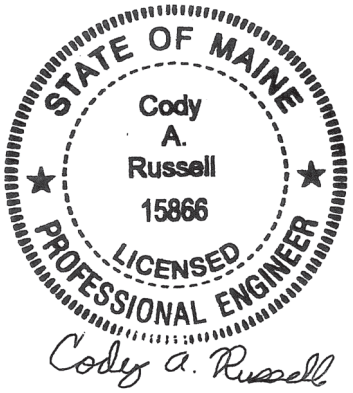
MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Construction of:

BABCOCK BRIDGE
ROUTE 2A
HAYNESVILLE, MAINE

Prepared by:
Cody Russell, P.E.
Geotechnical Engineer



Reviewed by:
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Senior Geotechnical Engineer

Aroostook County
WIN 18823.00
Bridge No. 6566

Soils Report 2023-02
Federal Project No. 1882300
January 20, 2023

Table of Contents

2.0 GEOLOGIC SETTING 1

3.0 SUBSURFACE INVESTIGATION 1

4.0 LABORATORY TESTING 2

5.0 SUBSURFACE CONDITIONS 2

6.0 GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS 3

6.1 Precast Concrete Box Culvert Design and Construction 3
6.2 Settlement 4
6.3 Bearing Resistance 4
6.4 Modulus of Subgrade Reaction 5
6.5 Scour and Riprap 5
6.6 Seismic Design Considerations 5
6.7 Construction Considerations 5

7.0 CLOSURE 6

Sheets

Sheet 1 - Location Map
Sheet 2 - Boring Location Plan & Interpretive Subsurface Profile with Boring Logs

Appendices

Appendix A - Boring Logs
Appendix B - Laboratory Test Results
Appendix C - Calculations

1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement an existing large culvert on Route 2A in Hayneville, Maine. A subsurface investigation has been completed at the site to evaluate subsurface conditions and to develop geotechnical design and construction recommendations for the replacement structure. This report presents the subsurface information obtained during the subsurface investigation and soil laboratory testing programs and provides design and construction recommendations and geotechnical design parameters for the culvert replacement.

The existing structure (#46921) consists of a 78-foot long, 5-foot diameter corrugated metal pipe (CMP) culvert on State Route 2A in Haynesville. The existing culvert is in fair condition with extensive rusting in the culvert bottom and light erosion at the inlet. State Route 2A is a Highway Corridor Priority 4 road.

The proposed replacement structure will be a 14-foot span by 6-foot rise by 84-foot long precast concrete box culvert on a skew of approximately 15 degrees to the roadway centerline. The invert of the proposed culvert is approximately 11 feet below the existing road grade at the roadway centerline. To facilitate fish passage, Habitat Connectivity Design elements will be used inside the proposed precast concrete box culvert as shown on the Special Details Sheet in the Plans. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V to protect against erosion.

2.0 GEOLOGIC SETTING

The existing culvert carries an unnamed stream under Route 2A in Haynesville and is located 1.33 miles northerly of the Glenwood Plantation town line as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Reconnaissance Surficial Geology of the Mattawamkeag Lake [15-minute] Quadrangle, Maine Open File No. 80-16 (1980) the surficial soils at the site consist of swamp and tidal-marsh deposits. These soils typically consist of peat, silt, sand and clay with poor drainage.

According to the map titled Bedrock Geologic Map of Maine (1985) published by the MGS, the bedrock in the vicinity of the site consists undifferentiated, interbedded Pelite and Sandstone, in part of the Allsbury Formation and in part unnamed.

3.0 SUBSURFACE INVESTIGATION

One (1) boring (HB-HAY-101) and one (1) probe (HB-HAY-102) were drilled on opposite, diagonal corners of the existing structure on August 4, 2016 by the MaineDOT drill crew using a trailer mounted CME 45C drill rig. Exploration locations are shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile with Boring Logs. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on the Boring Logs in Appendix A.

Boring HB-HAY-101 was drilled using solid stem auger, cased wash boring, and rock core drilling techniques. Soil samples were obtained in boring HB-HAY-101 at 5 foot intervals using Standard Penetration Test (SPT) methods. The MaineDOT drilled rig is equipped with an automatic hammer to drive the split spoon. The MaineDOT calibrated automatic hammer delivers approximately 57 percent more energy during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values (N_{60}) computed by applying an average energy transfer of 0.943 to the raw field N-values. Probe HB-HAY-102 was drilled using solid stem auger techniques. No soil samples were obtained in the probe.

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. A Northeast Transportation Training and Certification Program (NETTCP) certified subsurface inspector logged subsurface conditions encountered in the explorations. The boring and probe were located in the field by taping to surveyed site features after completion of the drilling program.

4.0 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 two (2) standard grain size analyses with natural water content and two (2) grain size analyses with hydrometer and natural water content. The results of the laboratory testing program are discussed in the following section and are included in Appendix B – Laboratory Test Results. Laboratory test information is also shown on the Boring Logs in Appendix A.

5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered at the test borings generally consisted of fill overlying till overlying bedrock. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on Sheet 2 – Boring Location Plan & Interpretive Subsurface Profile with Boring Logs.

