

**MAINE DEPARTMENT OF TRANSPORTATION  
HIGHWAY PROGRAM  
GEOTECHNICAL SECTION  
AUGUSTA, MAINE**

**GEOTECHNICAL DESIGN REPORT**

*For the Replacement of:*

**CROSS CULVERT #XC-226919  
OLD BATH ROAD  
BRUNSWICK, MAINE**

*Prepared by:*  
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Senior Geotechnical Engineer.

Cumberland County

WIN 18811.00  
April 30, 2019

Soils Report 2019-12

## **PROJECT DETAILS**

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical design and construction recommendations for the replacement of an existing approximately 37-foot long, 48-inch diameter corrugated metal pipe (CMP) cross culvert (#XC-226919) on Old Bath Road in Brunswick. The existing culvert is failing, with heavy rust along the invert. The culvert is located approximately 0.04 of a mile east of Bay Bridge Road as shown in the attached Location Map. Old Bath Road is a Highway Corridor Priority 4 road.

The proposed replacement structure will be a 95-inch span by 67-inch rise by 96-foot long steel pipe arch on a skew of approximately 34 degrees to the roadway centerline. The invert of the proposed culvert is approximately 9 feet below the existing road grade at the roadway centerline. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 3.4H:1V on the inlet end and 3.6H:1V with 2 feet of riprap on the outlet end to protect against erosion.

## **SUBSURFACE INVESTIGATION**

One (1) boring (HB-BRU-101) and five (5) probes (HB-BRU-102, HB-BRU-102A, HB-BRU-102B, HB-BRU-103 and HB-BRU-104) were drilled for this project on November 8, 2016 by New England Boring Contractors (NEBC) of Herman, Maine using a trailer mounted drill rig. Exploration locations are shown on the attached Boring Location Plan & Interpretive Subsurface Profile with Boring Logs sheet. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are shown on the attached boring logs.

The boring and probes were drilled using solid stem auger techniques. Soil samples were obtained in boring HB-BRU-101 at 5-foot intervals using Standard Penetration Test (SPT) methods. The NEBC drill rig is equipped with a rope and cathead to drive the split spoon. No soil samples were obtained in the probes.

The MaineDOT Geotechnical Team member selected the boring and probe locations, drilling methods, designated type and depth of sampling, reviewed field logs for accuracy and identified field and laboratory testing requirements. An experienced geotechnical engineer logged the subsurface conditions encountered. The boring and probes were located in the field by taping to surveyed site features after completion of the drilling program.

## **LABORATORY TESTING**

A laboratory testing program was conducted to assist in soil classification, evaluation of engineering properties of the soils and geologic assessment of the project site. Laboratory testing consisted of four (4) standard grain size analyses with natural water content. The results of the laboratory testing program are discussed in the following section and are shown on the attached boring logs, Laboratory Testing Summary Sheet, and Grain Size Distribution Curve sheet.

## SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test boring generally consisted of fill sand overlying native sand and sandy silt. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on the attached Boring Location Plan & Interpretive Subsurface Profile with Boring Logs sheet.

Boring HB-BRU-101 was drilled to a depth of approximately 17.0 feet below ground surface (bgs) and did not encounter a refusal surface. Probes HB-BRU-102, HB-BRU-102A, HB-BRU-102B and HB-BRU-103 were drilled to depths of 4.7 feet bgs, 4.5 feet bgs, 3.0 feet bgs and 24.5 feet bgs, respectively, where they each encountered a refusal surface. The exact nature of the refusal surface was not identified during the explorations. Probe HB-BRU-104 was drilled to a depth of approximately 15.0 feet bgs and did not encounter a refusal surface.

