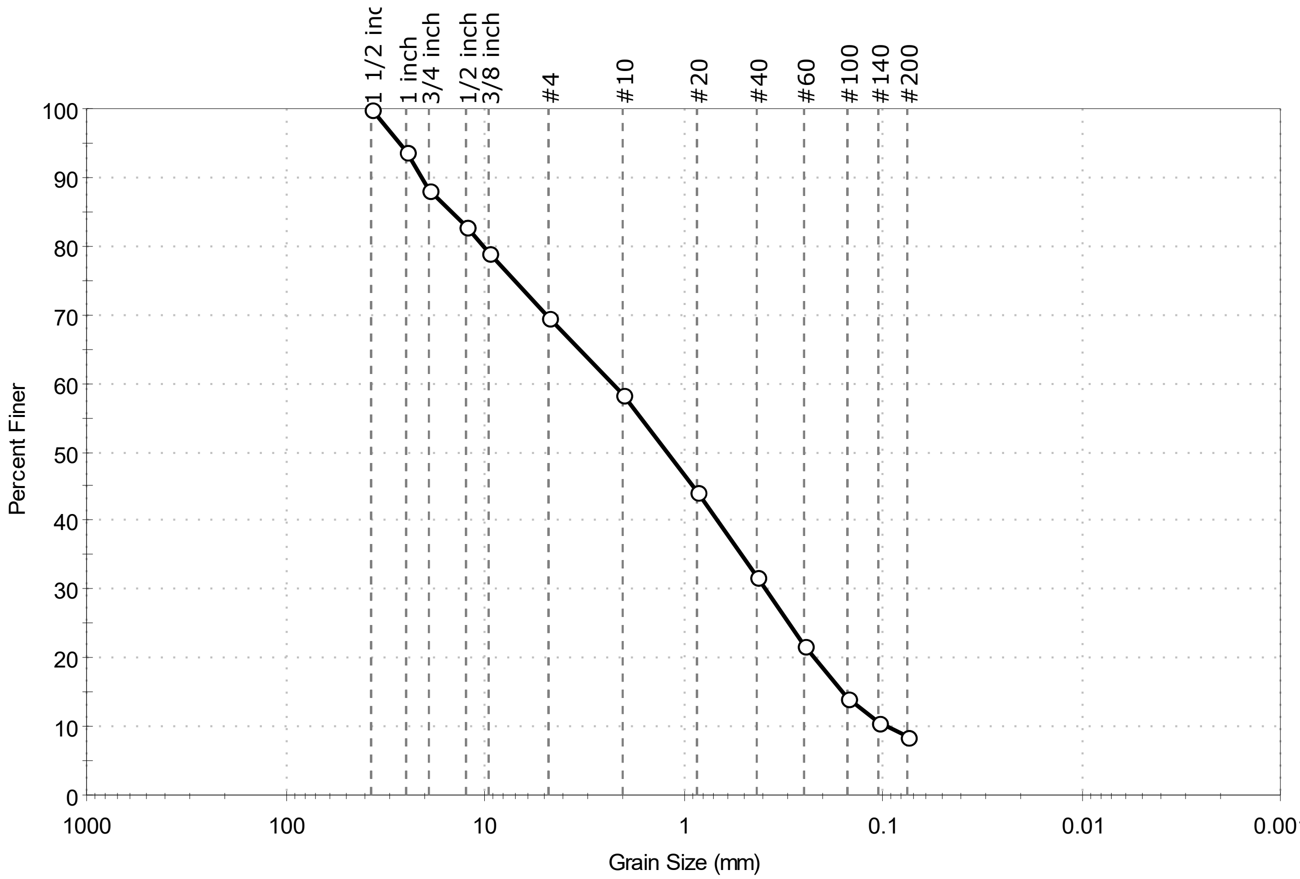
Client:	WSP USA, Inc.		
Project:	ME DOT Bowdoin W. Cathance Stream		
Location:	Bowdoin, ME	Project No:	GTX-317119
Boring ID: BB-BWCS-103	Sample Type: jar	Tested By:	ckg
Sample ID: S-10	Test Date: 05/01/23	Checked By:	ank
Depth : 42'-44'	Test Id: 713513		

Test Comment: ---
Visual Description: Moist, olive brown sand with silt and gravel
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	30.3	61.2	8.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 1/2 inch	37.50	100		
1 inch	25.00	94		
3/4 inch	19.00	88		
1/2 inch	12.50	83		
3/8 inch	9.50	79		
#4	4.75	70		
#10	2.00	58		
#20	0.85	44		
#40	0.42	32		
#60	0.25	22		
#100	0.15	14		
#140	0.11	11		
#200	0.075	8.5		

Coefficients

D_{85} =14.6420 mm D_{30} =0.3848 mm
D_{60} =2.2533 mm D_{15} =0.1585 mm
D_{50} =1.1987 mm D_{10} =0.0964 mm
C_u =23.374 C_c =0.682

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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Client: WSP USA, Inc.			
Project: ME DOT Bowdoin W. Cathance Stream			
Location: Bowdoin, ME		Project No:	GTX-317119
Boring ID: BB-BWCS-101	Sample Type: jar	Tested By:	cam
Sample ID: S-2	Test Date: 05/02/23	Checked By:	ank
Depth : 5'-7'	Test Id: 713499		

Test Comment: ---

Visual Description: Moist, very dark brown silty sand

Sample Comment: ---

Atterberg Limits - ASTM D4318

Sample Determined to be non-plastic

Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-2	-BWCS-1	5'-7'	36	n/a	n/a	n/a	n/a	

Dry Strength: LOW

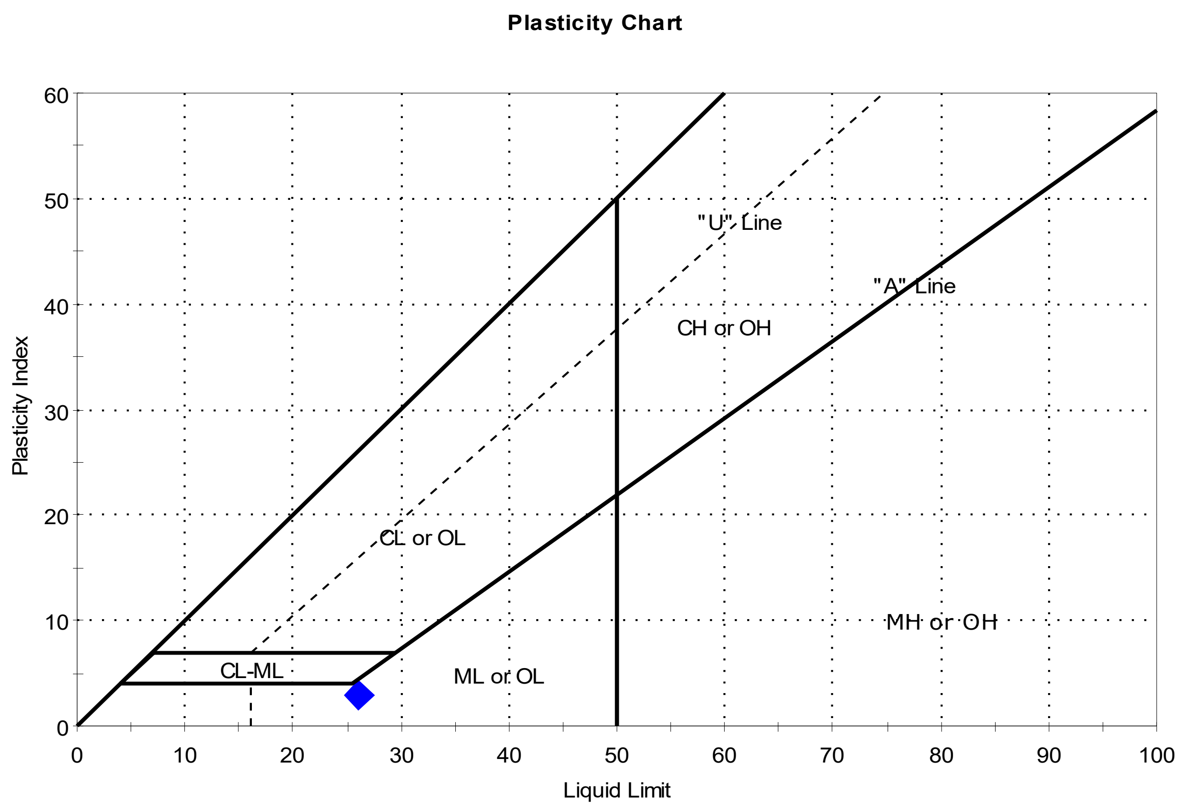
Dilatancy: RAPID

Toughness: n/a

The sample was determined to be Non-Plastic

Client:	WSP USA, Inc.				
Project:	ME DOT Bowdoin W. Cathance Stream				
Location:	Bowdoin, ME			Project No:	GTX-317119
Boring ID:	BB-BWCS-103	Sample Type:	jar	Tested By:	cam
Sample ID:	S-2	Test Date:	04/28/23	Checked By:	ank
Depth :	5'-7'	Test Id:	713500		
Test Comment:	---				
Visual Description:	Wet, dark grayish brown silty sand				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-2	-BWCS-1	5'-7'	36	26	23	3	4.2	

Sample Prepared using the WET method

Dry Strength: MEDIUM
Dilatancy: SLOW
Toughness: LOW

APPENDIX D

Calculations

CALCULATIONS

Date:	10/18/2023	**Made by:**	LMP
Project No.:	US0047101.4297	**Checked by:**	DEB
Subject:	Lateral Earth Pressure	**Reviewed by:**	CCB
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

OBJECTIVE

Determine lateral earth pressure acting on the proposed culvert wingwalls.

REFERENCES

1. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed. Cengage Learning, Stamford, CT.

2. WSP geotechnical test boring logs (Appendix A, Geotechnical Design Report).

3. Maine Department of Transportation Bridge Design Manual, dated August 2003 with 2018 updates.

ASSUMPTIONS

1. The backfill surface behind the wingwalls is assumed to be horizontal.

2. The design friction angles for the in-situ soil layers are based on correlation (Reference 1, Equation 18.15) to the average N60-values encountered in all borings for each layer (Reference 2). The design friction angle for the Fill material is based on the standard MaineDOT practice (Reference 3). The design friction angles are:

ϕ_{Fill} = 32 degrees
$\phi_{Alluvium}$ = 29 degrees
$\Psi_{Glaciomarine}$ = 36 degrees
$\phi_{Glacial\ Till}$ = 42 degrees

3. The design friction angles for the proposed fill construction materials (Reference 3), based on MaineDOT standard practice, are:

$\phi_{Granular\ Borrow}$ = 32 degrees
$\phi_{Gravel\ Borrow}$ = 36 degrees

CALCULATION

1. Calculate the at-rest lateral earth pressure coefficient.

$$K_o = 1 - \sin\phi$$ (Ref. 1, Eqn. 13.5)

where:
ϕ = internal friction angle of soil

K_0 =		
	0.47	Existing Fill
	0.52	Alluvium - In Situ
	0.41	Glaciomarine - In Situ
	0.33	Gracial Till - In Situ
	0.47	Granular Borrow - Fill
	0.41	Gravel Borrow - Fill

Date:	10/18/2023	**Made by:**	LMP
Project No.:	US0047101.4297	**Checked by:**	DEB
Subject:	Lateral Earth Pressure	**Reviewed by:**	CCB
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

2. Calculate the full active and full passive earth pressure coefficients using Rankine theory.

$$K_a = \tan^2\left(45° - \frac{\phi}{2}\right)$$ (Ref. 1, Eqn. 13.19)

$$K_p = \tan^2\left(45° + \frac{\phi}{2}\right)$$ (Ref. 1, Eqn. 13.22)

for horizontal backfill surface, where:
ϕ = internal friction angle of soil

K_a =	0.31	Existing Fill
	0.35	Alluvium - In Situ
	0.26	Glaciomarine - In Situ
	0.20	Gracial Till - In Situ
	0.31	Granular Borrow - Fill
	0.26	Gravel Borrow - Fill
K_p =	3.25	Existing Fill
	2.88	Alluvium - In Situ
	3.85	Glaciomarine - In Situ
	5.04	Gracial Till - In Situ
	3.25	Granular Borrow - Fill
	3.85	Gravel Borrow - Fill

CONCLUSIONS

For a non-yielding, stiff structure like the box culvert and wingwall system proposed for this project, an at-rest lateral earth pressure coefficient of 0.52 is reccomended for design.

CALCULATIONS

Date:	4/9/2025	**Made by:**	AMR - ATM
Project No.:	US0047101.4297	**Checked by:**	ATM - KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed by:**	CCB - MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

OBJECTIVE

Calculate the bearing resistance of the proposed culvert for the strength limit state and the service limit state at a location where the interpreted groundwater table is highest relative to the footing embedment depth (31 feet north of Route 125 Station 103+54 along the proposed culvert centerline).