Boring HB-HAY-101 was drilled to a depth of approximately 15.4 feet below ground surface (bgs) where it a encountered a refusal surface. Bedrock was cored in the boring for a total depth of approximately 20.4 feet bgs. Probe HB-HAY-102 was drilled to a depth of approximately 17.5 feet bgs, where it encountered a refusal surface. The exact nature of the refusal surface was not determined in the probe.

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

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 10.0	Fill – Brown, damp to moist, fine to coarse sand, some gravel, little silt, occasional cobble, and gravelly fine to coarse sand, little silt, occasional cobble.	A-1-b	SM	5.3 to 6.6
10.0 – 15.4	Glacial Till – Grey, wet, fine to coarse sand, some silt, little gravel, trace clay.	A-2-4	SC-SM	10.0 to 11.9
15.4 – 20.4	Bedrock – Undifferentiated, interbedded Pelite and Sandstone, in part of the Allsbury Formation and in part unnamed.	--	--	--

[1]BGS = below ground surface
[2]AASHTO = American Association of State Highway and Transportation Officials
[3]USCS = Unified Soil Classification System
[4]WC% = Water content in percent

SPT N-values taken in the fill ranged from 27 to 30 blows per foot (bpf) indicating that the fill is medium dense in consistency. One SPT N-value taken in the till was 22 bpf, indicating that the till is medium dense in consistency. The Rock Quality Designation (RQD) of the bedrock was determined to be 0 percent in boring HB-HAY-101, which correlates to a Rock Quality of very poor.

Groundwater was not recorded in the boring or the probe. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

6.0 GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following sections discuss geotechnical recommendations for the design and construction of the proposed precast concrete box culvert.

6.1 Precast Concrete Box Culvert Design and Construction

The proposed replacement structure will be a 14-foot span by 6-foot rise by 84-foot long precast concrete box on a skew of approximately 15 degrees to the roadway centerline. The proposed structure inlet and outlet slopes shall be riprapped with slopes no steeper than 2H:1V to protect against erosion. The proposed box culvert shall be designed and constructed in accordance with MaineDOT Standard Specification 534.

The invert of the proposed precast concrete box culvert ranges from approximate elevation 404.24 feet at the inlet end to approximate elevation 403.82 feet at the outlet end with a slope of approximately 0.5%. To facilitate fish passage, Habitat Connectivity Design elements will be used inside the precast concrete box culvert as shown on the Streambed Details Sheets in the Plans.

The full nature of the culvert bearing surface will not become evident until the culvert excavation is made. Any cobbles or boulders in excess of 6 inches encountered at the bedding elevation shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone ¾-Inch. Any disturbed soils at the bedding elevation resulting from excavation activities should be removed by hand prior to placement of the bedding material. The prepared subgrade shall be proofrolled 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.

6.2 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 structure is larger than the existing structure and will result in a net unloading of the site soils at the structure location. Any settlement due to elastic compression of the subgrade soils and bedding material will be immediate and negligible.

6.3 Bearing Resistance

The factored bearing resistances for the precast concrete box culvert bearing on compacted granular bedding material placed on native soils at the service and strength limit states are presented in the table below. Supporting calculations in accordance with AASHTO LRFD Bridge Design Specifications 9th Edition 2020 (LRFD) are provided in Appendix C – Calculations.

Limit State	Resistance Factor φ_b	AASHTO LRFD Reference	Factored Bearing Resistance (ksf)
Service	1.0	Article 10.5.5.1	5.0
Strength	0.45	Table 10.5.5.2.2-1	10.0

6.4 Modulus of Subgrade Reaction

A modulus of subgrade reaction (k_s) equal to 95 pounds per cubic inch shall be used for the structural design of the box culvert's base slab. Calculations are included in Appendix C – Calculations.

6.5 Scour and Riprap

Both the inlet and outlet of the precast concrete box culvert shall be protected against scour with riprap conforming to MaineDOT Standard Specification Section 703.26 Plain and Hand Laid Riprap. 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 bedding material 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.

6.6 Seismic Design Considerations

In conformance with LRFD Article 3.10.1, seismic analysis is not required for buried structures, except where they cross active faults. There are no known active faults in Maine; therefore, seismic analysis is not required.

6.7 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 proposed precast concrete box culvert will require deep 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 soil and underlying bedrock 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.

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.

7.0 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 an existing large culvert (#46921) under State Route 2A in Haynesville, 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.