The table below summarizes the field and laboratory information obtained in boring HB-BRU-101:

Approx. Depth BGS <sup>1</sup> (feet)	Soil Description	AASHTO <sup>2</sup> Classification	USCS <sup>3</sup>	WC% <sup>4</sup>
0 – 0.6	Pavement	--	--	--
0.5 – 10.0	Fill: Brown, damp to wet, fine to coarse SAND, trace to some silt, trace gravel, wood.	A-1-b or A-2-4	SP-SM or SM	8.1 to 57.1
10.0 – 17.0	Greyish brown, reddish brown, and grey, wet, fine to coarse SAND, trace silt, trace gravel. Change to grey fine sandy silt at approximately 17.0 feet bgs.	A-1-b	SP	18.7 to 20.0

<sup>1</sup>BGS = below ground surface

<sup>2</sup>AASHTO = American Association of State Highway and Transportation Officials

<sup>3</sup>USCS = Unified Soil Classification System

<sup>4</sup>WC% = Water content in percent

One (1) N-value obtained in the fill sand was 6 blows per foot (bpf) indicating that the fill sand is loose in consistency. Two (2) N-values obtained in the native sand ranged from 7 to 9 bpf indicating that the native sand is loose in consistency.

Groundwater was observed in boring HB-BRU-101 at a depth of approximately 5.5 feet bgs. Groundwater was not recorded in the probes. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

## GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

**Steel Pipe Arch Construction** – The proposed replacement structure will be a 95-inch span by 67-inch rise by 96-foot long steel pipe arch on a skew of approximately 34 degrees to the roadway

centerline. The proposed steel pipe arch shall be furnished and installed in accordance with MaineDOT Standard Specification 603. The invert and outlet of the proposed steel pipe arch will be set at approximate elevation 8.0 feet with a 0% slope.

The full nature of the proposed culvert bearing surface will not become evident until the culvert excavation is made. Any cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone  $\frac{3}{4}$ -Inch. The prepared subgrade shall be proof-rolled using a static roller to visually confirm the prepared subgrade is firm and stable. The exposed subgrade shall be free of ponded water so that bedding material placement and compaction can be completed in the dry.

The proposed structure shall be bedded on a 1-foot thick layer of Granular Borrow, Material for Underwater Backfill meeting the requirements of MaineDOT Standard Specification 703.19. The soil envelope and backfill shall consist of Standard Specification 703.19 - Granular Borrow with a maximum particle size of 4 inches. The granular borrow bedding and backfill material shall be placed in lifts of 6 to 8 inches loose measure and compacted to the manufacturer's specifications or, in the absence of manufacturer's specifications. The bedding and backfill soil shall be compacted to at least 92 percent of the AASHTO T-180 maximum dry density. All subgrade surfaces should be protected from construction traffic in order to limit disturbance.

**Settlement** – No settlement issues are anticipated at the site. No changes to the existing vertical or horizontal alignment are currently planned for this project. The proposed pipe arch is larger than the existing culvert and will result in a net unloading of the site soils at the proposed structure location. Any settlement due to elastic compression of the bedding material will be immediate and negligible.

**Scour and Riprap** – Both the inlet and outlet of the steel pipe arch shall be protected against scour with riprap conforming to MaineDOT Standard Specification Section 703.26 Plain and Hand Laid Riprap. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 3.4H:1V on the inlet end and 3.6H:1V on the outlet end with 2 feet of riprap. All other slopes shall be no steeper than 2H:1V. No specific scour protection recommendations are needed other than armoring with riprap. The riprap on the slopes shall be underlain by a non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03 that is underlain by a 1-foot layer of protective aggregate cushion consisting of Granular Borrow Material for Underwater Backfill (703.19). The toe of the riprap sections shall be keyed into the existing soils 1 foot below the streambed elevation.

**Construction Considerations** – Construction activities will include construction of cofferdams and earth support systems to control stream flow during construction. Construction activities will also include common earth excavation. Construction of the steel pipe arch will require soil excavation. Earth support systems shall be implemented if laying back slopes is not feasible. It is likely that the use of complex (four-sided) braced excavations with dewatering will be necessary due to the depth of the excavation. If this is the case, adequate embedment into the native sand will be necessary to allow for the excavation and maintenance of a stable excavation bottom. All earth support systems shall be designed by a Professional Engineer licensed in the State of Maine.

Regardless of the method of excavation, all excavations and earth support systems shall meet all applicable OSHA regulations.

