MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Construction of

ALFORD BROOK BRIDGE
ROUTE 235
WARREN, MAINE

Prepared by:
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Geotechnical Engineer

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Knox County
WIN 21835.00

Soils Report 2022-35
Bridge No. 6578

December 21, 2022

Table of Contents

1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of an existing large culvert (#46645) on Route 235 in Warren, 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 consists of an approximately 84-inch diameter, 57-foot long corrugated metal pipe (CMP) culvert with an approximately 48-inch diameter, 64-foot long CMP overflow culvert. The 84-inch diameter culvert is in poor condition, and is unzipped along its entire length. Route 235 is a Highway Corridor Priority 4 road.

The proposed replacement structure will be a 17-foot span by 7-foot rise by 100-foot long precast concrete box culvert on a skew of approximately 31 degrees to 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 invert of the proposed culvert is approximately 13.6 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 2H:1V to protect against erosion.

2.0 GEOLOGIC SETTING

The existing culvert carries Alford Brook under Route 235 in Warren and is located approximately 0.06 of a mile north of the Waldoboro town line as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Surficial Geology Union Quadrangle, Maine, Open File 14-25 (2014) the surficial soils at the site consist of Presumpscot Formation. Presumpscot Formation consists of glaciomarine silt, clay, and sand.

According to the map titled Bedrock Geologic Map of Maine (1985) published by the MGS, the bedrock in the vicinity of the site consists of Pelite of the Appleton Ridge Formation.

3.0 SUBSURFACE INVESTIGATION

One (1) boring (HB-WAR-101) and one (1) probe (HB-WAR-102) were drilled on opposite, diagonal corners of the existing structure on October 4, 2016 by the MaineDOT drill crew using a trailer mounted 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-WAR-101 was drilled using solid stem auger and cased wash boring drilling techniques. Soil samples were obtained in boring HB-WAR-101 at 5-foot intervals using Standard Penetration Test (SPT) methods. The MaineDOT drill 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 factor of 0.943 to the raw field N-values. One (1) in-situ vane shear test was conducted in the cohesive soils using a Geonor 55-mm by 110-mm rectangular vane. Probe HB-WAR-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. An experienced geotechnical engineer logged the subsurface conditions encountered in the boring and probe. 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 three (3) standard grain size analysis with natural water content, three (3) standard grain size analyses with hydrometer and natural water content, and one (1) Atterberg Limits test. 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 in the test boring and probe generally consisted of fill consisting of gravelly sand and sand underlain by Presumpscot Formation consisting of sandy silt and silt underlain by sand. 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-WAR-101 was drilled to a depth of approximately 24.0 feet below ground surface (bgs) and did not encounter a refusal surface. Probe HB-WAR-102 was drilled to a depth of approximately 23.9 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 obtained in boring HB-WAR-101:

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 0.3	HMA Pavement	--	--	--
0.3 – 9.5	Fill – Brown, damp, gravelly fine to coarse sand, little silt. Brown, moist, fine to coarse sand, some gravel, some silt.	A-1-b A-2-4	SM SW-SM	3.1 19.9
9.5 – 22.0	Presumpscot Formation – Greyish brown and dark grey, wet, fine to coarse sandy silt, trace clay, trace gravel. Grey, wet, silt, some clay, some fine to medium sand.	A-4	CL	26.0-40.6
22.0 – 24.0	Grey, wet, medium dense, fine to coarse sand, some silt, little gravel.	A-2-4 or A-4	SM	16.0

[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

N_{60}-values obtained in the fill ranged from 11 to 20 blows per foot (bpf) indicating that the fill is medium dense in consistency. N_{60}-values obtained in the Presumpscot Formation ranged from Weight of Hammer to 11 bpf indicating that Presumpscot Formation is very soft to stiff in consistency. One (1) N_{60}-value obtained in the sand was 16 bpf, indicating that the sand is medium dense in consistency.

One (1) vane shear test conducted within the sandy silt layer showed a measured undrained shear strength of approximately 580 pounds per square foot (psf) with a remolded shear strength of approximately 89 psf. Based on the ratio of undrained to remolded shear strength from the vane shear test, the sandy silt was determined to have a sensitivity of approximately 6.5 and is classified as sensitive.

The following table summarizes the results of Atterberg Limits tests done on one (1) sample of the sandy silt:

Boring No. and Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
HB-WAR-101 5D	27.4	27	20	7	1.06

Interpretation of these results indicate that the sandy silt has low plasticity. The sandy silt is on the verge of being a viscous liquid if disturbed. Overburden pressure and interparticle cementation is providing stability to keep the soil in its current state, but the slightest disturbance causing remolding could convert the soil into a viscous fluid.

Groundwater was recorded at a depth of approximately 17.5 feet bgs in 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 consist of a 17-foot span by 7-foot rise by 100-foot-long precast concrete box culvert on a skew of approximately 32 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 box culvert ranges from approximately 91.0 feet at the inlet end to approximately 90.9 feet at the outlet end with a slope of approximately 0.15%. 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 proposed structure shall be bedded on a 2-foot thick, geotextile wrapped, geogrid reinforced, crushed stone mat (Culvert Bedding Stone; Pay Item 203.55). The geogrid reinforcement shall meet the requirements of Special Provision 620, attached. The Reinforcement Geotextile shall meet the requirements of MaineDOT Standard Specification 722.01. The soils at the bedding elevation shall be excavated using a smooth-edged backhoe bucket to limit disturbance. Any disturbed soils at the bedding elevation resulting from excavation activities shall be removed by hand prior to placement of the geotextile wrapped, geogrid reinforced, crushed stone mat. All subgrade surfaces should be protected from construction traffic in order to limit disturbance. Groundwater and surface water levels shall be depressed sufficiently to allow work in the dry.