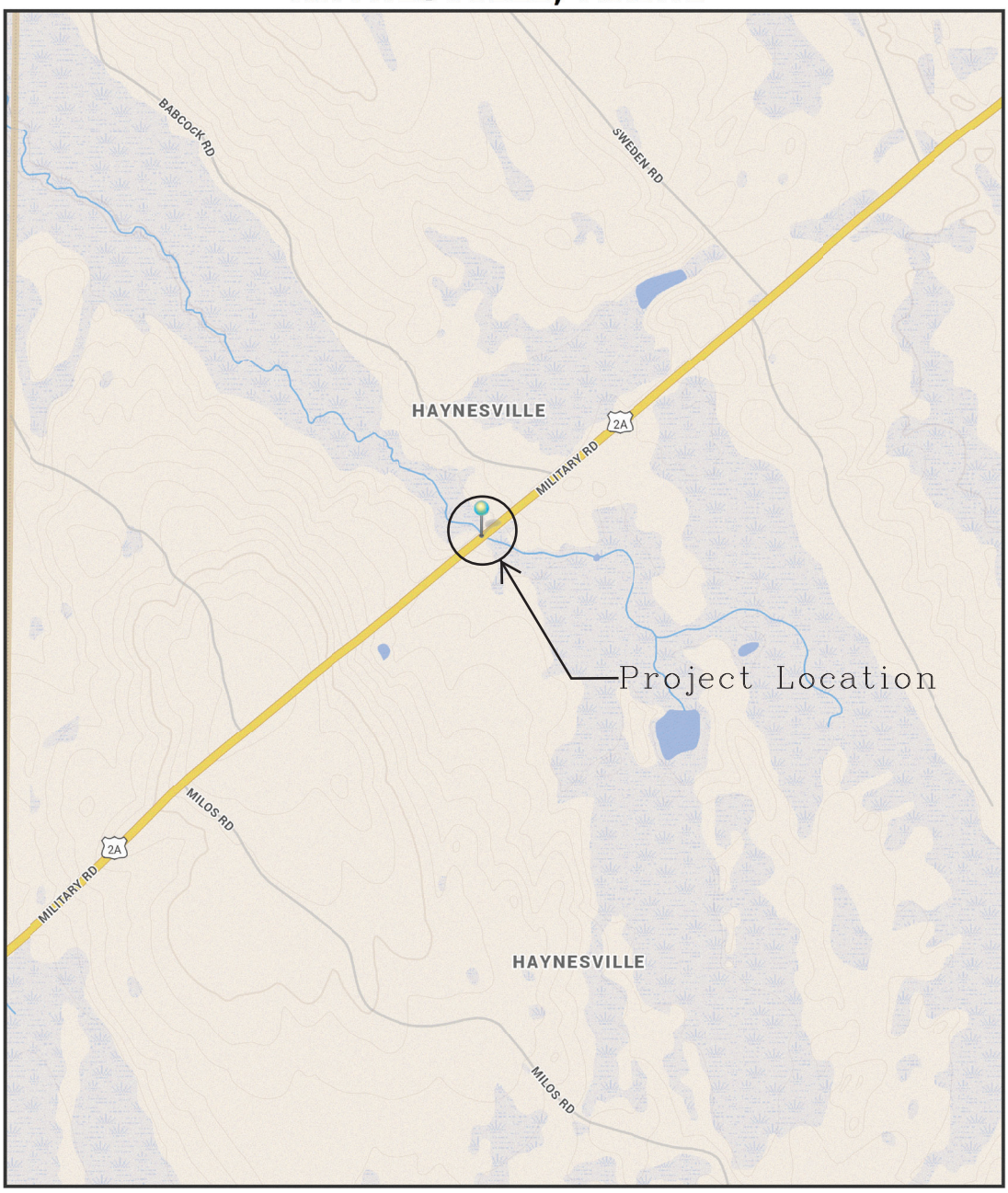
Sheets

Date:1/6/2023

Division: GEOTECH

Username: Cody.A.Russell

HAYNESVILLE, MAINE



The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch.