REFERENCES

1. WSP interpreted subsurface profile Sta. 103+54 (Figure 3, Geotechnical Design Report).
2. Soil/Rock Exploration Logs (Appendix A, Geotechnical Design Report).
3. WSP for State of Maine Department of Transportation. Bowdoin, Sagadahoc County, Lewis Bridge over West Cathance Stream, Main Street, Bridge No. 5396. Final PIC Plans, dated November 5, 2024.
4. AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.
5. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.

ASSUMPTIONS

1. The friction angle for each soil layer beneath the proposed culvert, based on correlation to the average of the N_{60}-values encountered in all borings for each layer (Reference 2) is:

$\phi_{Granular\ Backfill}$ = 32 degrees

$\phi_{GlacioMarine}$ = 36 degrees

$\phi_{Glacial\ Till}$ = 42 degrees

2. The proposed finish grade elevation and proposed culvert invert elevation at the location of analysis are (Reference 3, Sheet 6):

El. finish grade = 120.3 ft

El. proposed invert = 118.3 ft

3. Based on Reference 3, Sheet 6, the proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the culvert are estimated to be:

Proposed culvert bottom thickness = 1.3 ft

Excavation/fill thickness beneath culvert = 1.0 ft

4. The interpreted water table elevation, based on measurements taken during the subsurface exploration program and observed moisture content of the samples, is (Reference 1):

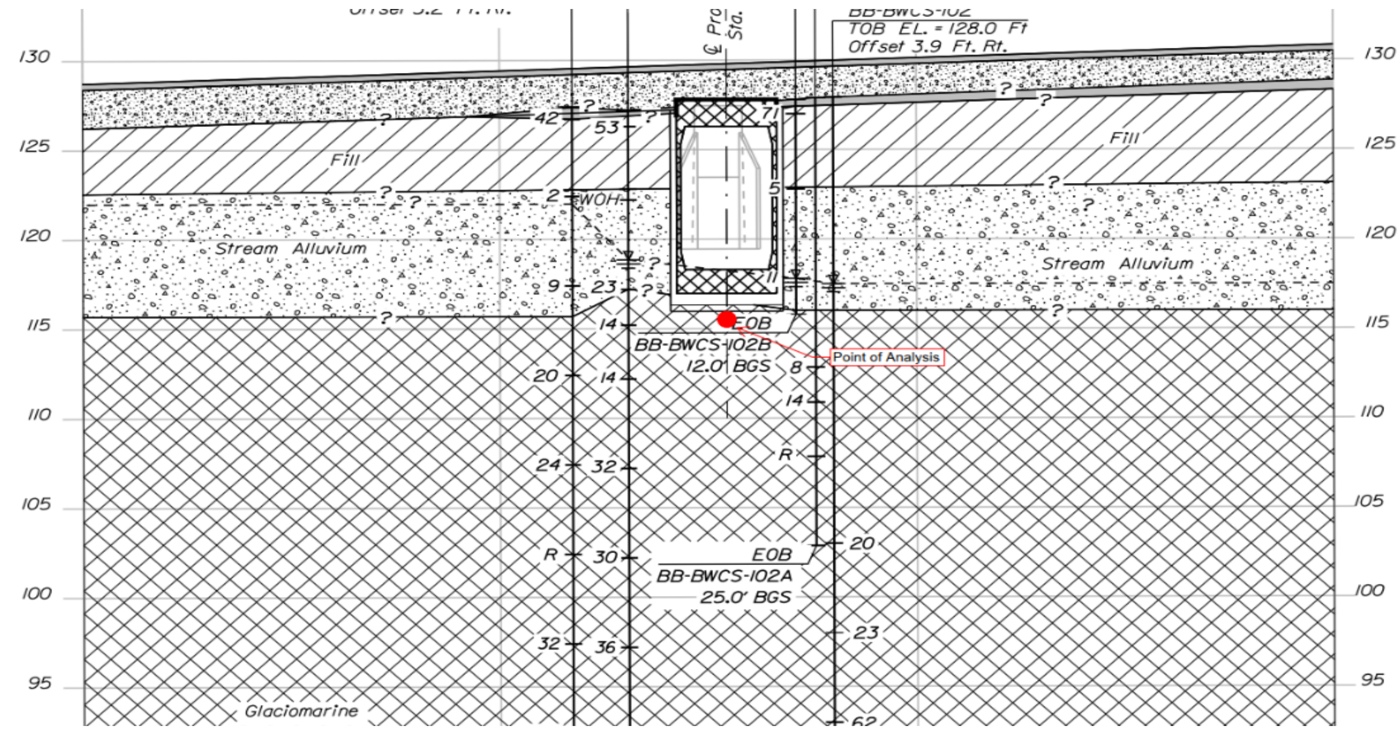
WL elev. = 122.0 ft

5. The material type for the proposed fill beneath the culvert is assumed to be granular backfill for structures (Ref. 3, Sheet 6) with an angle of internal friction of 32 degrees. However, because this layer is limited to 1.0 feet thick, bearing resistance is based on the glacio-marine soil below this layer.

6. This analysis is based on culvert dimensions of 24 feet by 5 feet. The proposed culvert will be installed in 5 foot long sections with ship lap style connections between the individual sections. This connection style will allow for deformations at the joints.

Date:	4/9/2025	**Made by:**	AMR - ATM
Project No.:	US0047101.4297	**Checked by:**	ATM - KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed by:**	CCB - MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

Location of Analysis:



(Reference 1)

Date:	4/9/2025	**Made by:**	AMR - ATM
Project No.:	US0047101.4297	**Checked by:**	ATM - KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed by:**	CCB - MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

CALCULATION

A. Determine the bearing resistance at the strength limit state. Use Article 10.6.3, Strength Limit Design, from the AASHTO LRFD Bridge Design Specifications.

Based on Reference 1, the proposed culvert invert will be founded within the glaciomarine layer.

1. Calculate the nominal bearing resistance.

$$q_n = cN_{cm} + \gamma_q D_f N_{qm} C_{wq} + 0.5\gamma_f B N_{\gamma m} C_{w\gamma}$$ (Ref. 4, Eqn. 10.6.3.1.2a-1)

where:

c = cohesion, ksf — c = 0 ksf

γ = total unit weight of soil, kcf — γ = 0.125 kcf
Since the same design unit weight is used for the soil above and below the bearing depth of the footing, $\gamma_q = \gamma_f$.

D_f = footing embedment depth, ft — D_f = 3.3 ft

$$N_{qm} = N_q s_q d_q i_q$$ (Ref. 4, Eqn. 10.6.3.1.2a-3) — N_{qm} = 43.6

N_q = surcharge factor — N_q = 37.8 (Table 10.6.3.1.2a-1)

$$s_q = 1 + \frac{B}{L}\tan\phi_f$$ (Ref. 4, Table 10.6.3.1.2a-3) — s_q = 1.2

B = footing width, ft — B = 5 ft Assumption 6

L = footing length, ft — L = 24 ft (Ref. 3, Sheet 6)

$$d_q = 1 + 2\tan\phi_f(1 - \sin\phi_f)^2 \arctan\left(\frac{D_f}{B}\right)$$ d_q = 1.0 (Eqn. 10.6.3.1.2a-10)

i_q = load inclination factor (neglected as per Ref. 4, Article C10.6.3.1.2a)

Since in Reference 4 C_{wq} and $C_{w\gamma}$ are determined based on D_w using Table 10.6.3.1.2a-2, which does not contain the value of D_w determined in this analysis, the equations in Reference 5 will be used instead.

$$C_{wq} = 0.5 + 0.5\left(\frac{D_w}{D_f}\right) \leq 1.0$$ (Ref. 5, Eqn. 5-10) — C_{wq} = 0.50

D_w = groundwater depth, ft — D_w = 0.0 ft

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$$ (Ref. 4, Eqn. 10.6.3.1.2a-4) — $N_{\gamma m}$ = 51.6

N_γ = unit weight factor — N_γ = 56.3 (Table 10.6.3.1.2a-1)

$$s_\gamma = 1 - 0.4\frac{B}{L}$$ (Ref. 4, Table 10.6.3.1.2a-3) — s_γ = 0.92

i_γ = load inclination factor (neglected as per Ref. 4, Article C10.6.3.1.2a)

$$C_{w\gamma} = 0.5 + 0.5\left(\frac{D_w}{1.5B_f + D_f}\right) \leq 1.0$$ (Ref. 5, Eqn. 5-9) — $C_{w\gamma}$ = 0.50

q_n = 17.1 ksf

Date:	4/9/2025	**Made by:**	AMR - ATM
Project No.:	US0047101.4297	**Checked by:**	ATM - KAR
Subject:	Bearing Resistance at Proposed Culvert	**Reviewed by:**	CCB - MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

2. Apply resistance factor.

$q_R = \varphi_b q_n$ (Ref. 4, Eqn. 10.6.3.1.1-1)

φ_b = resistance factor specified in LRFD 10.5.5.2.2 φ_b = 0.45 (Table 10.5.5.2.2-1)

Semi-empirical methods, all soils

q_R = 7.7 ksf

B. Determine the bearing resistance at the service limit state.
Use AASHTO LRFD (Ref. 4) Table C10.6.2.5.1-1 to determine the presumptive bearing resistance at the service limit state.

Type of Bearing Material:	Coarse to medium sand, and with little gravel (SW, SP)	Coarse to medium sand, and with little gravel (SW, SP)
Consistency in Place:	Medium dense to dense	Very dense
Bearing Resistance Recommended Value of Use:	6 ksf	8 ksf

Note: This bearing resistance is settlement limited (1 inch) and applies only at the service limit state.

Resistance factor for the service limit state = 1.0 (Ref 4 Article 10.5.5.1)

Factored bearing resistance = 6 ksf

CONCLUSIONS

For the proposed culvert, the recommended nominal bearing resistance is 17.1 ksf. A resistance factor of 0.45 is recommended for use at the strength limit state and a resistance factor of 1.0 is recommended for use at the service limit state. The factored bearing resistance for the strength limit state is estimated to be 7.7 ksf and the factored presumptive bearing resistance for the service limit state is estimated to be 6 ksf.

CALCULATIONS

Date:	10/31/2023	**Made by:**	DEB
Project No.:	US0047101.4297	**Checked by:**	AMR
Subject:	Modulus of Subgrade Reaction	**Reviewed by:**	CCB
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

OBJECTIVE

Determine the modulus of subgrade reaction in the glaciomarine fan deposit using two methods for comparrative purposes.

REFERENCES

1. Federal Highway Administration, 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.
2. Bridge Software Institute FB-MultiPier Soil Parameter Table (https://bsi.ce.ufl.edu/downloads/files/MultiPier_Soil_Table.pdf).
3. WSP geotechnical test boring logs (Appendix A, Geotechnical Design Report).

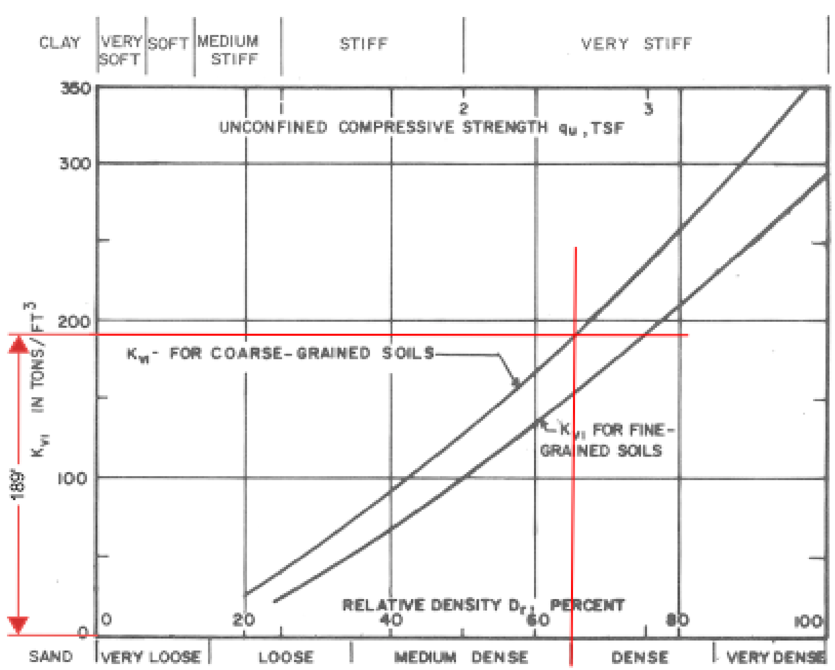
ASSUMPTIONS

1. The average design N_{60} value for the Glaciomarine Fan Deposit. N_{60} = 31
2. Density based on N_{60} value. Density = Dense

CALCULATION

1. Determine Modulus of Subgrade Reaction (Method 1).

Determine Modulus of Subgrade Reaction (K_{IV}) using Figure 8-3 below (Ref. 1). Based on WSP logs dense soil has N values ranging from 30 to 50. Based on the average N_{60} value of 31 in the Glaciomarine Fan Deposit, the beginning of the dense range, and the coarse grained soil curve are used to determine K_{VI}.