The soil backfill shall consist of Granular Borrow (703.19) with a maximum particle size of 4 inches. The Granular Borrow backfill 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, to at least 92 percent of the AASHTO T-180 maximum dry density. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

6.2 Settlement

No settlement issues are anticipated at the site. The proposed precast concrete box culvert will be constructed at a new location south (down station) of the existing culvert overlapping portions of the two (2) existing culvert locations. The proposed precast concrete box culvert is larger than both of the existing culverts and will result in a net unloading of the site soils at the proposed structure location. Placement of fill soils at the location of the existing structures is not anticipated to exceed the past loading condition of the site soils. Any settlement due to elastic compression of the 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	1.0
Strength	0.45	Table 10.5.5.2.2-1	1.5

6.4 Modulus of Subgrade Reaction

A modulus of subgrade reaction (k_s) equal to 10 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 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.

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 may 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 native silts 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 soils at the bedding elevation shall be excavated using a smooth-edged backhoe bucket to limit disturbance. Any disturbed soils at the bedding elevation resulting from excavation activities shall be removed by hand prior to placement of the geotextile wrapped, geogrid reinforced, crushed stone mat. All subgrade surfaces should be protected from construction traffic in order to limit disturbance. Groundwater and surface water levels shall be depressed sufficiently to allow work in the dry.

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 for specific application to the proposed replacement of an existing large culvert (#46645) under Route 235 in Warren, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

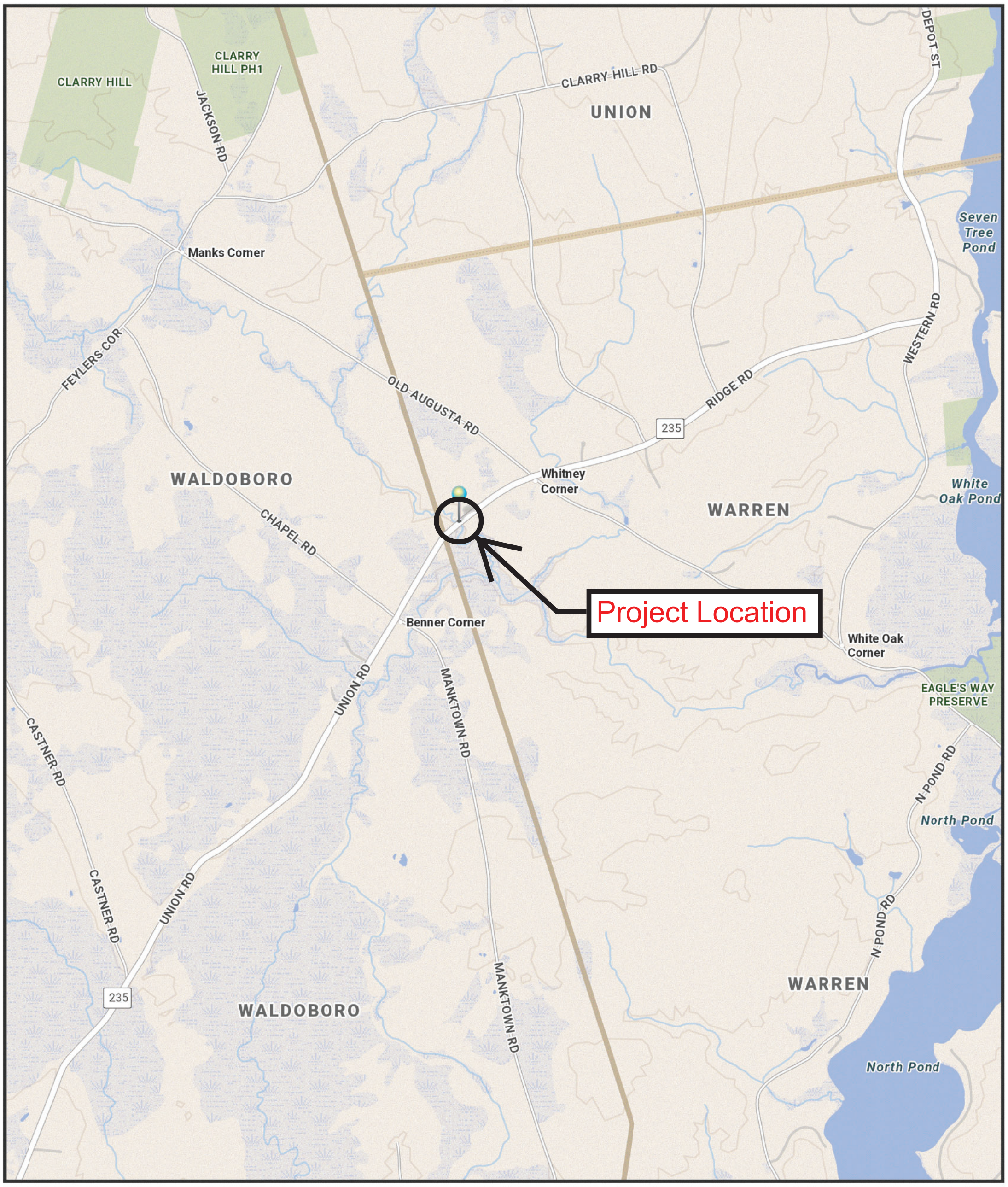
In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes 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