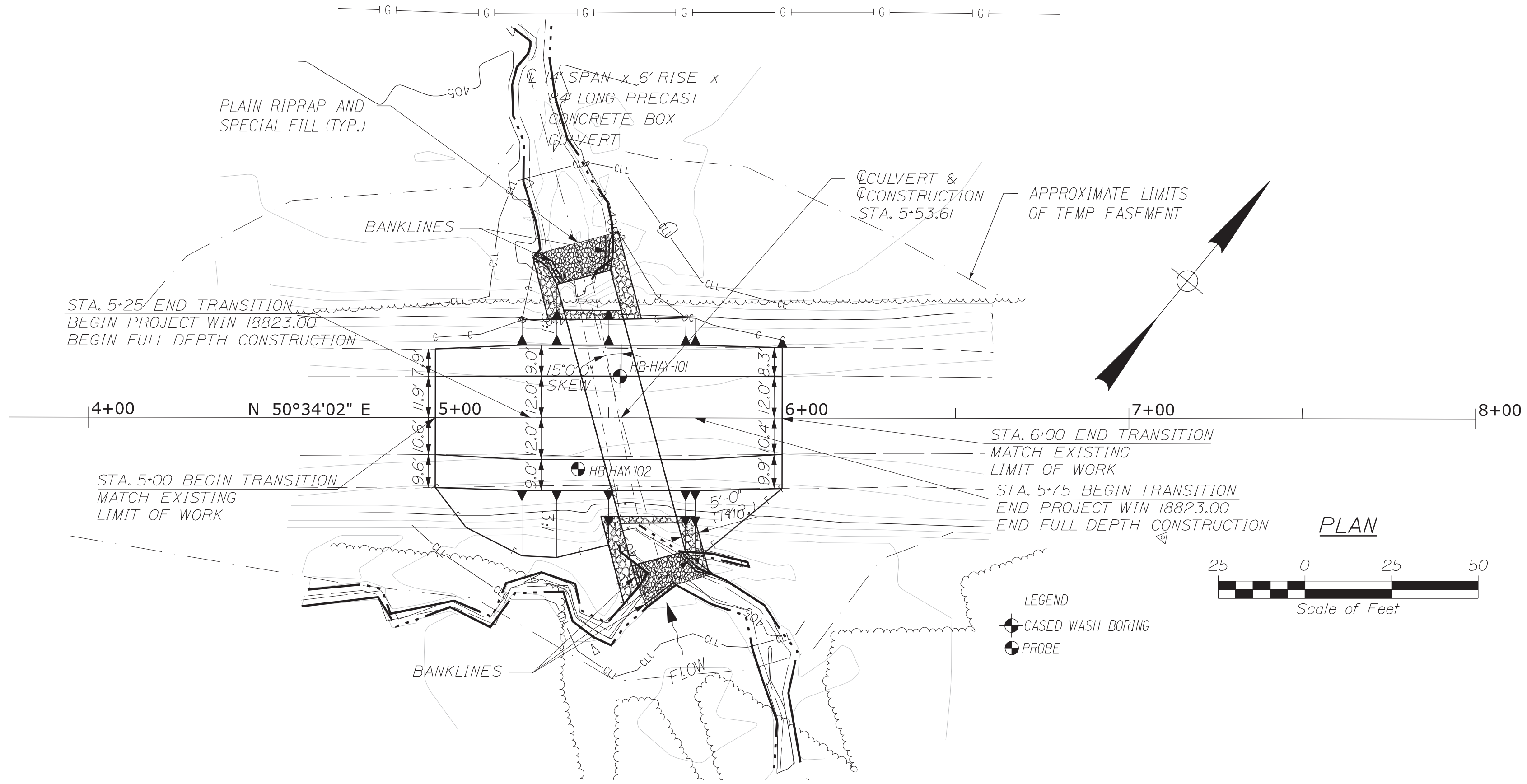
0.35 Miles

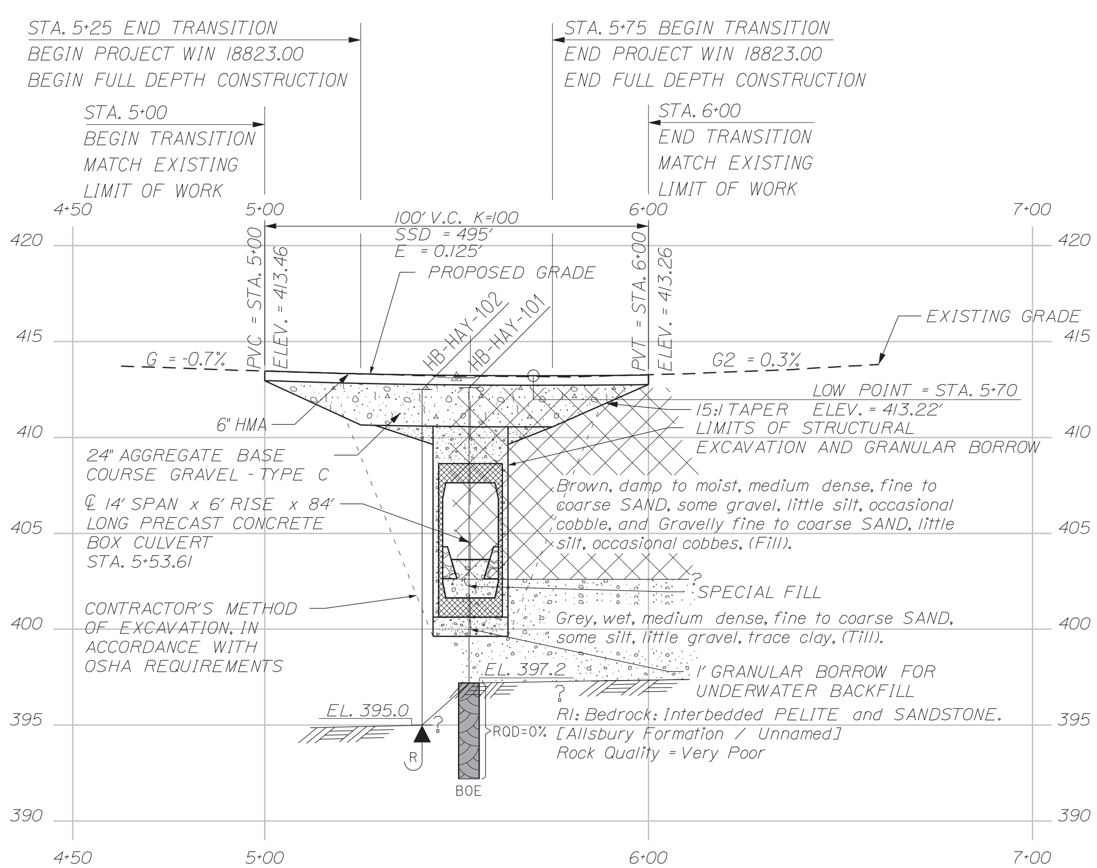
1 inch = 0.38 miles

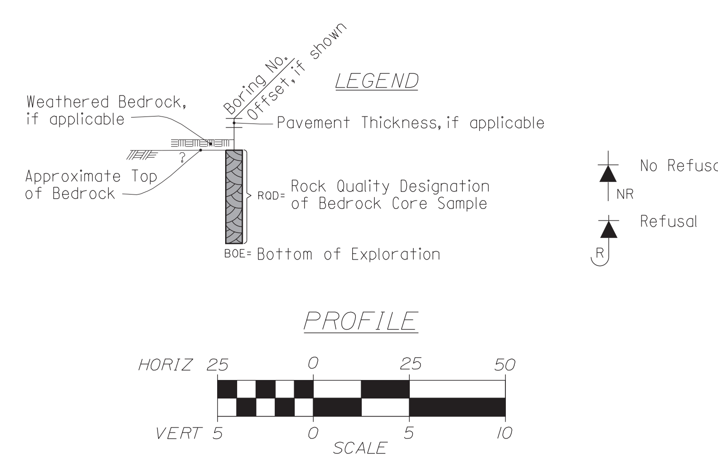
Date: 5/19/2017
Time: 10:07:54 AM

SHEET NUMBER 1 OF 2	ROUTE 2A LARGE CULVERT REPLACEMENT HAYNESVILLE AROOSTOOK COUNTY LOCATION MAP	STATE OF MAINE DEPARTMENT OF TRANSPORTATION 1882300 WIN 18823.00 HIGHWAY PLANS

Filename: ...\MSTA\002_BLP&ISP WBL1.dgn   Division: GEOTECH   Username: Cody.A.Russell   Date:1/31/2023







Note: This generalized interpretive soil profile is intended to conve trends in subsurface conditions. The boundaries between str 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 probabl more erratic. For more specific information refer to the explo logs.

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Route 2A Large Culvert Replacement
Location: Haynesville, Maine

Boring No.: HB-HAY-101
WIN: 18823.00

Driller:	MaineDOT	Elevation (ft.)	412.6	Auger ID/OD:	5" Dia.
Operator:	Daggett/Burpee	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	8/4/2016; 07:30-10:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	5+53.2, 11.9 ft Lt.	Casing ID/OD:	NW-3"	Water Level*:	None Observed
Hammer Efficiency Factor: 0.943		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0	1D	24/16	0.00 - 2.00	4/7/10/11	17	27	SSA		Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, occasional cobble, (Fill).	G#270910 A-1-b, SM WC=5.3%
5	2D	24/18	5.00 - 7.00	10/10/9/11	19	30			Brown, moist, medium dense, Gravelly fine to coarse SAND, little silt, occasional cobble, (Fill).	G#270911 A-1-b, SM WC=6.6%
10	3D	24/19	10.00 - 12.00	6/6/8/8	14	22		402.6	10.0 Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel, trace clay (Till).	G#270912 A-2-4, SC-SM WC=11.9%