Any cobbles or boulders encountered in excess of 6 inches shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill (MaineDOT 703.19) or Crushed Stone ¾-Inch (MaineDOT 703.13). All subgrade surfaces shall be proof-rolled using a static roller to provide a firm and stable surface and protected from any unnecessary construction equipment or traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted Granular Borrow for Underwater Backfill (703.19) or Crushed Stone ¾-Inch (703.13).

The Contractor shall control groundwater and surface water infiltration using temporary ditches, sumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water as needed to maintain a stable excavation and allow work in the dry.

Using the excavated native soils as backfill around the culvert shall not be permitted. The native soils may only be used as Common Borrow in accordance with MaineDOT Standard Specifications 203 and 703.

The Contractor will have to excavate the existing subbase and subgrade fill soils in the vicinity of the culvert. These materials should not be used to re-base the roadway. Excavated subbase sand and gravel may be used as fill below roadway subgrade level in fill areas provided all other requirements of MaineDOT Standard Specifications 203 and 703 are met.

## **CLOSURE**

This report has been prepared for the use of the MaineDOT Highway Program and their project design consultant for specific application to the proposed replacement of a cross culvert (#XC-226919) under Old Bath Road in Brunswick, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes in design. These analyses and recommendations are based in part upon a limited subsurface investigation at discrete exploratory location completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

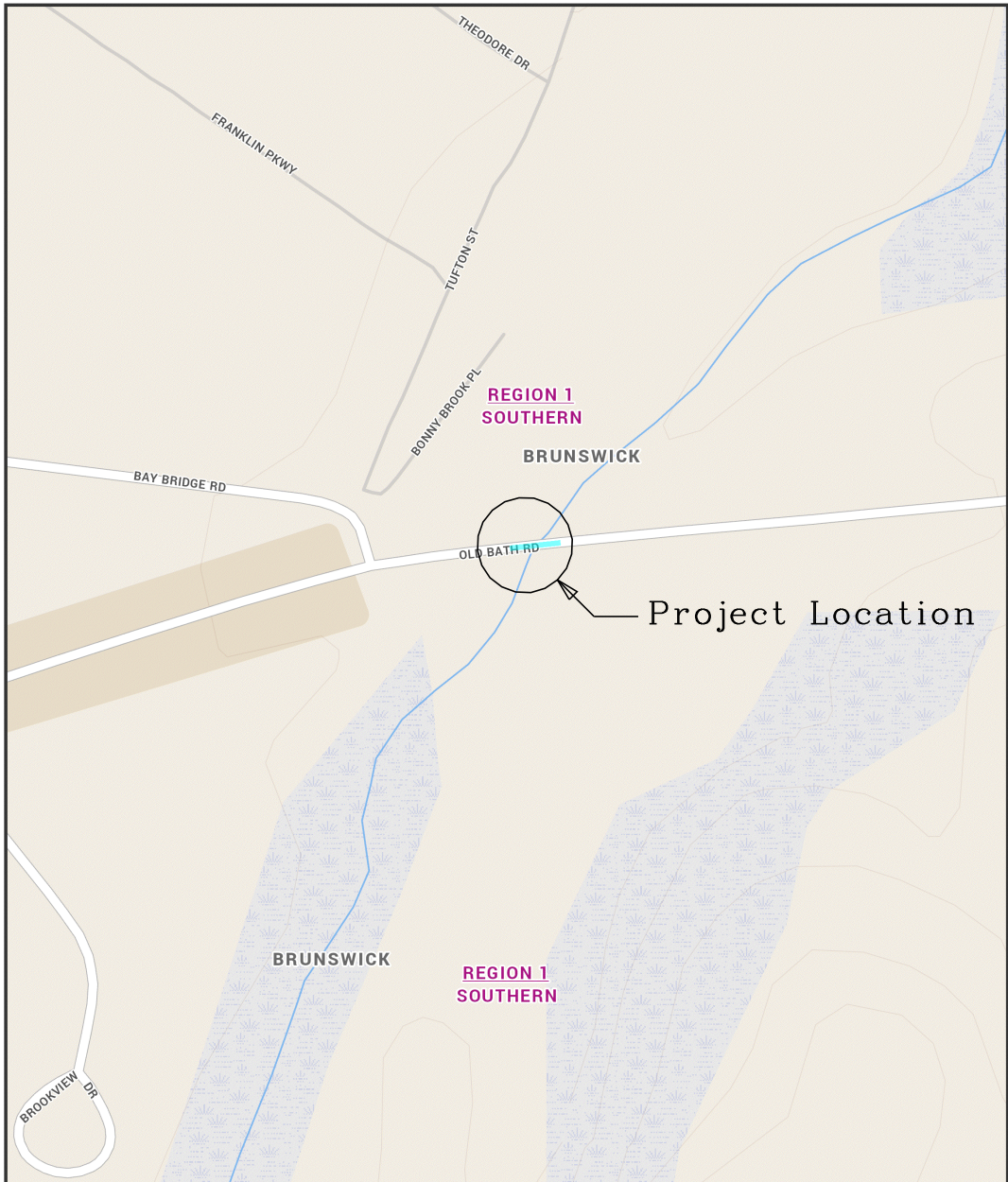
It is recommended that a geotechnical engineer be provided the opportunity for a review of the design and specifications in order that the earthwork and foundation recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications.