Username: Cody.A.Russell Division: GEOTECH Date:12/15/2022

WARREN, MAINE

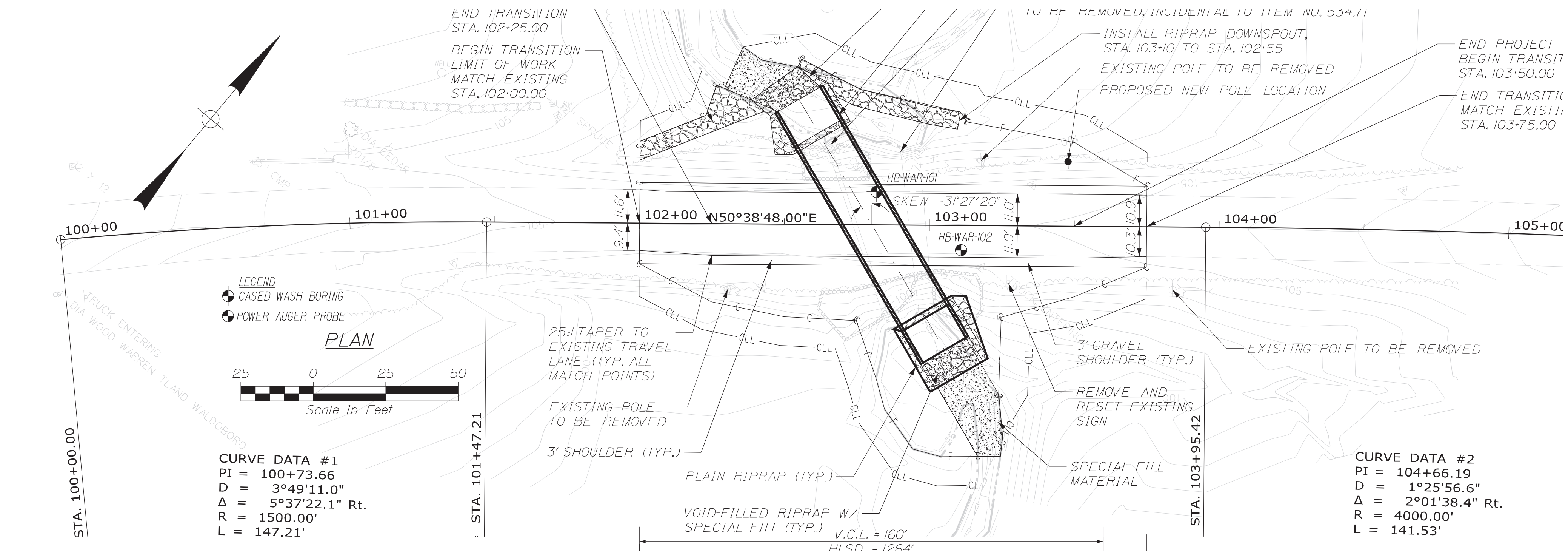


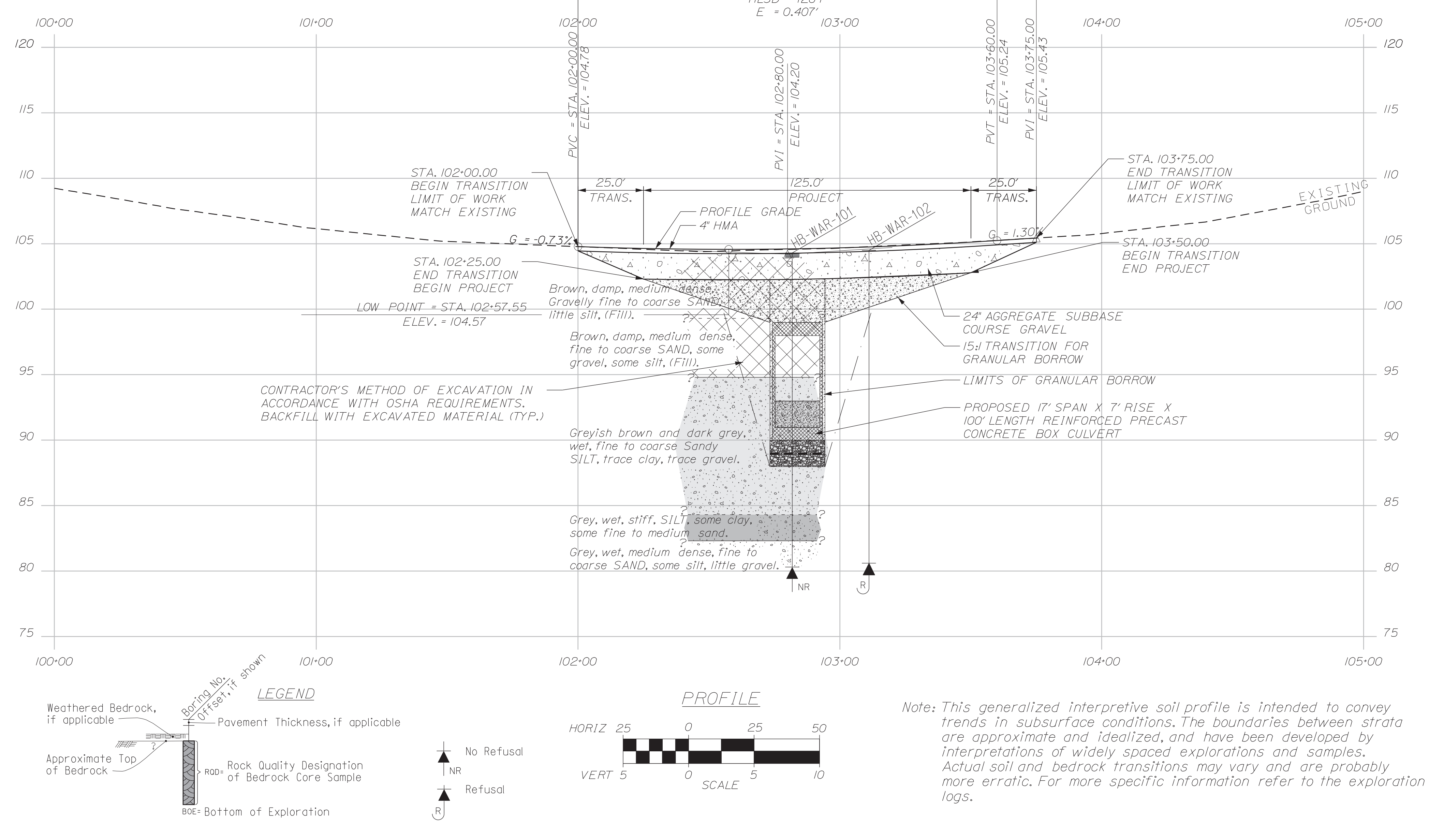
0.5 Miles
1 inch = 0.57 miles

Date: 12/8/2022
Time: 12:21:50 PM

SHEET NUMBER	WARREN ROUTE 235	STATE OF MAINE DEPARTMENT OF TRANSPORTATION
1		021835.00
OF 2	LOCATION MAP	WIN 21835.00 HIGHWAY PLANS

Date:12/22/2022
Username: Cody.A.Russell
Division: GEOTECH
Filename: ...\MSTA\002_BLP&ISP wBL1.dgn





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.