15	4D R1	4.8/4.8 60/60	15.00 - 15.40 15.40 - 20.40	50(4.8") RQD = 0%	---		a100 NQ-2	397.2	a100 blows for 0.4 ft. Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel, trace clay, (Till), (Weathered Rock in tip of spoon). 15.4 Top of Bedrock at Elev. 397.2 ft. R1: Bedrock: Grey/white, interbedded PELITE and SANDSTONE [Allsbury Formation / Unnamed]. R1: Core Times (min:sec) 15.4-16.4 ft (2:48) 16.4-17.4 ft (4:49) 17.4-18.4 ft (6:26) 18.4-19.4 ft (5:44) 19.4-20.4 ft (5:42) 100% Recovery	G#270913 A-2-4, SC-SM WC=10.0%
20								392.2	20.4 Bottom of Exploration at 20.4 feet below ground surface.	
25										

Remarks:

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.

Page 1 of 1
Boring No.: HB-HAY-101

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Route 2A Large Culvert Replacement
Location: Haynesville, Maine

Boring No.: HB-HAY-102
WIN: 18823.00

Drilling Contractor:	MaineDOT	Elevation (ft.)	412.5	Auger ID/OD:	5" Dia.
Operator:	Daggett/Burpee	Datum:	NAVD88	Sampler:	N/A
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	N/A
Date Start/Finish:	8/4/2016; 07:30-10:00	Drilling Method:	Solid Stem Auger	Core Barrel:	N/A
Boring Location:	5+41, 14.8 ft Rt.	Casing ID/OD:	N/A	Water Level*:	None Observed

Definitions:
D = Spilt Spoon Sample
S = Sample off Auger Flights
B = Bucket Sample off Auger Flights
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MV = Unsuccessful Field Vane Shear Test Attempt
V = Field Vane Shear Test, PP= Pocket Penetrometer
MU = Unsuccessful Thin Wall Tube Sample 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 1 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-value = Raw Field SPT N-value
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent ≑ = Similar or Equal too
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-value	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0						SSA			Probe, no soil samples taken.	
5										
10										
15							395.00		17.50 Bottom of Exploration at 17.5 feet below ground surface. REFUSAL	
20										
25										

Remarks:

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.