CALCULATIONS

Date:	10/31/2023	**Made by:**	DEB
Project No.:	US0047101.4297	**Checked by:**	AMR
Subject:	Modulus of Subgrade Reaction	**Reviewed by:**	CCB
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

DEFINITIONS

ΔH_i = IMMEDIATE SETTLEMENT OF FOOTING
q = FOOTING UNIT LOAD IN tsf
B = FOOTING WIDTH

D = DEPTH OF FOOTING BELOW GROUND SURFACE
K_{vi} = MODULUS OF VERTICAL SUBGRADE REACTION

COARSE-GRAINED SOILS

(MODULUS OF ELASTICITY INCREASING LINEARLY WITH DEPTH)
SHALLOW FOOTINGS $D \leq B$
FOR $B \leq 20$ FT:

$$\Delta H_i = \frac{4 q B^2}{K_{vi}(B+1)^2}$$

FOR $B \geq 40$ FT:

$$\Delta H_i = \frac{2 q B^2}{K_{vi}(B+1)^2}$$

INTERPOLATE FOR INTERMEDIATE VALUES OF B

DEEP FOUNDATION $D \geq 5B$
FOR $B \leq 20$ FT:

$$\Delta H_i = \frac{2 q B^2}{K_{vi}(B+1)^2}$$

NOTES: 1. NONPLASTIC SILT IS ANALYZED AS COARSE-GRAINED SOIL WITH MODULUS OF ELASTICITY INCREASING LINEARLY WITH DEPTH.
2. VALUES OF K_{vi} SHOWN FOR COARSE-GRAINED SOILS APPLY TO DRY OR MOIST MATERIAL WITH THE GROUNDWATER LEVEL AT A DEPTH OF AT LEAST 1.5B BELOW BASE OF FOOTING. IF GROUNDWATER IS AT BASE OF FOOTING, USE $K_{vi}/2$ IN COMPUTING SETTLEMENT

$K_{IV=}$ 189 Tons/ft^3 $K_{IV=}$ 219 pci

2. Determine Modulus of Subgrade Reaction (Method 2).

Determine Modulus of Subgrade Reaction (K) using FB-Multipier Soil Parameter Table (Ref. 2), using the average N_{60} value of 31 in the Glaciomarine Fan Deposit. Subgrade Modulus was determined for the below water table condition.

Cohesionless Soil

Soil properties for preliminary design only.

Cohesionless Soil Properties	Symbol	Units	Loose		Medium		Dense	
Total Unit Weight	γ	pcf	90	115	110	130	110	140
Corrected SPT Blow Count	N_{60}		4	10	10	30	30	50
Relative Density	D_r	%	15	35	35	65	65	85
Angle of Internal Friction	ϕ	deg	29	30	30	36	36	41
Coefficient of Lateral Earth Pressure (From Eqn. (1) using ϕ)	K_0		0.51	0.5	0.5	0.41	0.41	0.34
Subgrade Modulus (Below Water Table)	k_{bw}	pci	20	30	30	100	100	160

$K_{bw=}$ 89 Tons/ft^3 $K_{bw=}$ 103 pci

CONCLUSIONS

The modulus of subgrade reaction (K) has been determined using two methods based on using the average N_{60} value within the Glaciomarine Fan Deposit. The lower value of K =103 pci determined is recommended.

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

OBJECTIVE

Calculate the immediate settlement beneath the edge of the proposed culvert at a location where the proposed embankment is thickest (18 feet north of Station 103+50 along the proposed culvert centerline).

REFERENCES

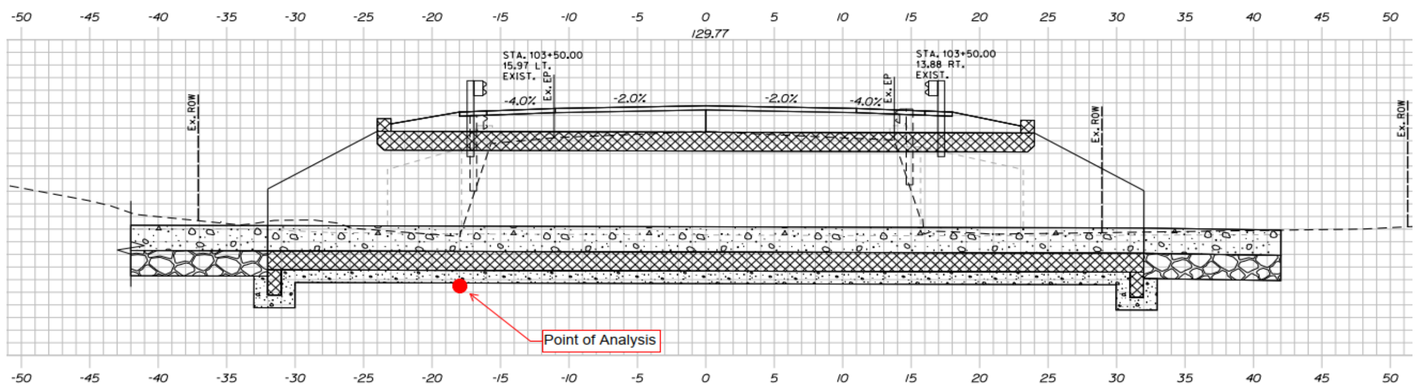
1. WSP interpreted subsurface profile A-A' (Figure 3, Geotechnical Design Report).
2. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed. Cengage Learning, Stamford, CT.
3. WSP for State of Maine Department of Transportation. Bowdoin, Sagadahoc County, Lewis Bridge over West Cathance Stream, Main Street, Bridge No. 5396. Final PIC Plans, dated November 5, 2024.
4. Holtz, R.D. and Kovacs, W.D. 1981. An Introduction to Geotechnical Engineering, 1st ed. Prentice Hall, Englewood Cliffs, NJ.
5. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.
6. Maine Department of Transportation Bridge Design Manual, dated August 2003 with 2018 updates.

ASSUMPTIONS

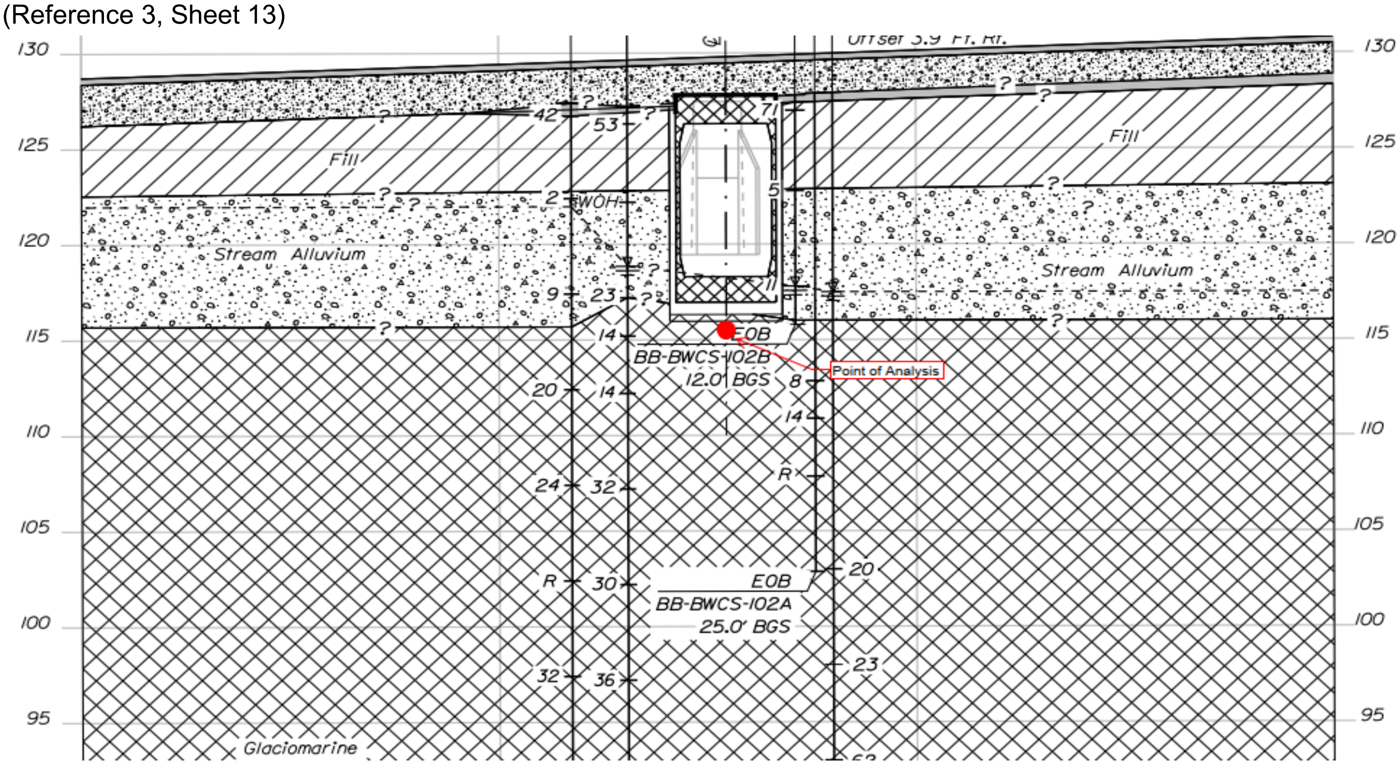
Assumption	Parameter	Value	Unit
1. The existing stratigraphy and water table surface are estimated from samples and groundwater measurements encountered during drilling and interpreted in Reference 1.	GS EL =	119.4	ft
	WL EL =	122.0	ft
2. N_{60}-values for the soil layers, based on correlation (Reference 2, Equation 18.5) to the design friction angles determined for each layer, are:	$N_{60,Fill}$ =	42	
	$N_{60,Alluvium}$ =	4	
	$N_{60,Glaciomarine}$ =	31	
	$N_{60,Glacial\ Till}$ =	75	
3. The proposed road grade elevation and proposed culvert invert elevation at the location of analysis are (Reference 3, Sheet 6):	Road EL =	129.3	ft
	Proposed invert EL =	118.3	ft
4. Based on Reference 3, Sheet 6, the proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the culvert are estimated to be:	Proposed culvert wall thickness =	1.3	ft
	Excavation/fill thickn. beneath culvert =	1	ft
5. Based on Reference 3, Sheet 6, the culvert interior will be filled with Stream Channel Rock and Special Fill with a thickness of:	Stone fill thickness =	2.7	ft
6. The unit weight for the proposed fill construction material (Reference 6), based on MaineDOT standard practice, are:	Unit weight - Granular Borrow =	125	pcf
7. The stream elevation within the culvert is assumed to be the groundwater elevation measured at Boring BB-BWCS-102A.	Stream EL above Stream Channel Fill =	122.0	ft
8.The stress will be uniformly distributed over the culvert box length. Localized stress concentration is not considered for the analysis.			

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

Location of Analysis:



(Reference 3, Sheet 13)



(Reference 1)

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

CALCULATION

A. Determine the change in effective stress state within the soil beneath the proposed culvert to identify if settlement or heave will occur. Calculate the vertical stress change beneath the proposed culvert due to culvert construction.

The change in effective stress state due to change in stratigraphy is determined at the lower limit of structure excavation at the location of analysis along the culvert centerline: elevation 116.0 ft (culvert invert EL 118.3 ft minus culvert base thickness 1.3 ft and excavation/fill thickness 1.0 ft). Based on Reference 1, the excavation limit will be founded within the glaciomarine fan layer.