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Alford Brook Bridge Route 235.
Location: Warren, Maine
Boring No.: HB-WAR-101
WIN: 21835.00

Driller:	MaineDOT	Elevation (ft.)	104.3	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Burpee	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	Be Schonewald	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	10/4/2016; 09:05-11:50	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	102+81.8, 11.5 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
0							SSA	104.0		4" HMA. 0.3	
	1D	24/13	2.50 - 4.50	5/6/7/7	13	20				Brown, damp, medium dense, Gravelly fine to coarse SAND, little silt, (Fill).	G#304215 A-1-a, SW-SM WC=3.1%
5	2D	24/8	5.00 - 7.00	7/4/3/2	7	11	10	99.3		5.0 Brown, moist, medium dense, fine to coarse SAND, some gravel, some silt; 1-inch thick seam Silty fine to medium SAND in bottom of sample.	G#304216 A-2-4, SM WC=19.9%
							9				
							15				
							15				
							18	94.8		9.5	
10	3D	24/16	10.00 - 12.00	1/2/5/4	7	11	11			Greyish brown, wet, stiff, fine to coarse Sandy SILT, trace clay, trace gravel with wood fibers throughout; 2-inch thick seam grey, Sandy SILT, near bottom of sample.	G#304217 A-4, CL WC=38.1%
							39				
							33				
							31				
							30				
15	4D	24/20	15.00 - 17.00	WOH/WOH/WOH/1	---		23			Dark grey, wet, very soft, fine to medium Sandy SILT, trace clay.	G#304218 A-4, CL WC=40.6%
							25				
	5D V1	24/24	17.00 - 19.00	vane interval Su=580/89 psf	---		24			Dark grey, wet, very soft, fine to medium Sandy SILT, trace clay. 55x110 mm vane raw torque readings: V1: 13.0/2.0 ft-lbs. Failed 55x100 mm vane attempt, unable to push beyond 18.8 ft bgs.	#304219 A-4, CL-ML WC=27.4% LL=27 PL=20 PI=7
	MV		17.63 - 18.00				24				
							24				
20	6D	24/12	20.00 - 22.00	2/4/3/17	7	11		84.3		20.0 Grey, wet, stiff, SILT, some clay, some fine to medium sand.	G#304220 A-4, CL WC=26.0%
	7D	24/12	22.00 - 24.00	7/6/4/5	10	16		82.3		22.0 Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel.	G#304221 A-2-4, SM WC=16.0%
								80.3		24.0 Bottom of Exploration at 24.0 feet below ground surface. NO REFUSAL	
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-WAR-101

Maine Department of Transportation
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Alford Brook Bridge Route 235.
Location: Warren, Maine
Boring No.: HB-WAR-102
WIN: 21835.00

Drilling Contractor:	MaineDOT	Elevation (ft.)	104.5	Auger ID/OD:	5" Dia.
Operator:	Daggett/Burpee	Datum:	NAVD88	Sampler:	N/A
Logged By:	Be Schonewald	Rig Type:	CME 45C	Hammer Wt./Fall:	N/A
Date Start/Finish:	10/4/2016; 12:10-12:50	Drilling Method:	Soild Stem Auger	Core Barrel:	N/A
Boring Location:	103+11.1, 8.4 ft Rt.	Casing ID/OD:	N/A	Water Level*:	Approx. 17.5 ft bgs (open)

Definitions: D = Split 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	104.17		4" HMA. 0.33 Brown, Gravelly fine to coarse SAND, little to some silt, boney. Based on auger cuttings.	
5									Approximately change to less boney material; smooth, easy advancement.	
10										
15										
20									Silty CLAY with fine sand noted in auger cuttings.	
									Fetch up; difficult, but not grinding.	
							80.60		23.90 Bottom of Exploration at 23.9 feet below ground surface. AUGER REFUSAL	
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-WAR-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
021835.00
HIGHWAY PLANS
WIN
21835.00

SIGNATURE
P.E. NUMBER
DATE

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	C.RUSSELL	
DESIGN3-DETAILED3	T.WHITE	DEC 2022
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

WARREN
ROUTE 235

BORING LOCATION PLAN & 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

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-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):

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

*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	

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Alford Brook Bridge Route 235.
Location: Warren, Maine