**Attachments:**

Location Map  
Boring Location Plan & Interpretive Subsurface Profile  
Key to Soil and Rock Descriptions and Terms  
Boring Logs  
Laboratory Testing Summary Sheet  
Grain Size Distribution Curves



# BRUNSWICK, MAINE

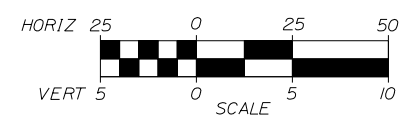
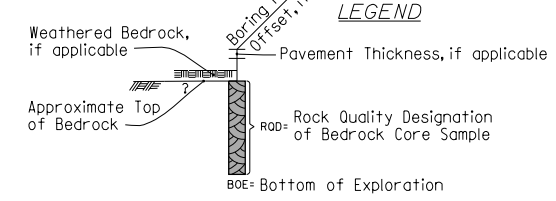
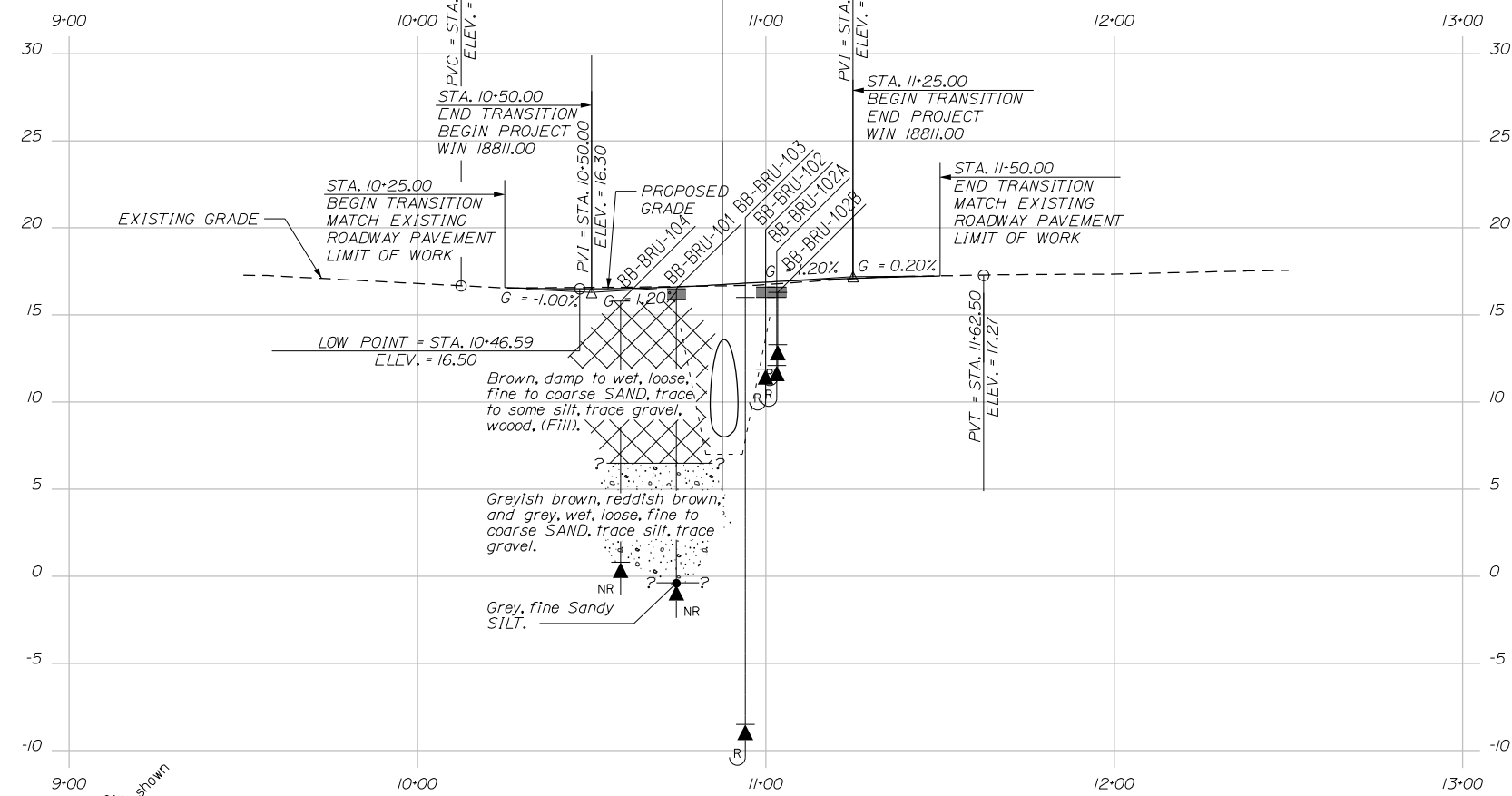
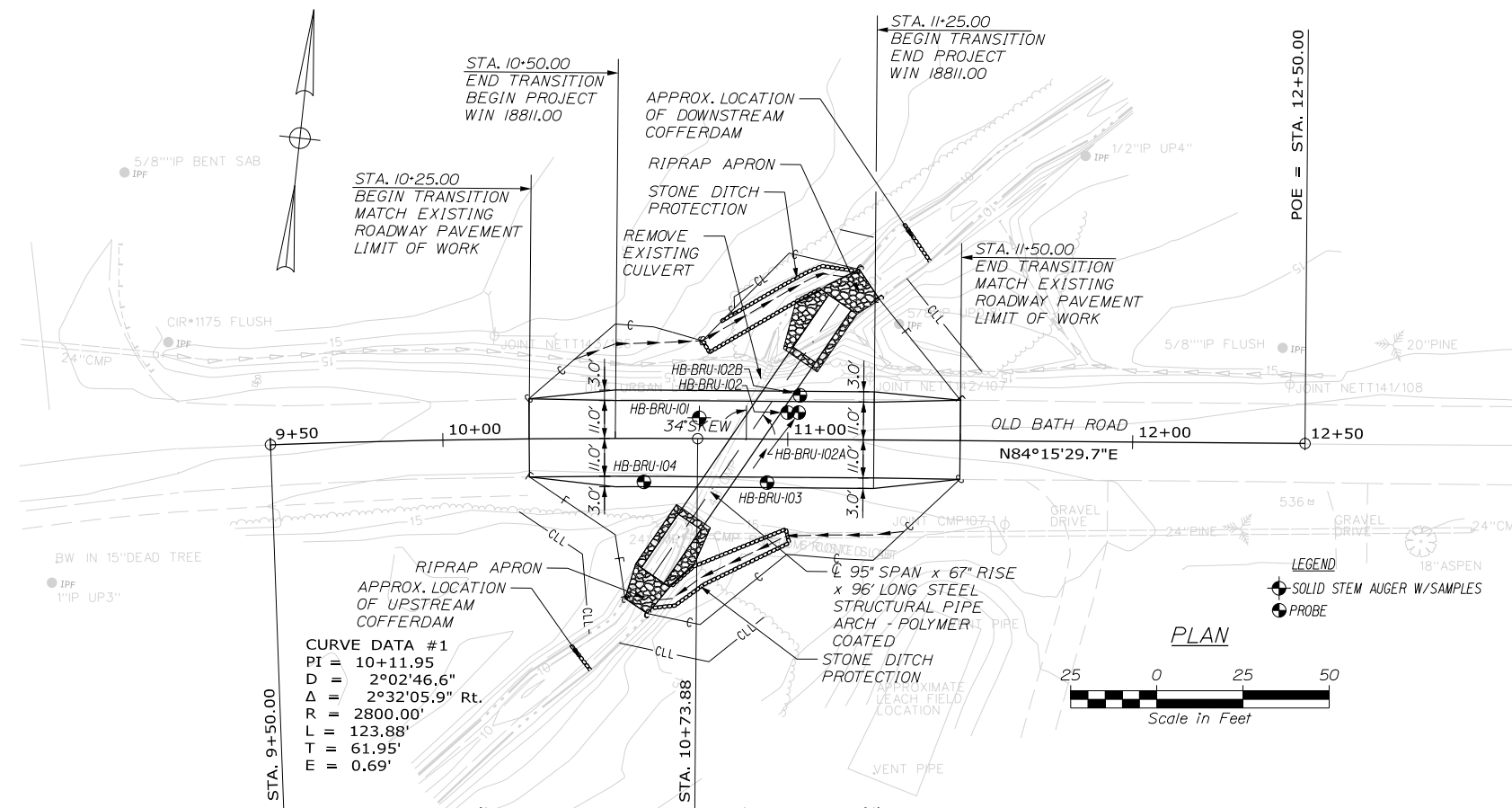