Load from proposed culvert concrete, per linear foot:

	Width (ft)	Height (ft)	Area (ft^2)	Unit weight of concrete (pcf)	Weight per linear foot of culvert (lb/ft)	Distributed weight per linear foot (psf)
External dimensions	24.0	10.8	259.2			
Internal dimensions (Ref. 3, Sheet 4)	22	8	176.0			
Taper	1	1	2			
		Culvert concrete:	85.2	150	12780.0	532.5

Existing Conditions:

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vert. Stress Contribution of Layer (psf)	Vert. Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Alluvium	115	119.4	116.6	2.8	322	147
Glaciomarine	125	116.6	116.0	0.6	81	41

After Construction:

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vert. Stress Contribution of Layer (psf)	Vert. Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Agg. Subbase	135	129.3	127.8	1.5	203	203
Culvert	N/A	127.8	117.0	10.8	533	533
Stream (inside)	62.4	122.0	120.9	1.1	69	69
Stream Channel Rock and Special Fill (inside)	140	120.9	118.3	2.7	371	206
Granular Borrow Backfill	125	117.0	116.0	1.0	125	63

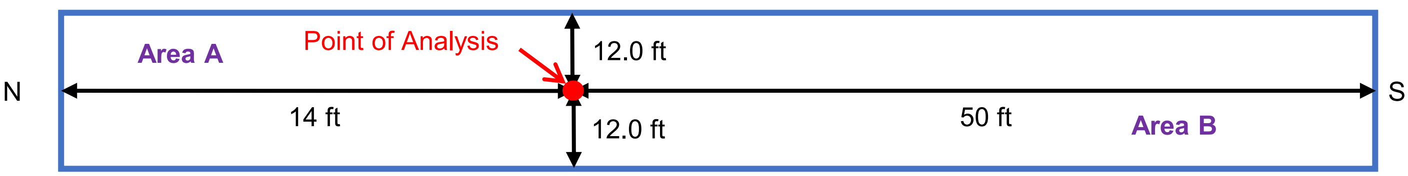
Calculate the increase or decrease in effective stress as a result of construction.

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

	σv at Elev. 116 ft (psf)	σ'v at Elev. 116 ft (psf)	Δσ'v at Elev. 116ft (psf)	Result
Existing conditions	403	188	884	Settlement
After construction	1300	1072		

Subdivide the subsurface soils into layers no larger than 10 ft thick and to a depth of either twice the footing width or to bedrock. Calculate the vertical stress increase at each layer, assuming the Boussinesq stress distribution method for stress under the corner of a rectangular load.

Assumed Loading (plan view):



$$\sigma_z = q_0 \times I$$ Reference 4, Eqn. 8-30

$$m = x/z$$ Reference 4, Figure 8.21

$$n = y/z$$ Reference 4, Figure 8.21

where:

	Area A	Area B		
σ_z = half of the vertical stress increase, psf	(each half of the culvert width is calculated separately for each area)			
q_0 = net stress applied by culvert	884		psf	(Part A)
x = half of the width of the loading area, ft	12.0	12.0	ft	(Ref. 3, Sheet 4)
y = length of the loading area, ft	14	50	ft	(Ref. 1)
z = depth to midpoint of layer, ft	(z_{max} = twice the footing width = 48 ft)			

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

Area A:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Glaciomarine	1	0-10	10.0	5.0	2.4	2.8	0.240	424
Glaciomarine	2	10-20	10.0	15.0	0.8	0.9	0.163	288
Glaciomarine	3	20-30	10.0	25.0	0.5	0.6	0.097	171
Glaciomarine	4	30-40	10.0	35.0	0.3	0.4	0.048	85
Glaciomarine	5	40-43.1	3.1	41.6	0.3	0.3	0.038	67
Glacial Till	6	43.1-48	4.9	45.6	0.3	0.3	0.038	67

Area B:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Glaciomarine	1	0-10	10.0	5.0	2.4	10.0	0.242	428
Glaciomarine	2	10-20	10.0	15.0	0.8	3.3	0.183	324
Glaciomarine	3	20-30	10.0	25.0	0.5	2.0	0.136	240
Glaciomarine	4	30-40	10.0	35.0	0.3	1.4	0.086	152
Glaciomarine	5	40-43.1	3.1	41.6	0.3	1.2	0.083	147
Glacial Till	6	43.1-48	4.9	45.6	0.3	1.1	0.082	145

Area A + Area B:

Layer		Depth below lower limit of excavation (ft)	Stress Increase σ_z (psf)
Glaciomarine	1	0-10	852
Glaciomarine	2	10-20	612
Glaciomarine	3	20-30	412
Glaciomarine	4	30-40	237
Glaciomarine	5	40-43.1	214
Glacial Till	6	43.1-48	212

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

B. Use the Hough method to estimate settlement of the soil layers beneath the proposed culvert.

1 Determine σ'_{v0} and C' at layer midpoints for in situ existing soil. Use Ref. 5 Figures 5-18 and 5-19 to obtain corrected N' and C' for Layers 1 to 6, assuming the Glaciomarine and glacial till are "Well graded silty SAND & GRAVEL ".

Stress due to existing soil above point of analysis (Part A)	σ'_{v0} (psf)
	188

Water unit weight (pcf)
62.4

Layer		Layer Thickness (ft)	Unit Weight of Layer (pcf)	σ'_{v0} at layer midpoint (psf)	σ'_{v0} at layer midpoint (kPa)	N_{60}	N'	C'
Glaciomarine	1	10.0	125	501	24.0	31	62	220
Glaciomarine	2	10.0	125	1127	53.9	31	41	135
Glaciomarine	3	10.0	125	1753	83.9	31	33	110
Glaciomarine	4	10.0	125	2379	113.9	31	28	98
Glaciomarine	5	3.1	125	2789	133.5	31	26	93
Glacial Till	6	4.9	135	3064	146.7	75	61	219

2 Calculate the total settlement of the sand/silty sand till and the silt till (Layers 1 to 3) using the Hough method:

General Equation (Ref. 5, Eqn 5-24)

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}\right)$$

where:

ΔH_i	settlement in each layer, ft
H_c	initial height of layer i, ft
C'	bearing capacity index from Ref. 5, Figure 5-19
$\Delta\sigma_v$	vertical stress increase, ksf

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

ΔH_i (Layer 1)	ft	0.020
	in	0.24

ΔH_i (Layer 2)	ft	0.014
	in	0.17

ΔH_i (Layer 3)	ft	0.008
	in	0.10

ΔH_i (Layer 4)	ft	0.004
	in	0.05

ΔH_i (Layer 5)	ft	0.001
	in	0.01

ΔH_i (Layer 6)	ft	0.001
	in	0.01

	Settlement Based on Calc. Loading Stress
Layer	ΔH_i (in)
1	0.24
2	0.17
3	0.10
4	0.05
5	0.01
6	0.01
Total Settlement (in)	0.58

CONCLUSIONS

The immediate settlement beneath the proposed culvert after construction is estimated to be less than one inch. Since clay soil was not encountered beneath the proposed culvert location, consolidation settlement is not expected.

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

OBJECTIVE

Calculate the immediate settlement beneath the center of the proposed culvert after construction, at a location where the proposed embankment is thickest (Station 103+50 along the proposed culvert centerline).

REFERENCES

1. WSP interpreted subsurface profile A-A' (Figure 3, Geotechnical Design Report).
2. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed. Cengage Learning, Stamford, CT.
3. WSP for State of Maine Department of Transportation. Bowdoin, Sagadahoc County, Lewis Bridge over West Cathance Stream, Main Street, Bridge No. 5396. Final PIC Plans, dated November 5, 2024.
4. Holtz, R.D. and Kovacs, W.D. 1981. An Introduction to Geotechnical Engineering, 1st ed. Prentice Hall, Englewood Cliffs, NJ.
5. FHWA. 2002. Geotechnical Engineering Circular No. 6: Shallow Foundations. Report No. FHWA-SA-02-054.
6. Maine Department of Transportation Bridge Design Manual, dated August 2003 with 2018 updates.

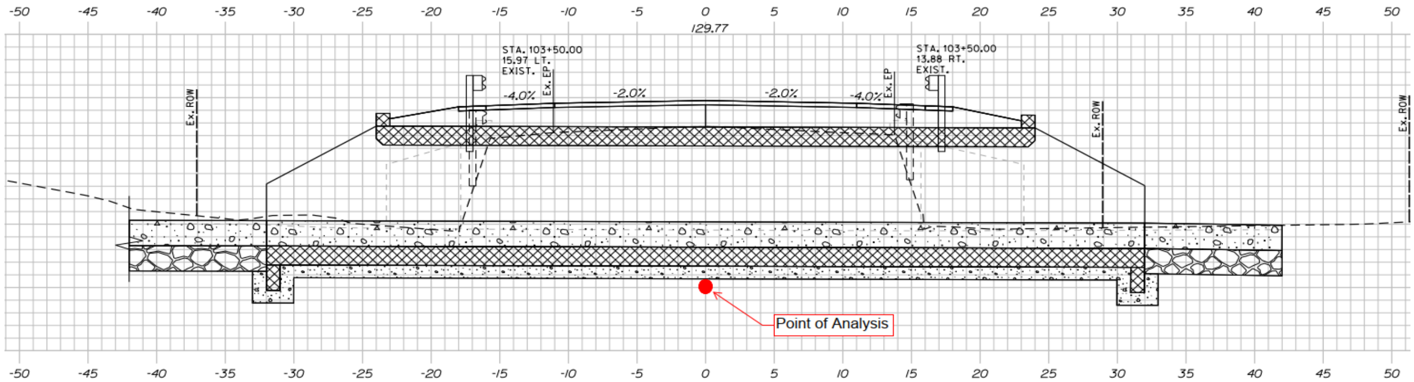
ASSUMPTIONS

1. The existing stratigraphy and water table surface are estimated from samples and groundwater measurements encountered during drilling and interpreted in Reference 1.	GS EL =	127.7	ft
	WL EL =	122.0	ft
2. N_{60}-values for the soil layers, based on correlation (Reference 2, Equation 18.5) to the design friction angles determined for each layer, are:	$N_{60,Fill}$ =	42	
	$N_{60,Alluvium}$ =	4	
	$N_{60,Glaciomarine}$ =	31	
	$N_{60,Glacial\ Till}$ =	75	
3. The proposed road grade elevation and proposed culvert invert elevation at the location of analysis are (Reference 3, Sheet 6):	Road EL =	129.8	ft
	Proposed invert EL =	118.2	ft
4. Based on Reference 3, Sheet 6, the proposed culvert wall thickness and the proposed thickness of excavation/fill beneath the culvert are estimated to be:	Proposed culvert wall thickness =	1.3	ft
	Excavation/fill thickn. beneath culvert =	1	ft
5. Based on Reference 3, Sheet 6, the culvert interior will be filled with Stream Channel Rock and Special Fill with a thickness of:	Stone fill thickness =	2.7	ft
6. The unit weight for the proposed fill construction material (Reference 6), based on MaineDOT standard practice, are:	Unit weight - Granular Borrow =	125	pcf
7. The stream elevation within the culvert is assumed to be the groundwater elevation measured at Boring BB-BWCS-102A.	Stream EL above Stream Channel Fill =	122.0	ft
8.The stress will be uniformly distributed over the culvert box length. Localized stress concentration is not considered for the analysis.			

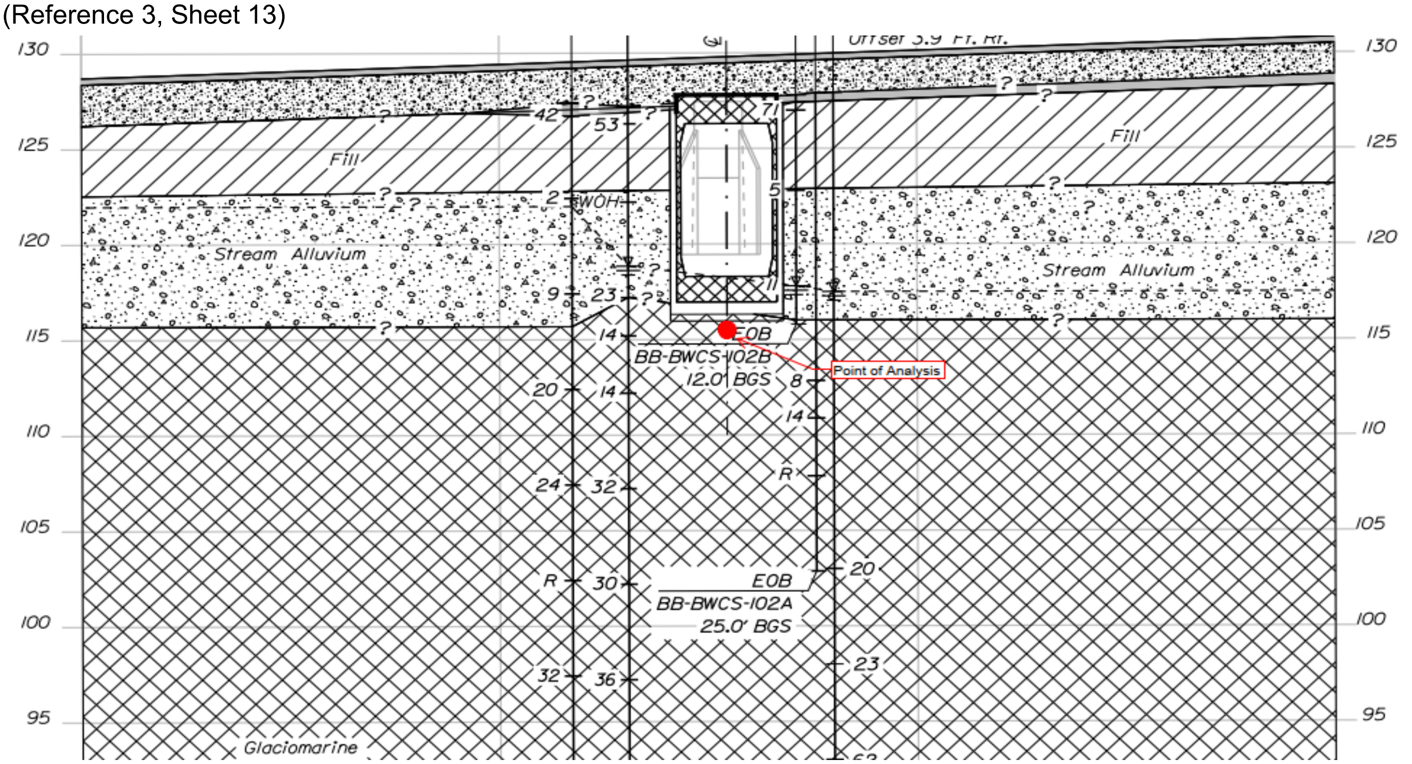
CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

Location of Analysis:



(Reference 3, Sheet 13)



(Reference 1)

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

CALCULATION

A. Determine the change in effective stress state within the soil beneath the proposed culvert to identify if settlement or heave will occur. Calculate the vertical stress change beneath the proposed culvert due to culvert construction.