Boring No.: HB-WAR-101
WIN: 21835.00

Driller:	MaineDOT	**Elevation (ft.)**	104.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Burpee	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	Be Schonewald	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	10/4/2016; 09:05-11:50	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	102+81.8, 11.5 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.
0							SSA	104.0		4" HMA. 0.3	
	1D	24/13	2.50 - 4.50	5/6/7/7	13	20				Brown, damp, medium dense, Gravelly fine to coarse SAND, little silt, (Fill).	G#304215 A-1-a, SW-SM WC=3.1%
5	2D	24/8	5.00 - 7.00	7/4/3/2	7	11	10			Brown, medium dense, fine to coarse SAND, some gravel, some silt; 1-inch thick seam Silty fine to medium SAND in bottom of sample.	G#304216 A-2-4, SM WC=19.9%
							9				
							15				
							15				
							18	94.8		9.5	
10	3D	24/16	10.00 - 12.00	1/2/5/4	7	11	11			Greyish brown, stiff, fine to coarse Sandy SILT, trace clay, trace gravel with wood fibers throughout; 2-inch thick seam grey, Sandy SILT, near bottom of sample.	G#304217 A-4, CL WC=38.1%
							39				
							33				
							31				
							30				
15	4D	24/20	15.00 - 17.00	WOH/WOH/WOH/1	---		23			Dark grey, very soft, fine to medium Sandy SILT, trace clay.	G#304218 A-4, CL WC=40.6%
							25				
	5D V1	24/24	17.00 - 19.00 17.63 - 18.00	vane interval Su=580/89 psf	---		24			Dark grey, very soft, fine to medium Sandy SILT, trace clay. 55x110 mm vane raw torque readings: V1: 13.0/2.0 ft-lbs. Failed 55x100 mm vane attempt, unable to push beyond 18.8 ft bgs.	#304219 A-4, CL-ML WC=27.4% LL=27 PL=20 PI=7
	MV						24				
							24				
20	6D	24/12	20.00 - 22.00	2/4/3/17	7	11				Grey, stiff, SILT, some clay, some fine to medium sand.	G#304220 A-4, CL WC=26.0%
	7D	24/12	22.00 - 24.00	7/6/4/5	10	16		82.3		22.0 Grey, wet, medium dense, fine to coarse SAND, some silt, little gravel.	G#304221 A-2-4, SM WC=16.0%
								80.3		24.0 **Bottom of Exploration at 24.0 feet below ground surface.** NO REFUSAL	
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: Alford Brook Bridge Route 235.
Location: Warren, Maine

Boring No.: HB-WAR-102
WIN: 21835.00

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	104.5	**Auger ID/OD:**	5" Dia.
Operator:	Daggett/Burpee	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	Be Schonewald	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	10/4/2016; 12:10-12:50	**Drilling Method:**	Soild Stem Auger	**Core Barrel:**	N/A
Boring Location:	103+11.1, 8.4 ft Rt.	**Casing ID/OD:**	N/A	**Water Level*:**	Approx. 17.5 ft bgs (open)

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	104.2		4" HMA. 0.3	
									Brown, Gravelly fine to coarse SAND, little to some silt, boney. Based on auger cuttings.	
5										
									Approximately change to less boney material; smooth, easy advancement.	
10										
15										
20									Silty CLAY with fine sand noted in auger cuttings.	
									Fetch up; difficult, but not grinding.	
							80.6		23.9	
									Bottom of Exploration at 23.9 feet below ground surface. AUGER REFUSAL	
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): Warren   Work Number: 21835.00

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-WAR-101, 1D	102+81.8	11.5 Lt.	2.5-4.5	304215	1	3.1			SW-SM	A-1-a	0
HB-WAR-101, 2D	102+81.8	11.5 Lt.	5.0-7.0	304216	1	19.9			SM	A-2-4	II
HB-WAR-101, 3D	102+81.8	11.5 Lt.	10.0-12.0	304217	1	38.1			CL	A-4	IV
HB-WAR-101, 4D	102+81.8	11.5 Lt.	15.0-17.0	304218	1	40.6			CL	A-4	IV
HB-WAR-101, 5D	102+81.8	11.5 Lt.	17.0-19.0	304219	---	27.4	27	7	CL-ML	A-4	IV
HB-WAR-101, 6D	102+81.8	11.5 Lt.	20.0-22.0	304220	2	26.0			CL	A-4	IV
HB-WAR-101, 7D	102+81.8	11.5 Lt.	22.0-24.0	304221	2	16.0			SM	A-2-4	II

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.

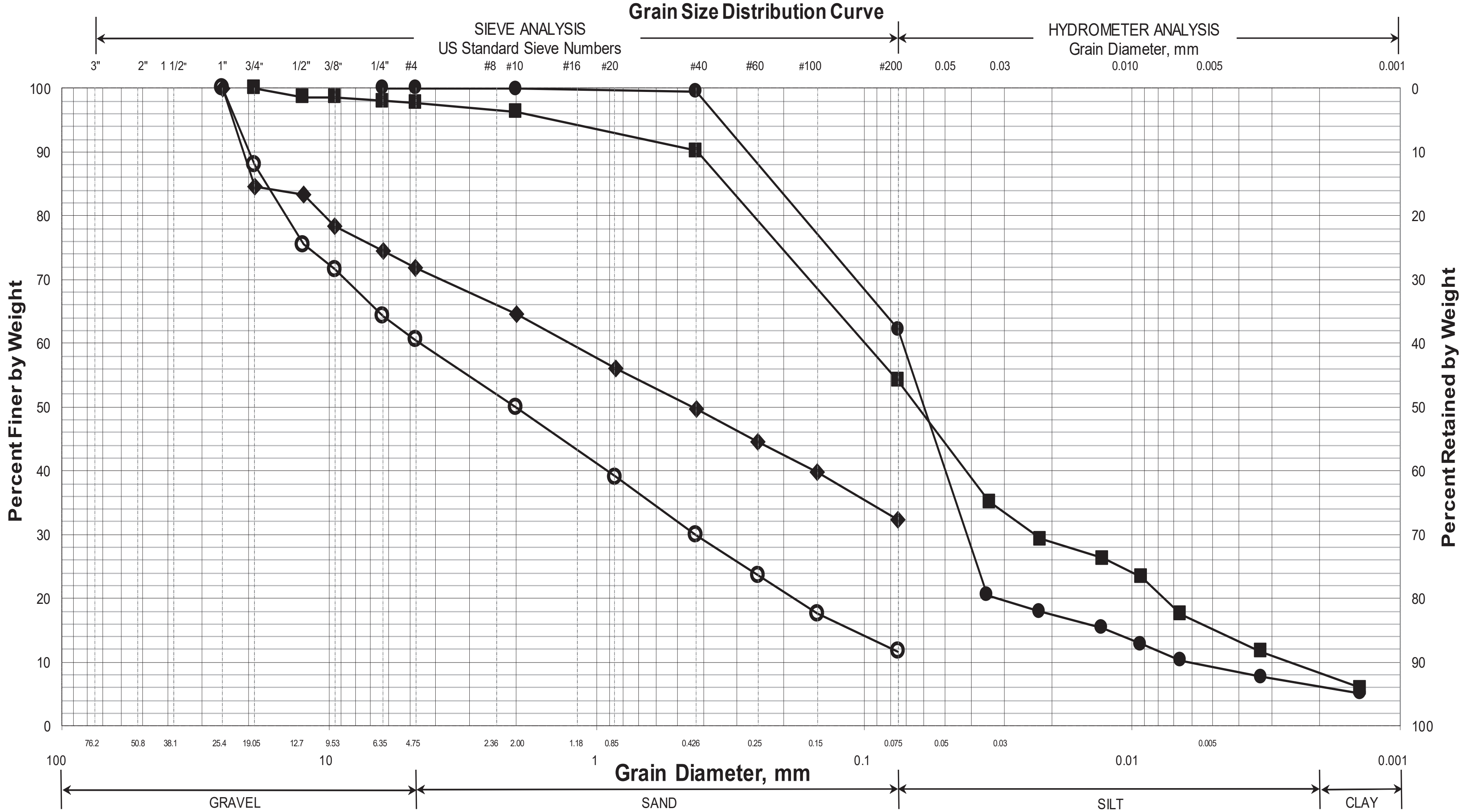
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