Page 1 of 1
Boring No.: HB-HAY-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
1882300
WIN 18823.00
HIGHWAY PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	C.RUSSELL	T.WHITE	JAN 2023
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE
P.E. NUMBER
DATE

HAYNESVILLE
ROUTE 2A LARGE CULVERT
BORING LOCATION PALN & INTERPRETIVE SUBSURFACE PROFILE WITH BORING LOGS

SHEET NUMBER
2
OF 2

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

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-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-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))

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

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 2A Large Culvert Replacement

Location: Haynesville, Maine

Boring No.: HB-HAY-101

WIN: 18823.00

Driller:	MaineDOT	**Elevation (ft.)**	412.6	**Auger ID/OD:**	5" Dia.
Operator:	Daggett/Burpee	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	8/4/2016; 07:30-10:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	5+53.2, 11.9 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor: 0.943		**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.
	Sample Information										
0	1D	24/16	0.00 - 2.00	4/7/10/11	17	27	SSA			Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, occasional cobble, (Fill).	G#270910 A-1-b, SM WC=5.3%
5	2D	24/18	5.00 - 7.00	10/10/9/11	19	30				Brown, moist, medium dense, Gravelly fine to coarse SAND, little silt, occasional cobble, (Fill).	G#270911 A-1-b, SM WC=6.6%
10	3D	24/19	10.00 - 12.00	6/6/8/8	14	22		402.6		10.0 Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel, trace clay (Till).	G#270912 A-2-4, SC-SM WC=11.9%
15	4D R1	4.8/4.8 60/60	15.00 - 15.40 15.40 - 20.40	50(4.8") RQD = 0%	---		a100 NQ-2	397.2		[a]100 blows for 0.4 ft. Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel, trace clay, (Till), (Weathered Rock in tip of spoon). 15.4 Top of Bedrock at Elev. 397.2 ft. R1: Bedrock: Grey/white, interbedded PELITE and SANDSTONE [Allsbury Formation / Unnamed]. R1: Core Times (min:sec) 15.4-16.4 ft (2:48) 16.4-17.4 ft (4:49) 17.4-18.4 ft (6:26) 18.4-19.4 ft (5:44) 19.4-20.4 ft (5:42) 100% Recovery	G#270913 A-2-4, SC-SM WC=10.0%
20								392.2		20.4 **Bottom of Exploration at 20.4 feet below ground surface.**	
25											

Remarks:

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.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 2A Large Culvert Replacement

Location: Haynesville, Maine

Boring No.: HB-HAY-102

WIN: 18823.00

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	412.5	**Auger ID/OD:**	5" Dia.
Operator:	Daggett/Burpee	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	8/4/2016; 07:30-10:00	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	5+41, 14.8 ft Rt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed

Definitions:
D = Spilt Spoon Sample; S = Sample off Auger Flights; B = Bucket Sample off Auger Flights; MD = Unsuccessful Split Spoon Sample Attempt; U = Thin Wall Tube Sample; MV = Unsuccessful Field Vane Shear Test Attempt; V = Field Vane Shear Test, PP= Pocket Penetrometer
MU = Unsuccessful Thin Wall Tube Sample 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 1 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-value = Raw Field SPT N-value; T_v = Pocket Torvane Shear Strength (psf); WC = Water Content, percent ≅ = Similar or Equal too
LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; G = Grain Size Analysis; C = Consolidation Test

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-value	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0						SSA			Probe, no soil samples taken.	
5										
10										
15										
							395.0		17.5 **Bottom of Exploration at 17.5 feet below ground surface.** REFUSAL	
20										
25										

Remarks:

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

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Haynesville Work Number: 18823.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
HB-HAY-101, 1D	5+53.2	11.9 Lt.	0.0-2.0	270910	1	5.3			SM	A-1-b	II
HB-HAY-101, 2D	5+53.2	11.9 Lt.	5.0-7.0	270911	1	6.6			SM	A-1-b	II
HB-HAY-101, 3D	5+53.2	11.9 Lt.	10.0-12.0	270912	1	11.9			SC-SM	A-2-4	III
HB-HAY-101, 4D	5+53.2	11.9 Lt.	15.0-15.4	270913	1	10.0			SC-SM	A-2-4	III