The change in effective stress state due to change in stratigraphy is determined at the lower limit of structure excavation at the location of analysis along the culvert centerline: elevation 115.9 ft (culvert invert EL 118.2 ft minus culvert base thickness 1.3 ft and excavation/fill thickness 1.0 ft). Based on Reference 1, the excavation limit will be founded within the glaciomarine fan layer.

Load from proposed culvert concrete, per linear foot:

	Width (ft)	Height (ft)	Area (ft^2)	Unit weight of concrete (pcf)	Weight per linear foot of culvert (lb/ft)	Distributed weight per linear foot (psf)
External dimensions	24.0	10.8	259.2			
Internal dimensions (Ref. 3, Sheet 4)	22	8	176.0			
Taper	1	1	2			
		Culvert concrete:	85.2	150	12780.0	532.5

Existing Conditions:

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vert. Stress Contribution of Layer (psf)	Vert. Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Alluvium	115	127.7	116.6	11.1	1277	584
Glaciomarine	125	116.6	115.9	0.7	87	44

After Construction:

Layer	Unit weight (pcf)	Elevation (ft)		Thickness (ft)	Vert. Stress Contribution of Layer (psf)	Vert. Effective Stress Contribution of Layer (psf)
		Top	Bottom			
Agg. Subbase	135	129.8	127.7	2.1	279	279
Culvert	N/A	127.7	116.9	10.8	533	533
Stream (inside)	62.4	122.0	120.9	1.1	72	72
Stream Channel Rock and Special Fill (inside)	140	120.9	118.2	2.7	371	206
Granular Borrow Backfill	125	116.9	115.9	1.0	125	63

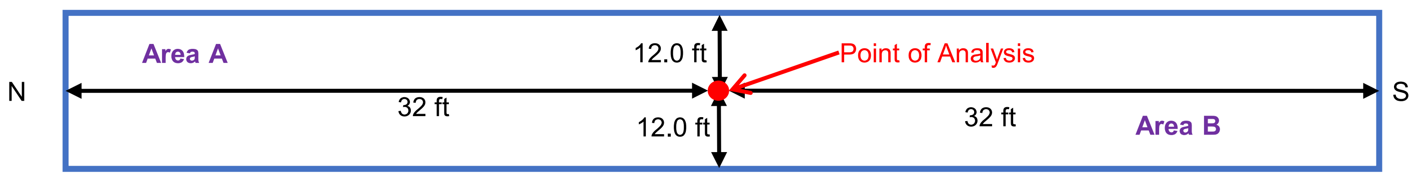
Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

Calculate the increase or decrease in effective stress as a result of construction.

	σv at Elev. 115.9 ft (psf)	σ'v at Elev. 115.9 ft (psf)	Δσ'v at Elev. 115.9ft (psf)	Result
Existing conditions	1364	628	524	Settlement
After construction	1380	1152		

Subdivide the subsurface soils into layers no larger than 10 ft thick and to a depth of either twice the footing width or to bedrock. Calculate the vertical stress increase at each layer, assuming the Boussinesq stress distribution method for stress under the corner of a rectangular load.

Assumed Loading (plan view):



$$\sigma_z = q_0 \times I$$ Reference 4, Eqn. 8-30

$$m = x/z$$ Reference 4, Figure 8.21

$$n = y/z$$ Reference 4, Figure 8.21

where:

	Area A	Area B		
σ_z = half of the vertical stress increase, psf	(each half of the culvert width is calculated separately for each area)			
q_0 = net stress applied by culvert	524		psf	(Part A)
x = half of the width of the loading area, ft	12.0	12.0	ft	(Ref. 3, Sheet 4)
y = length of the loading area, ft	32	32	ft	(Ref. 1)
z = depth to midpoint of layer, ft	(z_{max} = twice the footing width = 48 ft)			

CALCULATIONS

Date: 4/9/2025 **Made by:** LMP-ATM
Project No.: US0047101.4297 **Checked by:** DEB-KAR
Subject: Settlement of Proposed Culvert **Reviewed by:** CCB-MEL
Project Short Title: West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine

Area A:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Glaciomarine	1	0-10	10.0	5.0	2.4	6.4	0.242	254
Glaciomarine	2	10-20	10.0	15.0	0.8	2.1	0.181	190
Glaciomarine	3	20-30	10.0	25.0	0.5	1.3	0.128	134
Glaciomarine	4	30-40	10.0	35.0	0.3	0.9	0.078	82
Glaciomarine	5	40-43.1	3.1	41.5	0.3	0.8	0.074	78
Glacial Till	6	43.1-48	4.9	45.5	0.3	0.7	0.07	73

Area B:

Layer		Depth below lower limit of excavation (ft)	Layer Thickness (ft)	z (ft)	m	n	I	Stress Increase $\sigma_z \times 2$ (psf)
Glaciomarine	1	0-10	10.0	5.0	2.4	6.4	0.242	254
Glaciomarine	2	10-20	10.0	15.0	0.8	2.1	0.181	190
Glaciomarine	3	20-30	10.0	25.0	0.5	1.3	0.128	134
Glaciomarine	4	30-40	10.0	35.0	0.3	0.9	0.078	82
Glaciomarine	5	40-43.1	3.1	41.5	0.3	0.8	0.074	78
Glacial Till	6	43.1-48	4.9	45.5	0.3	0.7	0.070	73

Area A + Area B:

Layer		Depth below lower limit of excavation (ft)	Stress Increase σ_z (psf)
Glaciomarine	1	0-10	507
Glaciomarine	2	10-20	379
Glaciomarine	3	20-30	268
Glaciomarine	4	30-40	163
Glaciomarine	5	40-43.1	155
Glacial Till	6	43.1-48	147

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

B. Use the Hough method to estimate settlement of the soil layers beneath the proposed culvert.

1 Determine σ'_{v0} and C' at layer midpoints for in situ existing soil. Use Ref. 5 Figures 5-18 and 5-19 to obtain corrected N' and C' for Layers 1 to 6, assuming the Glaciomarine and glacial till are "Well graded silty SAND & GRAVEL ".

Stress due to existing soil above point of analysis (Part A)	σ'_{v0} (psf)
	628

Water unit weight (pcf)
62.4

Layer		Layer Thickness (ft)	Unit Weight of Layer (pcf)	σ'_{v0} at layer midpoint (psf)	σ'_{v0} at layer midpoint (kPa)	N_{60}	N'	C'
Glaciomarine	1	10.0	125	941	45.0	31	45	151
Glaciomarine	2	10.0	125	1567	75.0	31	35	132
Glaciomarine	3	10.0	125	2193	105.0	31	30	104
Glaciomarine	4	10.0	125	2819	134.9	31	26	92
Glaciomarine	5	3.1	125	3227	154.5	31	24	86
Glacial Till	6	4.9	135	3502	167.7	75	57	200

2 Calculate the total settlement of the sand/silty sand till and the silt till (Layers 1 to 3) using the Hough method:

General Equation (Ref. 5, Eqn 5-24)

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_{v0} + \Delta\sigma_v}{\sigma'_{v0}}\right)$$

where:

- ΔH_i settlement in each layer, ft
- H_c initial height of layer i, ft
- C' bearing capacity index from Ref. 5, Figure 5-19
- $\Delta\sigma_v$ vertical stress increase, ksf

CALCULATIONS

Date:	4/9/2025	**Made by:**	LMP-ATM
Project No.:	US0047101.4297	**Checked by:**	DEB-KAR
Subject:	Settlement of Proposed Culvert	**Reviewed by:**	CCB-MEL
Project Short Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

ΔH_i (Layer 1)	ft	0.012
	in	0.15

ΔH_i (Layer 2)	ft	0.007
	in	0.09

ΔH_i (Layer 3)	ft	0.005
	in	0.06

ΔH_i (Layer 4)	ft	0.003
	in	0.03

ΔH_i (Layer 5)	ft	0.001
	in	0.01

ΔH_i (Layer 6)	ft	0.000
	in	0.01

	Settlement Based on Calc. Loading Stress
Layer	ΔH_i (in)
1	0.15
2	0.09
3	0.06
4	0.03
5	0.01
6	0.01
Total Settlement (in)	0.35

CONCLUSIONS

The immediate settlement beneath the proposed culvert after construction is estimated to be less than one inch. Since clay soil was not encountered beneath the proposed culvert location, consolidation settlement is not expected.

CALCULATIONS

Date:	4/8/2025	**Made by:**	AMR / KAR
Project No.:	US0047101.4297	**Checked by:**	ATM
Subject:	Global Stability Analysis at Station 103+75	**Reviewed by:**	MEL
Project Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

OBJECTIVE

Determine the global stability factor of safety for existing and proposed conditions of the Route 125 roadway embankment at Station 103+75 as part of the proposed bridge/culvert replacement at West Cathance Stream, Bowdoin, Maine.

REFERENCES

1. WSP soil/rock exploration logs (Appendix A, Geotechnical Design Report).
2. WSP corrected N_{60}-value to friction angle correlation.
3. WSP for State of Maine Department of Transportation. Bowdoin, Sagadahoc County, Lewis Bridge over West Cathance Stream, Main Street, Bridge No. 5396. Final PIC Plans, dated November 5, 2024.
4. Guertin Elkerton & Associates for Maine Department of Transportation. Bridge Design Guide. Dated August 2003 with 2018 updates.
5. Rocscience Slide2 software package, version 9.038, build date February 28, 2025.
6. American Association of State Highway and Transportation Officials (AASHTO). 2024. LRFD Bridge Design Specifications, 10th Edition.
7. Das, Braja M. 2011. Principles of Foundation Engineering, 7th ed.

ATTACHMENTS

1. Slide2 material properties.
2. Slide2 output figures for model with current conditions.
3. Slide2 output figures for model with proposed conditions.

ASSUMPTIONS

1. Circular failure surfaces were analyzed using the Spencer method with an auto refine search. Non-circular failure surfaces were analyzed using the Spencer method with a Cuckoo search plus surface altering optimization.
2. Per AASHTO LRFD Articles 11.6.3.7 and C11.6.3.7 (Ref. 6), a stability resistance factor of 0.75, corresponding to a minimum allowable design factor of safety (FS) of 1.3, based on having sufficient subsurface information available for the site, was used to assess satisfactory global stability conditions.
3. Per the MaineDOT Bridge Design Guide (Ref. 4, Table 3-4), the live load surcharge from vehicular traffic loading on the embankment is modeled as a 2-foot equivalent height of soil: 2 feet x 125 pcf (granular borrow) = 250 psf.
4. The analyzed water table elevation was estimated from measured water levels during the boring program (Ref. 1).
5. The ground surface elevations for the existing and proposed conditions were taken from the PIC plans (Ref. 3, Sheet 13).
6. The interpreted subsurface soil profile at Station 103+75 was determined by interpolating subsurface information from the nearest boring locations onto the cross-section in the PIC plans (Ref. 3, Sheet 13).

Date:	4/8/2025	**Made by:**	AMR / KAR
Project No.:	US0047101.4297	**Checked by:**	ATM
Subject:	Global Stability Analysis at Station 103+75	**Reviewed by:**	MEL
Project Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

CALCULATION

1. Perform global slope stability analysis based on the current site conditions (Ref. 3) at Station 103+75.

a. The material properties selected for use in the Slide2 models are shown in the table below and in Attachment 1.

b. The friction angles for the in-situ soil layers were correlated from SPT N_{60} values encountered in the borings performed at site, based on the Peck, Hanson, and Thornburn (1974) correlation as provided in Ref. 7, Eqn. 2.26.

c. The unit weight parameters for the in-situ soil layers and the bedrock layer were selected based on local engineering experience.