Maine Department of Transportation
Grain Size Distribution Curve



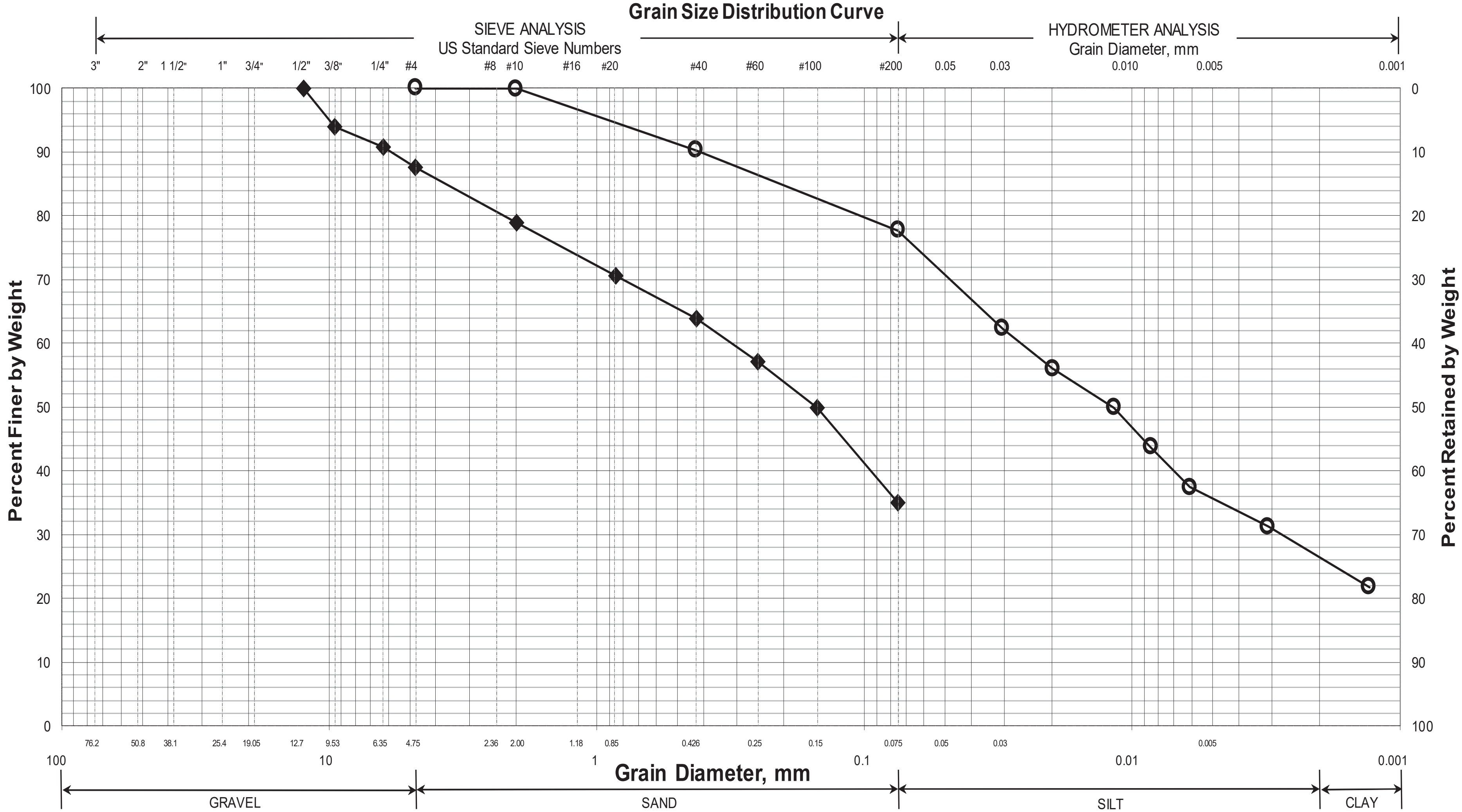
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-WAR-101/1D	102+81.8	11.5 LT	2.5-4.5	Gravelly SAND, little silt.	3.1			
◆	HB-WAR-101/2D	102+81.8	11.5 LT	5.0-7.0	SAND, some gravel, some silt.	19.9			
■	HB-WAR-101/3D	102+81.8	11.5 LT	10.0-12.0	Sandy SILT, trace clay, trace gravel.	38.1			
●	HB-WAR-101/4D	102+81.8	11.5 LT	15.0-17.0	Sandy SILT, trace clay.	40.6			
▲									
×									