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0.035 Miles  
1 inch = 0.04 miles

Date: 3/15/2019  
Time: 12:15:27 PM

SHEET NUMBER  <b>1</b>  OF 2	BRUNSWICK  OLD BATH ROAD	STATE OF MAINE DEPARTMENT OF TRANSPORTATION
	LOCATION MAP	018811.00  WIN 18811.00 HIGHWAY PLANS



Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE DEPARTMENT OF TRANSPORTATION		018811.00	WIN 18811.00	HIGHWAY PLANS
BRUNSWICK OLD BATH ROAD BORING LOCATION PLAN & INTERPRETIVE SURFACE PROFILE				
PROJ. MANAGER	BY	DATE	SIGNATURE	P.E. NUMBER
DESIGN-DETAILED	T. WHITE	APR 2019	[Signature]	
CHECKED-REVIEWED	C. RUSSELL			
DESIGNS-DETAILED				
DESIGNS-DETAILED				
REVISIONS 1				
REVISIONS 2				
REVISIONS 3				
REVISIONS 4				
FIELD CHANGES				
SHEET NUMBER				
2				
OF 2				

UNIFIED SOIL CLASSIFICATION SYSTEM				MODIFIED BURMISTER SYSTEM																											
MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES	Descriptive Term	Portion of Total (%)																										
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	GW Well-graded gravels, gravel-sand mixtures, little or no fines.	trace	0 - 10																										
		(little or no fines)	GP Poorly-graded gravels, gravel sand mixtures, little or no fines.	little	11 - 20																										
	SANDS  (more than half of coarse fraction is smaller than No. 4 sieve size)	GRAVEL WITH FINES (Appreciable amount of fines)	GM Silty gravels, gravel-sand-silt mixtures.	some	21 - 35																										
		CLEAN SANDS	SW Well-graded sands, gravelly sands, little or no fines	adjective (e.g. sandy, clayey)	36 - 50																										
		(little or no fines)	SP Poorly-graded sands, gravelly sand, little or no fines.	<b>TERMS DESCRIBING DENSITY/CONSISTENCY</b> <b>Coarse-grained soils</b> (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).  <table border="1"> <thead> <tr> <th>Density of Cohesionless Soils</th> <th>Standard Penetration Resistance N-Value (blows per foot)</th> </tr> </thead> <tbody> <tr><td>Very loose</td><td>0 - 4</td></tr> <tr><td>Loose</td><td>5 - 10</td></tr> <tr><td>Medium Dense</td><td>11 - 30</td></tr> <tr><td>Dense</td><td>31 - 50</td></tr> <tr><td>Very Dense</td><td>&gt; 50</td></tr> </tbody> </table>		Density of Cohesionless Soils	Standard Penetration Resistance N-Value (blows per foot)	Very loose	0 - 4	Loose	5 - 10	Medium Dense	11 - 30	Dense	31 - 50	Very Dense	> 50														