Material Name	Unit Weight (pcf)	Strength Type	Cohesion (psf)	Friction Angle (°)
Existing Fill	125	Mohr-Coulomb	0	32
Alluvium	115	Mohr-Coulomb	0	29
Glaciomarine Fan Deposit	125	Mohr-Coulomb	0	36
Glacial Till	135	Mohr-Coulomb	0	42
Bedrock (Schist)	170	Infinite Strength	-	-

The soil layer properties shown above were used to analyze circular and non-circular failure surfaces using the Spencer method.

The results of the Slide2 stability analyses are summarized in the following table.

Station	Failure Surface Location	Surface Type	Factor of Safety	Attachment Figure #	Condition
103+75	Northeastern Slope (Left)	Circular	1.15	2A	Existing slope geometry
	Northeastern Slope (Left)	Non-Circular	1.14	2B	
	Southwestern Slope (Right)	Circular	2.35	2C	
	Southwestern Slope (Right)	Non-Circular	1.80	2D	

2. Analyze slope stability based on the proposed conditions shown in the PIC plans (Ref. 3) at Station 103+75.

a. The material properties selected for use in the Slide2 models are shown in the table below and in Attachment 1.

b. The friction angles for the in-situ soil layers were correlated from SPT N_{60} values encountered in the borings performed at site, based on the Peck, Hanson, and Thornburn (1974) correlation as provided in Ref. 7, Eqn. 2.26.

c. The unit weight parameters for the in-situ soil layers and the bedrock layer were selected based on local engineering experience.

d. The friction angles and unit weight parameters for the proposed construction materials were taken from the design values provided in the MaineDOT Bridge Design Guide (Ref. 4, Table 3-3) or assumed based on local engineering experience.

CALCULATIONS

Date:	4/8/2025	**Made by:**	AMR / KAR
Project No.:	US0047101.4297	**Checked by:**	ATM
Subject:	Global Stability Analysis at Station 103+75	**Reviewed by:**	MEL
Project Title:	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine		

Material Name	Unit Weight (pcf)	Strength Type	Cohesion (psf)	Friction Angle (°)
Existing Fill	125	Mohr-Coulomb	0	32
Alluvium	115	Mohr-Coulomb	0	29
Glaciomarine Fan Deposit	125	Mohr-Coulomb	0	36
Glacial Till	135	Mohr-Coulomb	0	42
Bedrock (Schist)	170	Infinite Strength	-	-
Pavement	140	Mohr-Coulomb	0	45
Granular Borrow	125	Mohr-Coulomb	0	32
Aggregate Subbase Gravel	135	Mohr-Coulomb	0	36
Riprap	140	Mohr-Coulomb	0	42

The soil layer properties shown above were used to analyze circular and non-circular failure surfaces using the Spencer method.

The results of the Slide2 stability analyses are summarized in the following table.

Station	Failure Surface Location	Surface Type	Factor of Safety	Attachment Figure #	Condition
103+75	Northeastern Slope (Left)	Circular	1.49	3A	Proposed slope geometry
	Northeastern Slope (Left)	Non-Circular	1.41	3B	
	Southwestern Slope (Right)	Circular	1.33	3C	
	Southwestern Slope (Right)	Non-Circular	1.32	3D	

CONCLUSIONS

1) The analyzed existing site conditions at Station 103+75 have an estimated factor of safety that is less than the recommended FS ≥ 1.3 for circular and non-circular potential slope failure surfaces on the northeastern embankment slope. However, the estimated factor of safety for existing conditions is greater than FS = 1, consistent with the lack of current slope failures observed at site.

2) The analyzed proposed site conditions at Station 103+75 have an estimated factor of safety that meets the requirement of FS ≥ 1.3 for circular and non-circular potential slope failure surfaces.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu
Pavement		140	Mohr-Coulomb	0	45		Piezometric Line 1	Custom	1
Existing Fill		125	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1
Granular Borrow		125	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1
Alluvium		115	Mohr-Coulomb	0	29		Piezometric Line 1	Custom	1
Glaciomarine		125	Mohr-Coulomb	0	36		Piezometric Line 1	Custom	1
Glacial Till		135	Mohr-Coulomb	0	42		Piezometric Line 1	Custom	1
Bedrock (Schist)		170	Infinite Strength			No	Piezometric Line 1	Custom	1
Riprap		140	Mohr-Coulomb	0	42		Piezometric Line 1	Custom	1
Aggregate Subbase		135	Mohr-Coulomb	0	36		Piezometric Line 1	Custom	1

120 100 80 60 40

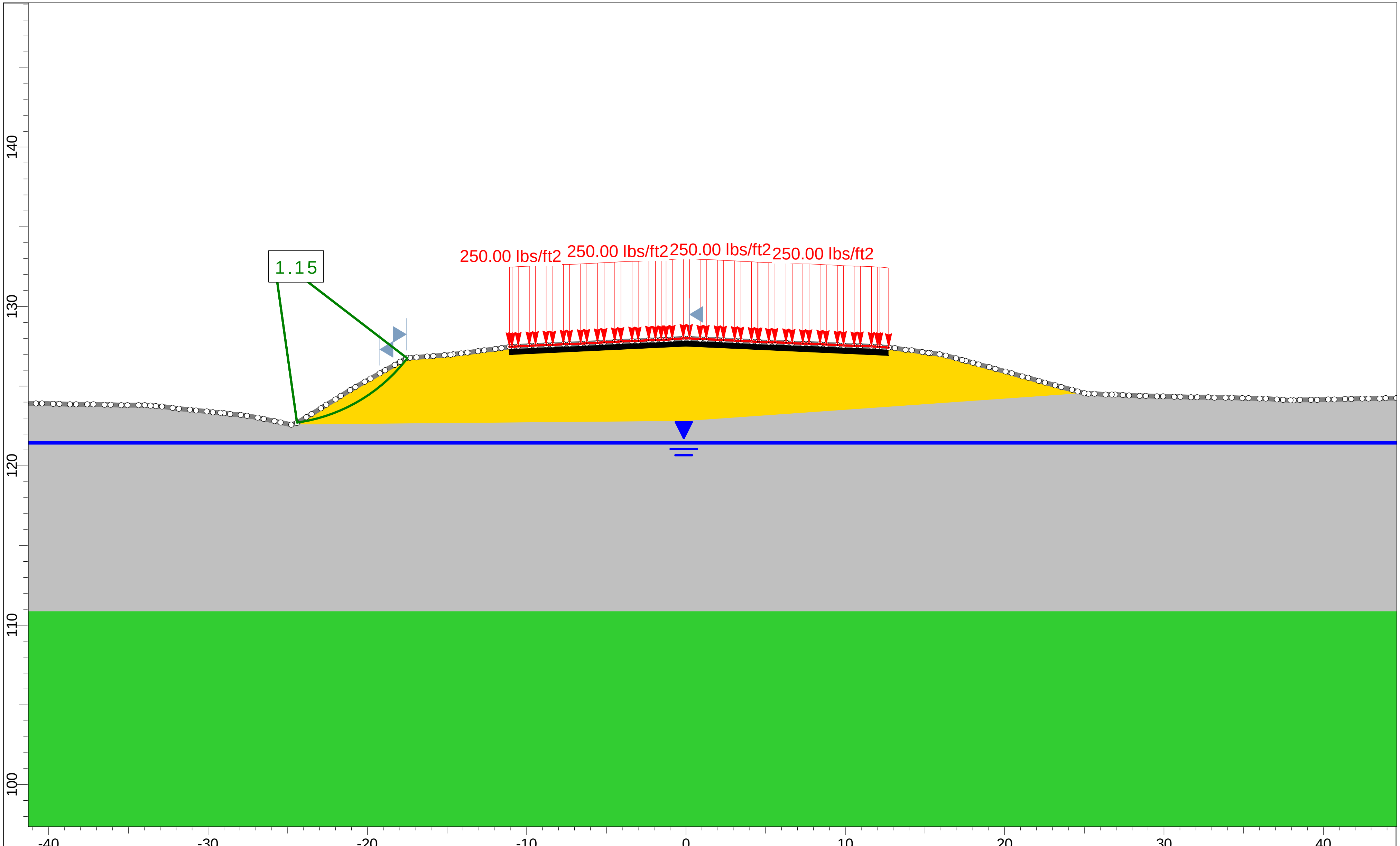
-260 -240 -220 -200 -180 -160 -140 -120 -100

wsp

SLIDE 9.038

Project	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine						
Analysis Description	Material Properties Table for Station 103+75						
Drawn By	KAR	*Checked By*	ATM	*Reviewed By*	MEL	*Scale*	N/A
Date	4/7/2025	*File Name*	Sta.103+75_PIcupdates.slmd				

Figure 1



Project: West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine

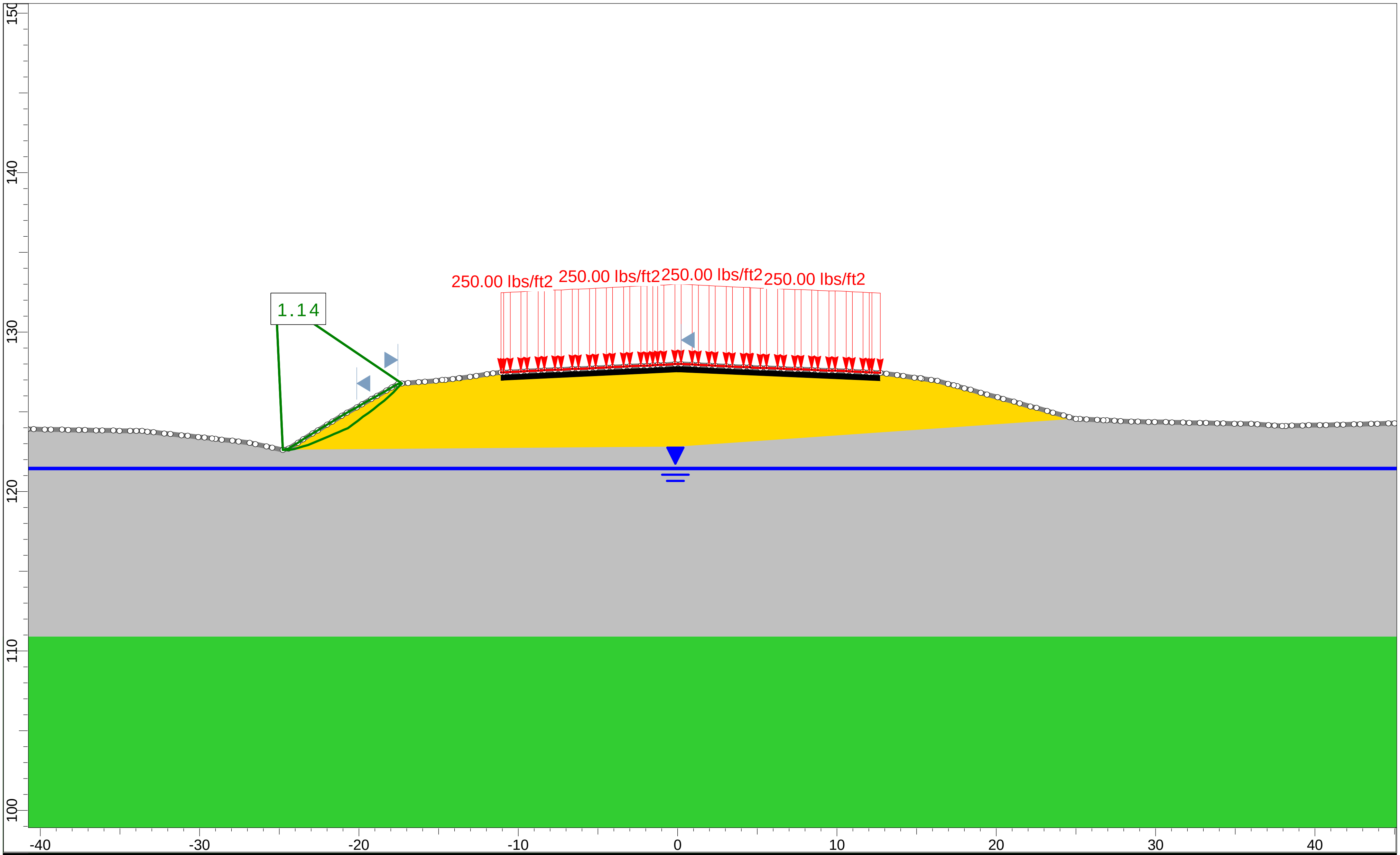
Analysis Description: Sta. 103+75 Existing Conditions (Left) - Circular