WIN
021835.00
Town
Warren
Reported by/Date
WHITE, TERRY A 12/8/2022

SHEET 1

Maine Department of Transportation
Grain Size Distribution Curve



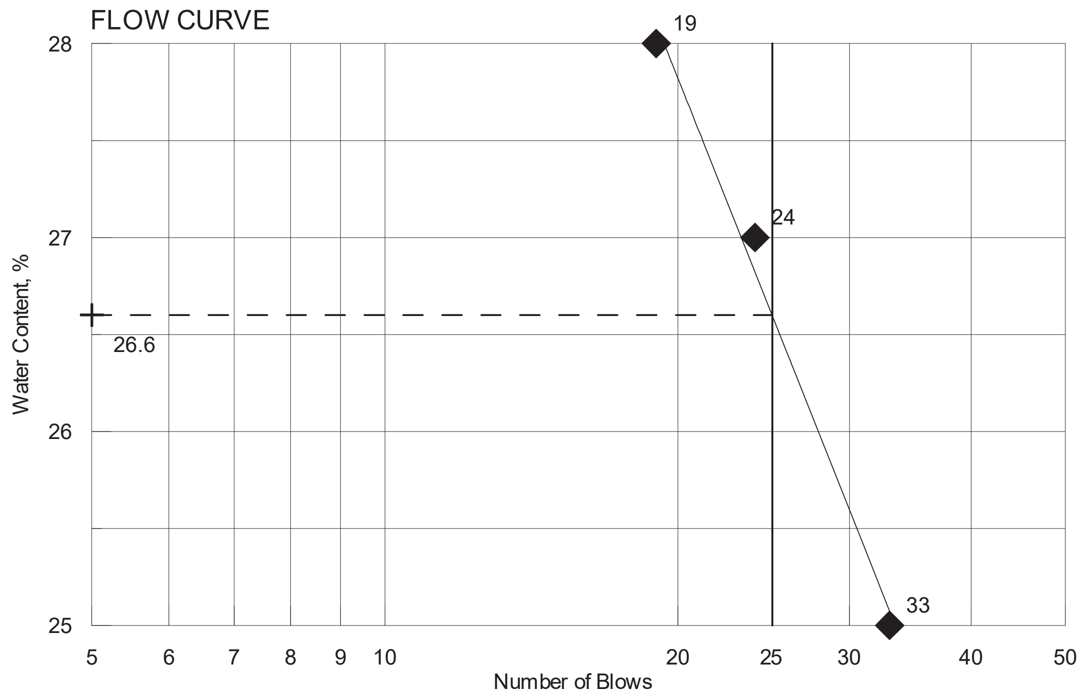
UNIFIED CLASSIFICATION

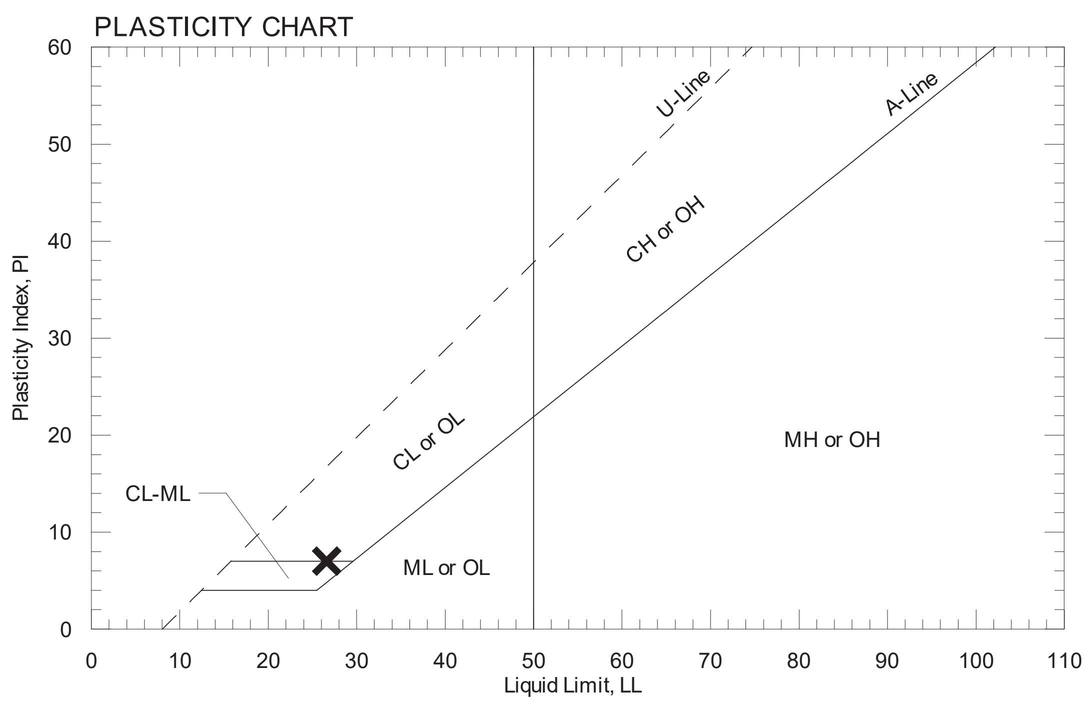
	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-WAR-101/6D	102+81.8	11.5 LT	20.0-22.0	SILT, some clay, some sand.	26.0			
◆	HB-WAR-101/7D	102+81.8	11.5 LT	22.0-24.0	SAND, some silt, little gravel.	16.0			
■									
●									
▲									
×									

WIN	
021835.00	
Town	
Warren	
Reported by/Date	
WHITE, TERRY A	12/8/2022

SHEET 2

TOWN	Warren	Reference No.	304219
WIN	021835.00	Water Content, %	27.4
Sampled	10/4/2016	Liquid Limit @ 25 blows (T 89), %	27
Boring No./Sample No.	HB-WAR-101/5D	Plastic Limit (T 90), %	20
Station	102+81.8	Plasticity Index (T 90), %	7
Depth	17.0-19.0	Tested By	BBURR





Appendix C

Calculations

Alford Brook Bridge	By: Cody Russell
Warren	December 8, 2022
WIN 21835.00	Checked by: KM 12/2022