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

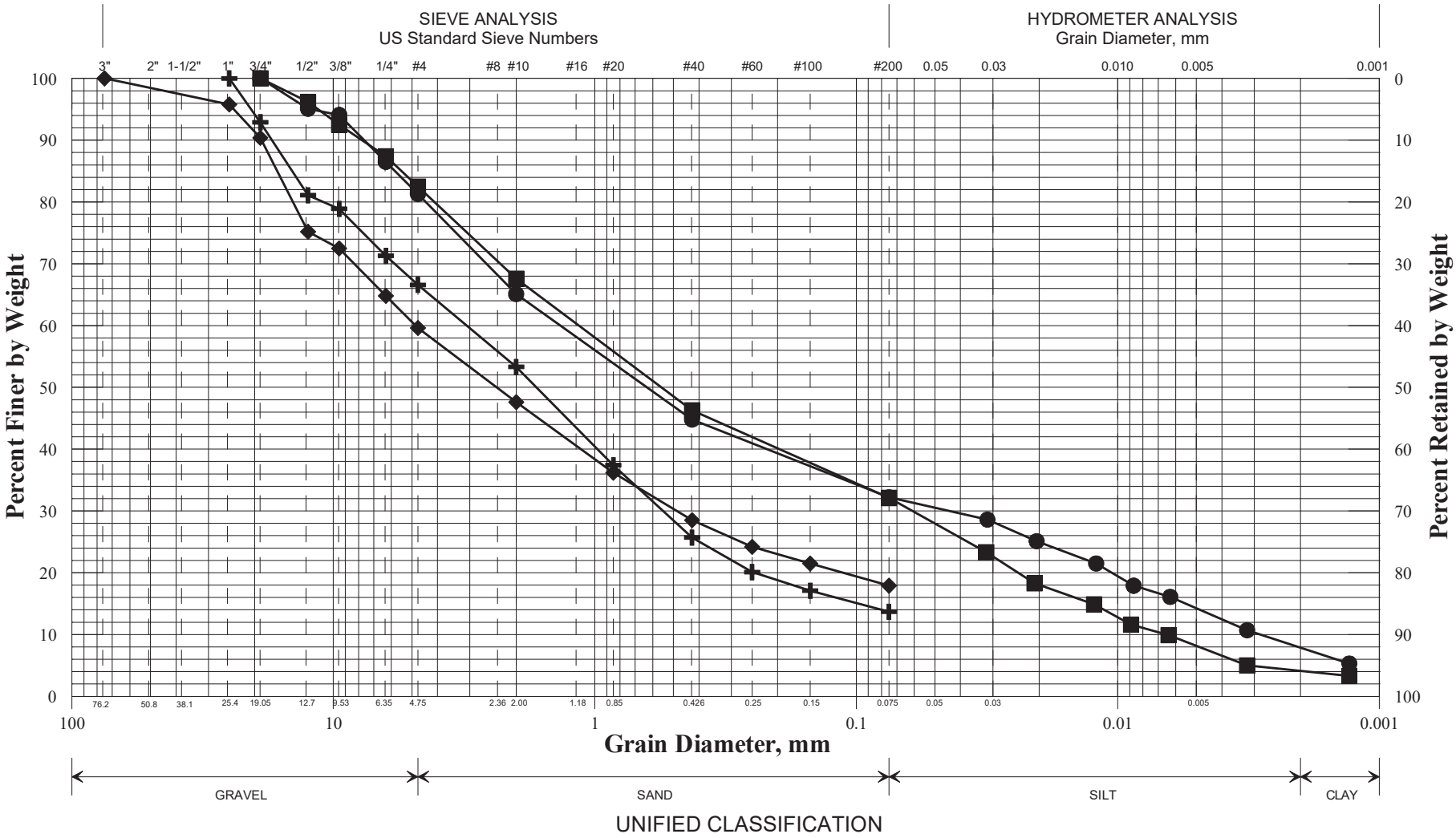
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98 NP = Non Plastic

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	HB-HAY-101/1D	5+53.2	11.9 LT	0.0-2.0	SAND, some gravel, little silt.	5.3			
◆	HB-HAY-101/2D	5+53.2	11.9 LT	5.0-7.0	Gravelly SAND, little silt.	6.6			
■	HB-HAY-101/3D	5+53.2	11.9 LT	10.0-12.0	SAND, some silt, little gravel, trace clay.	11.9			
●	HB-HAY-101/4D	5+53.2	11.9 LT	15.0-15.4	SAND, some silt, little gravel, trace clay.	10.0			
▲									
✖									

WIN
018823.00
Town
Haynesville
Reported by/Date
WHITE, TERRY A 8/17/2016

Appendix C

Calculations

Babcock Bridge	By: Cody Russell
Haynesville	January 4, 2022
WIN 18823.00	Checked by: KM 1/2023

Bearing Resistance - Precast Concrete Box Culvert on Sand:

Part 1 -Service Limit State

Nominal and factored Bearing Resistance

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 9th Edition 2020
Table C10.6.2.5.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Sand (SC-SM). Use values for Silty Sand.
Based on N-values, soils are medium dense near the bearing elevation
Density in Place: medium dense
Bearing Resistance: Ordinary Range (ksf) 4-8

AASHTO Recommended Value of Use: q_{nom}= 5 ksf

Resistance factor at the **service limit state** = 1.0 (LRFD Article 10.5.5.1) φ= 1.0