Drawn By	Checked By	Reviewed By	Scale
AMR	ATM	CCB	1:100

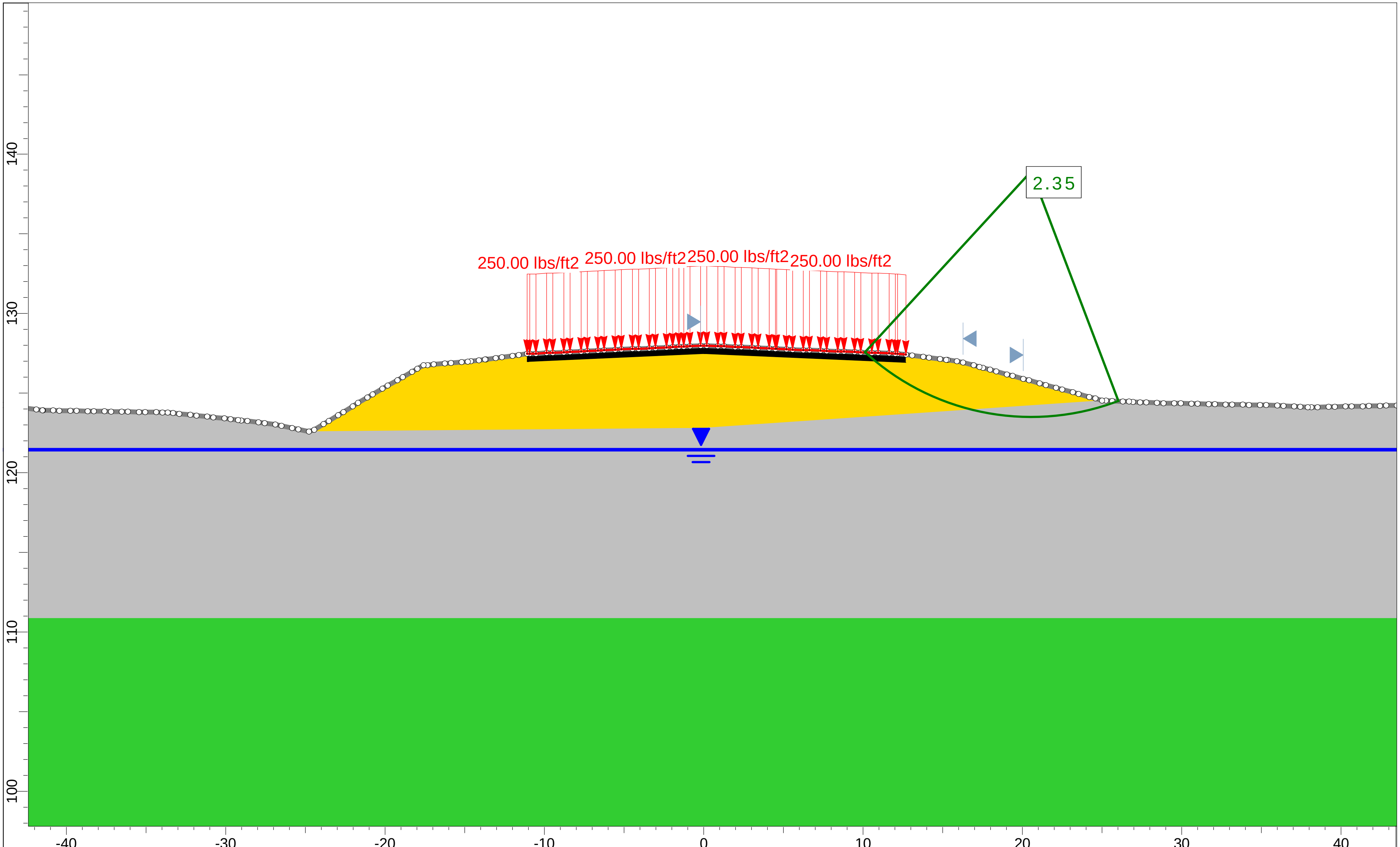
Date	File Name
10/25/2023	Sta.103+75.slmd

Figure 2A

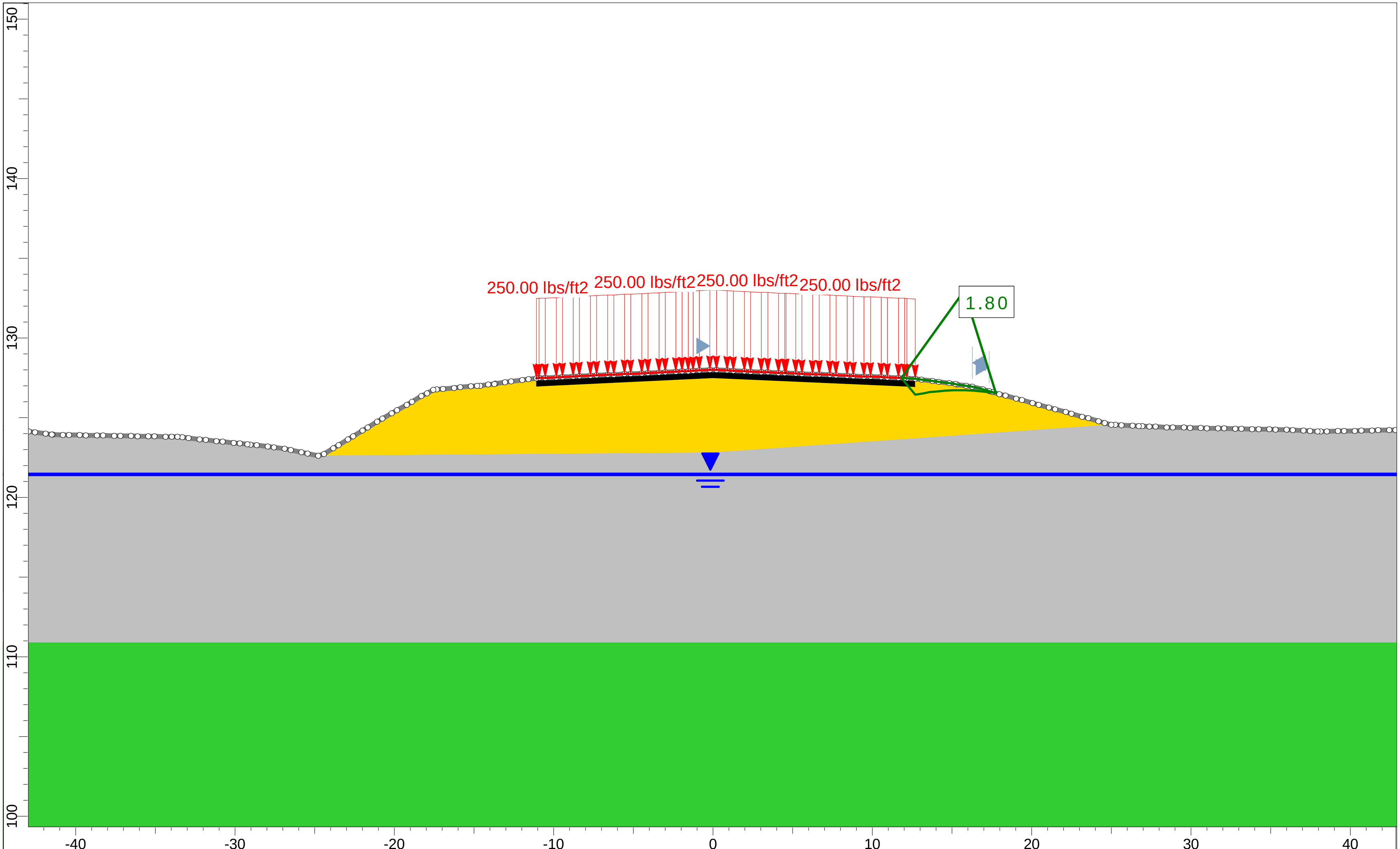
SLIDEINTERPRET 9.026



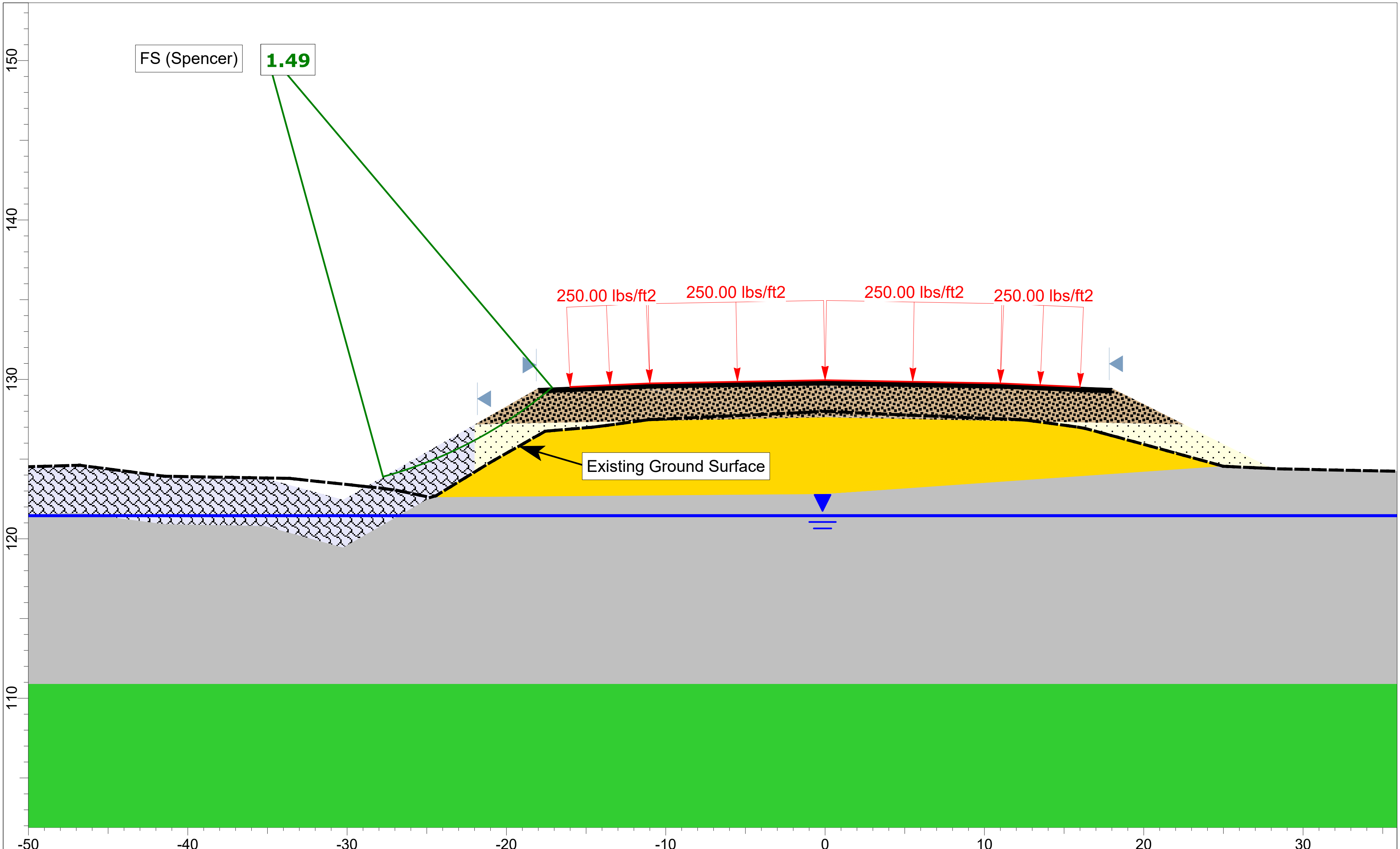
wsp	Project: West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine			
	Analysis Description: Sta. 103+75 Existing Conditions (Left) - Non-Circular			
	Drawn By: AMR	Checked By: ATM	Reviewed By: CCB	Scale: 1:100
SLIDEINTERPRET 9.026	Date: 10/25/2023	File Name: Sta.103+75.slmd		Figure 2B