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SANDS WITH FINES (Appreciable amount of fines)	SM Silty sands, sand-silt mixtures	<b>Fine-grained soils</b> (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.  <table border="1"> <thead> <tr> <th>Consistency of Cohesive soils</th> <th>SPT N-Value (blows per foot)</th> <th>Approximate Undrained Shear Strength (psf)</th> <th>Field Guidelines</th> </tr> </thead> <tbody> <tr><td>Very Soft</td><td>WOH, WOR, WOP, &lt;2</td><td>0 - 250</td><td>Fist easily penetrates</td></tr> <tr><td>Soft</td><td>2 - 4</td><td>250 - 500</td><td>Thumb easily penetrates</td></tr> <tr><td>Medium Stiff</td><td>5 - 8</td><td>500 - 1000</td><td>Thumb penetrates with moderate effort</td></tr> <tr><td>Stiff</td><td>9 - 15</td><td>1000 - 2000</td><td>Indented by thumb with great effort</td></tr> <tr><td>Very Stiff</td><td>16 - 30</td><td>2000 - 4000</td><td>Indented by thumbnail</td></tr> <tr><td>Hard</td><td>&gt;30</td><td>over 4000</td><td>Indented by thumbnail with difficulty</td></tr> </tbody> </table>		Consistency of Cohesive soils	SPT N-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
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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.	<b>Rock Quality Designation (RQD):</b> RQD (%) = $\frac{\text{sum of the lengths of intact pieces of core} * > 4 \text{ inches}}{\text{length of core advance}}$ *Minimum NQ rock core (1.88 in. OD of core)  Correlation of RQD to Rock Mass Quality <table border="1"> <thead> <tr> <th>Rock Mass Quality</th> <th>RQD (%)</th> </tr> </thead> <tbody> <tr><td>Very Poor</td><td>≤25</td></tr> <tr><td>Poor</td><td>26 - 50</td></tr> <tr><td>Fair</td><td>51 - 75</td></tr> <tr><td>Good</td><td>76 - 90</td></tr> <tr><td>Excellent</td><td>91 - 100</td></tr> </tbody> </table>			Rock Mass Quality	RQD (%)	Very Poor	≤25	Poor	26 - 50	Fair	51 - 75	Good	76 - 90	Excellent	91 - 100														
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Fair	51 - 75																														
Good	76 - 90																														
Excellent	91 - 100																														
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.	<b>Desired Rock Observations (in this order, if applicable):</b> 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 mass quality (very poor, poor, etc.) ref: ASTM D6032 and AASHTO Standard Specification for Highway Bridges, 17th Ed. Table 4.4.8.1.2A Recovery (inch/inch and percentage) Rock Core Rate (X.X ft - Y.Y ft (min:sec))																													
	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.																														
<b>Desired Soil Observations (in this order, if applicable):</b> 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				<b>Sample Container Labeling Requirements:</b> WIN Blow Counts Bridge Name / Town Sample Recovery Boring Number Date Sample Number Personnel Initials Sample Depth																											
<b>Maine Department of Transportation  Geotechnical Section  Key to Soil and Rock Descriptions and Terms  Field Identification Information</b>																															