$q_{factored\_bc}=q_{nom}*\varphi$ $q_{factored\_bc}$= 5 ksf

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

Part 2 - Strength Limit State

Nominal and factored Bearing Resistance - Box Culvert on Sand

Reference: AASHTO LRFD Bridge Design Specifications 9th Edition 2020 - Article 10.6.3.1

Assumptions:

1. The box will be founded at ~ Elev 402.0 feet
   Bottom of Construction will be 2 ft below box invert $D_{footing}$= 2 ft
2. Assumed parameters for fill soils:
   Saturated Unit Weight: γ_s= 125 pcf
   Internal Friction Angle: φ_{ns} = 32 degrees= 0.558505 radians
   Undrained Shear Strength: c_{ns}= 0 psf
3. Box Culvet parameters
   Width of Box Culvert, B B_{box}= 14 ft
   Length of Box Culvert, L L_{box}= 84 ft

Nominal Bearing Resistance per LRFD Equation 10.6.3.1.2a-1

$$q_n=cN_{cm}+\gamma D_f N_{qm} C_{wq}+0.5\gamma B N_{\gamma m} C_{w\gamma}$$

Bearing Capacity Factors - LRFD Table 10.6.3.1.2a-1

For φ=32 deg N_c= 35.5 N_q= 23.2 N_γ= 30.2

Shape Correction Factors LRFD Table 10.6.3.1.2a.-3

for φ=32 degrees

$s_C=1+(B_{box}/L_{box})(N_q/N_c)$ s_C= 1.11

$s_\gamma=1-0.4*(B_{box}/L_{box})$ s_γ= 0.9333

$s_q=1+((B_{box}/L_{box})*\tan(\varphi_{ns}))$ s_q= 1.10

Load Inclination Factors:

Assume all are 1.0 (LRFD Article C10.6.3.1.2a)

i_c= 1.0 i_q= 1.0 i_γ= 1.0

Depth Correction Factor LRFD Eq 10.6.3.1.2a-10

$d_q=1+2*\tan(\varphi_{ns})*(1-\sin(\varphi_{ns}))^2*\tan(D_{footing}/B_{box})^{-1}$ d_q= 2.92

$N_{cm}=N_c*s_c*i_c$ N_{cm}= 39.37

$N_{qm}=N_q*s_q*d_q*i_q$ N_{qm}= 74.80

$N_{\gamma m}=N_\gamma*s_\gamma*i_\gamma$ $N_{\gamma m}$= 28.19

Coefficients for Groundwater Depths LRFD Table 10.6.3.1.2a-2

Depth to the water table: D_w = 0 ft C_{wq}= 0.5 $C_{w\gamma}$= 0.5

$q_{nominal}=c_{ns}*N_{cm}+\gamma_s*D_{footing}*N_{qm}*C_{wq}+0.5*(\gamma_s)*B_{box}*N_{\gamma m}*C_{w\gamma}$

$q_{nominal}$= 21.7 ksf Resistance Factor φ_b= 0.45

$q_{factored}=q_{nominal}*\varphi_b$ $q_{factored}$= 9.756656144

Recommend a limiting factored bearing resistance of 10.0 ksf for the Strength Limit State.

Modulus of Subgrade Reaction

Reference: Foundation Analysis and Design 5th Edition JE Bowles Section 9-6

Width of Box Culvert, B	B_{box}=	14	ft	
Length of Box Culvert, L	L_{box}=	84	ft	
Thickness of box culvert, t	t_{box}=	12	in	assumed
Depth of box, D	D_{box}=	11	ft	
Bearing Resistance:	$q_{factored\_bc}$=	5	ksf	calculated above

Modulus of Elasticity: Site soils at bearing elevation are sand.
From Bowles Table 2-8 Modulus E_s for dense sand ranges from 1000 to 1700 ksf

Use Modulus of Elasticity, E_s= 1000 ksf

Poisson's Ratio: Site conditions at bearing elevation are sand.
From Bowles Table 2-7 Possion's Ratio μ for sand ranges from 0.3 to 0.4.

Use Poisson's Ratio, μ= 0.35

$E_{prime\_s}=(1-\mu^2)/E_s$ E_{prime_s}= 0.0008775 ft^2/kip

Analyze corner:

Take H as 5*B as recommended in Bowles Chapter 5

$H_{inf}=(5*B_{box})/B_{box}$ H_{inf}= 5 N in Table 5-2

L_{box}/B_{box}= 6.0 M in Table 5-2

I_1= 0.548

I_2= 0.120

Determine Steinbrenner influence factor - Bowles Section 5-6, Eq 5-16c, pg 306

$I_s=I_1+[(1-(2*\mu))/(1-\mu)*I_2$ I_s= 0.6034

Determine Influence factor for footing depth - Bowles Figure 5-7

Depth ratio: D_{box}/B_{box}= 0.785714 L_{box}/B_{box}= 6.0

μ= 0.35 I_F= 0.85

Calculate Modulus of Subgrade Reaction

$k_s=1/(B_{box}*E_{prime\_s}*I_s*I_F)$ Bowles Eq. 9-7

k_s= 158.7127 kcf k_s= 92 pci

Recommend Modulus of Subgrade Reaction of 95 pci