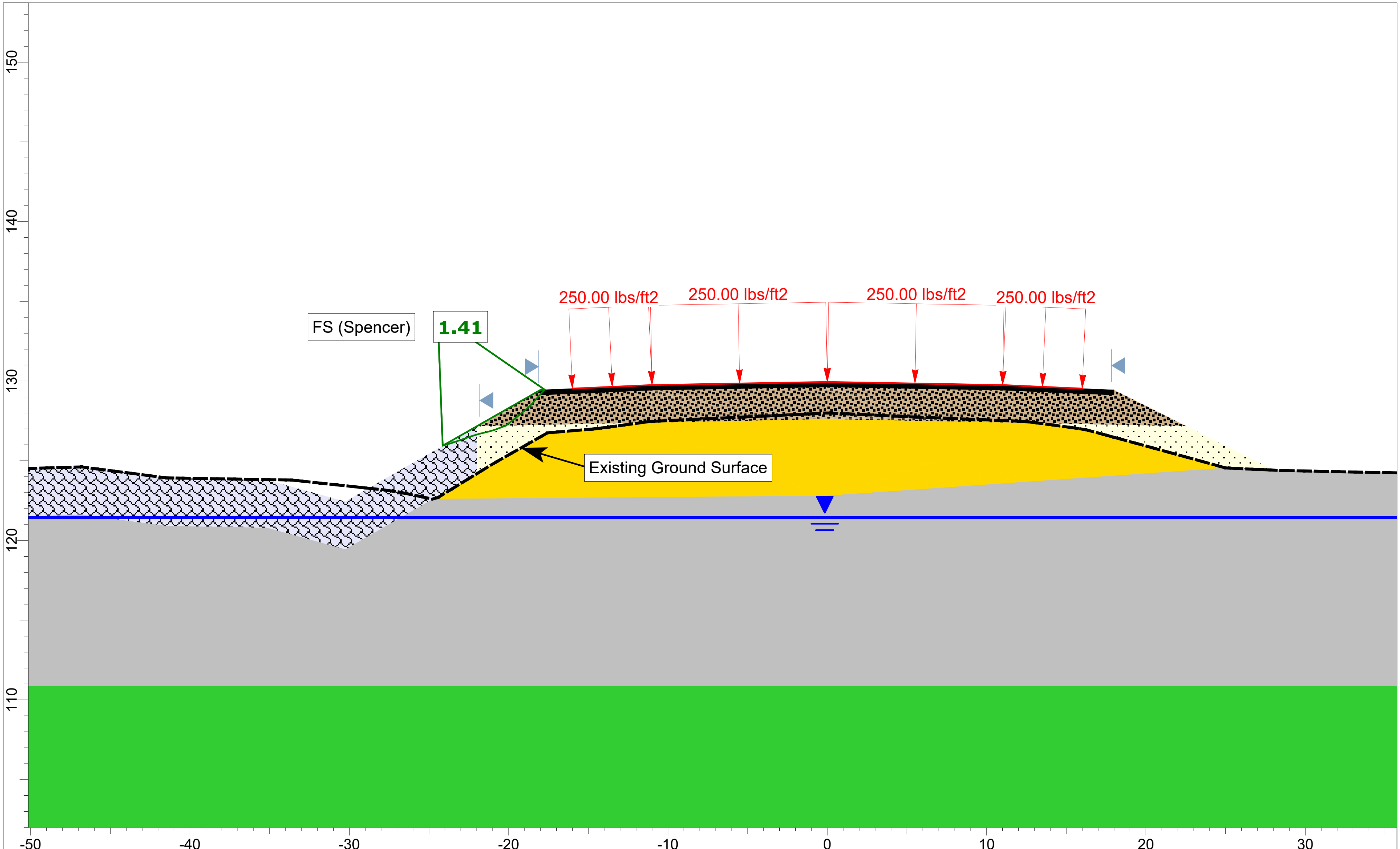
wsp	*Project*	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine					
	Analysis Description	Sta. 103+75 Existing Conditions (Right) - Circular					
	Drawn By	AMR	*Checked By* ATM	*Reviewed By* CCB	*Scale* 1:100	Figure 2C	
SLIDEINTERPRET 9.026	*Date*	10/25/2023	*File Name* Sta.103+75.slmd				



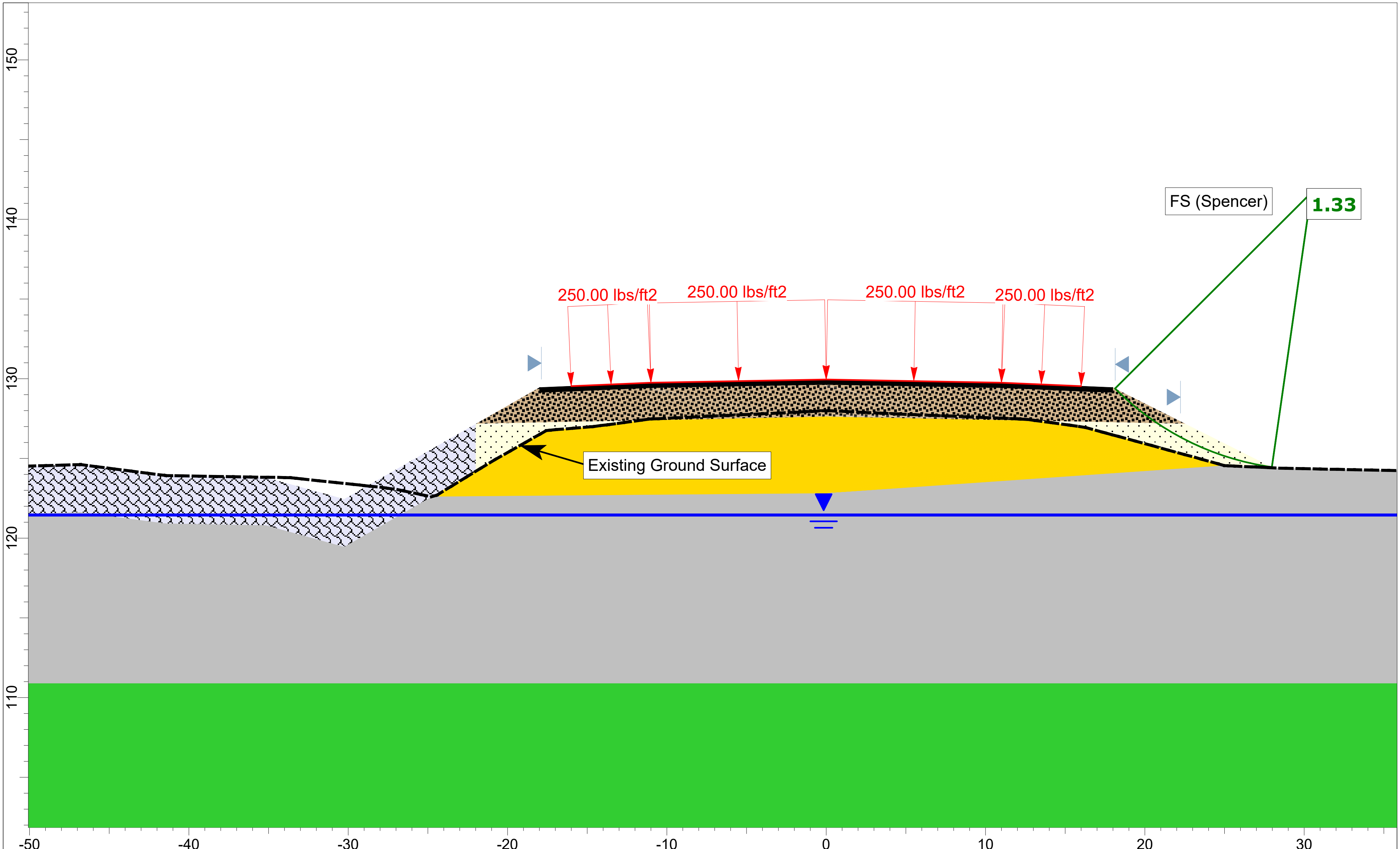
	Project	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine						
	Analysis Description	Sta. 103+75 Existing Conditions (Right) - Non-Circular						
	Drawn By	AMR	*Checked By*	ATM	*Reviewed By*	CCB	*Scale* 1:100	Figure 2D
SLIDEINTERPRET 9.026	*Date*	10/25/2023	*File Name*	Sta.103+75.slmd				



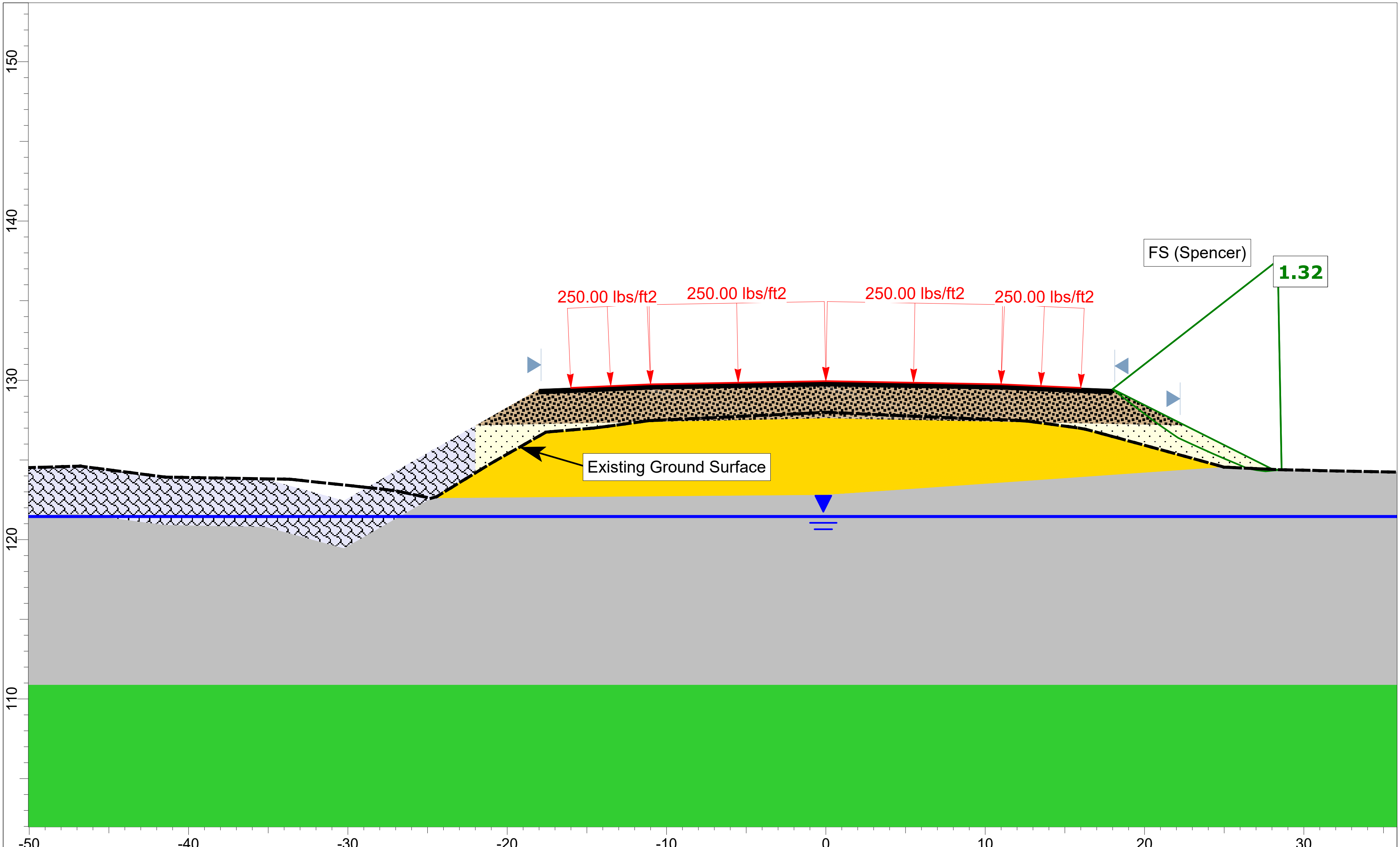
wsp	*Project*	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine					
	Analysis Description	Station 103+75 Proposed Conditions (Northern Slope) - Circular Failure Surface					
	Drawn By KAR	*Checked By* ATM	*Reviewed By* MEL	*Scale* 1:100	**Figure 3A**		
SLIDEINTERPRET 9.038	*Date* 4/7/2025	*File Name* Sta.103+75_PICupdates.slmd					



SLIDEINTERPRET 9.038	*Project*	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine					
	Analysis Description	Station 103+75 Proposed Conditions (Northern Slope) - NonCircular Failure Surface					
	Drawn By	KAR	*Checked By* ATM	*Reviewed By* MEL	*Scale*	1:100	**Figure 3B**
	Date	4/7/2025	*File Name*	Sta.103+75_PICupdates.slmd			



SLIDEINTERPRET 9.038	*Project*	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine					
	Analysis Description	Station 103+75 Proposed Conditions (Southern Slope) - Circular Failure Surface					
	Drawn By KAR	*Checked By* ATM		*Reviewed By* MEL		*Scale* 1:100	**Figure 3C**
	Date 4/7/2025	*File Name* Sta.103+75_PICupdates.slmd					



SLIDEINTERPRET 9.038

Project	West Cathance Stream Lewis Bridge No. 5396, Bowdoin, Maine							
Analysis Description	Station 103+75 Proposed Conditions (Southern Slope) - NonCircular Failure Surface							
Drawn By	KAR	*Checked By*	ATM	*Reviewed By*	MEL	*Scale*	1:100	**Figure 3D**
Date	4/7/2025	*File Name*	Sta.103+75_PICupdates.slmd					

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