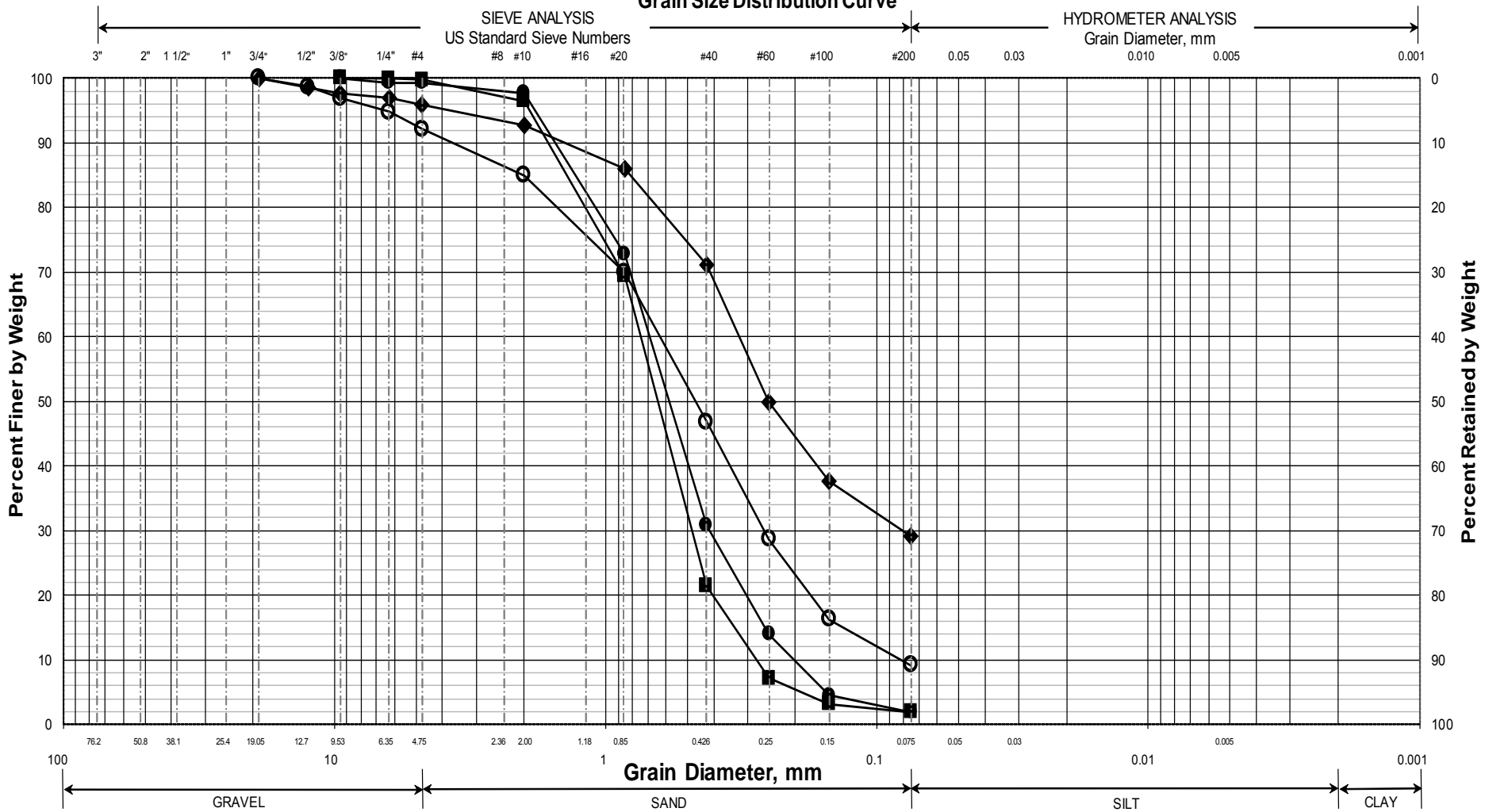








## Maine Department of Transportation Grain Size Distribution Curve



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-BRU-101/1D	10+74.3	6.1 LT	0.6-2.0	SAND, trace silt, trace gravel.	8.1			
◆	HB-BRU-101/2D	10+74.3	6.1 LT	5.0-7.0	SAND, some silt, trace gravel.	57.1			
■	HB-BRU-101/3D	10+74.3	6.1 LT	10.0-12.0	SAND, trace silt, trace gravel.	18.7			
●	HB-BRU-101/4D	10+74.3	6.1 LT	15.0-17.0	SAND, trace silt, trace gravel.	20.0			
▲									
X									

WIN
018811.00
Town
Brunswick
Reported by/Date
WHITE, TERRY A      2/8/2019