Bearing Resistance - Precast Concrete Box Culvert on Sandy Silt:

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: Sandy Silt (CL). Use values for Silty Sand.
Based on N-values, soils are very soft near the bearing elevation
Density in Place: loose
Bearing Resistance: Ordinary Range (ksf) 1-2

AASHTO Recommended Value of Use: q_{nom}= 1 ksf

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

$q_{factored\_bc}=q_{nom}*\varphi$ $q_{factored\_bc}$= 1 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 Sandy Silt

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

Assumptions:

1. The box will be founded at ~ Elev 90.0 feet
   Bottom of Construction will be 3 ft below box invert $D_{footing}$= 3 ft
2. Assumed parameters for foundation soils:

Saturated Unit Weight:	γ_s=	125	pcf		
Internal Friction Angle:	φ_{ns} =	0	degrees=	0	radians
Undrained Shear Strength:	c_{ns}=	580	psf		

3. Box Culvet parameters

Width of Box Culvert, B	B_{box}=	17	ft
Length of Box Culvert, L	L_{box}=	100	ft

Nominal Bearing Resistance per LRFD Equation 10.6.3.1.2a-1

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

Bearing Capacity Factors - LRFD Table 10.6.3.1.2a-1

For φ=0 deg N_c= 5.14 N_q= 1 N_γ= 0

Shape Correction Factors LRFD Table 10.6.3.1.2a.-3

for φ=0 degrees

$s_C=1+B_{box}/(5*L_{box})$ s_C= 1.03

$s_\gamma=1$ s_γ= 1.0

$s_q=1$ s_q= 1.0

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= 1.00

$N_{cm}=N_c*s_c*i_c$ N_{cm}= 5.31

$N_{qm}=N_q*s_q*d_q*i_q$ N_{qm}= 1.00

$N_{\gamma m}=N_\gamma*s_\gamma*i_\gamma$ $N_{\gamma m}$= 0.00

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

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

$q_{nominal}$= 3.3 ksf Resistance Factor φ_b= 0.45

$q_{factored}=q_{nominal}*\varphi_b$ $q_{factored}$= 1.470285

Recommend a limiting factored bearing resistance of 1.5 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}=	17	ft	
Length of Box Culvert, L	L_{box}=	100	ft	
Thickness of box culvert, t	t_{box}=	12	in	assumed
Depth of box, D	D_{box}=	11.6	ft	
Bearing Resistance:	$q_{factored\_bc}$=	1	ksf	calculated above

Modulus of Elasticity: Site soils at bearing elevation are sandy silt.
From Bowles Table 2-8 Modulus E_s for silt ranges from 40 to 400 ksf

Use Modulus of Elasticity, E_s= 100 ksf

Poisson's Ratio: Site conditions at bearing elevation are sandy silt. Use values for silt.
From Bowles Table 2-7 Possion's Ratio μ for silt ranges from 0.3 to 0.35.

Use Poisson's Ratio, μ= 0.3

$E_{prime\_s}=(1-\mu^2)/E_s$ E_{prime_s}= 0.0091 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}= 5.9 M in Table 5-2

I_1= 0.548 By Interpolation

I_2= 0.119

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= 0.6160

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

Depth ratio: D_{box}/B_{box}= 0.682353 L_{box}/B_{box}= 5.9

μ= 0.3 I_F= 0.83

Calculate Modulus of Subgrade Reaction

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

k_s= 12.64302 kcf k_s= 7 pci

Recommend Modulus of Subgrade Reaction of 10 pci

<u>Appendix D</u>

Special Provision 620 – Geotextiles (Reinforcement Geogrid)

SPECIAL PROVISION
SECTION 620 – GEOTEXTILES
(Reinforcement Geogrid)

Amend Standard Specification 620 – GEOTEXTILES to include the following:

620.01 Description This work shall consist of furnishing and installing Reinforcement Geogrid within the Culvert Bedding Stone in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the plans or as directed by the Resident.

620.02 Material Reinforcement Geogrid shall consist of a regular network of integrally connected, polymeric tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate or other material. The Reinforcement Geogrid structure shall be dimensionally stable to retain its geometry under construction stresses and shall have high resistance to damage during construction, ultraviolet degradation, and all forms of chemical and biological degradation encountered in the soil being reinforced.

The Reinforcement Geogrid shall meet or exceed the Minimum Average Roll Values (MARV) of the properties in Table 1. Acceptable manufacturers for Reinforcement Geogrids must be approved by the Resident.

Table 1 - Physical Property Requirements
(Biaxial Reinforcement Geogrid)

Reinforcement Geogrid Mechanical Property	Test Method	Minimum Average Roll Value (MARV)[1]
Tensile strength at 5% Strain MD or XD	ASTM D 6637	1,200 lb/ft
Rib Junction Strength	GRI-GG2	1,000 lb/ft in both directions
Aperture Openings		Between 0.75 and 3 inches
Percent Open Area		50 to 80%

[1] Values are minimum average roll values determined in accordance with ASTM D 4759

A biaxial Reinforcement Geogrid shall be used in this application.

620.03 Placement Reinforcement Geogrid shall be installed, in accordance with the manufacturer's recommendations, unless otherwise modified by this Special Provision. The Reinforcement Geogrid shall be placed within the layers of Crushed Stone Bedding at the proper elevation and alignment as shown on the Plans or as directed by the Resident.

1. The Reinforcement Geogrid shall be placed in continuous longitudinal strips. Splicing along the length will not be allowed. Reinforcement Geogrid shall be oriented such that the roll length runs either parallel or perpendicular to the construction centerline. The Contractor shall verify correct orientation of the Reinforcement Geogrid.

2. Reinforcement Geogrid may be temporarily secured in-place with staples, pins, sand bags or backfill as required by fill properties, fill placement procedures, or weather conditions, or as directed by the Resident.

3. Coverage of less than 100 percent shall not be allowed.

4. The Reinforcement Geogrid shall be lightly anchored and pulled taut to reduce any slack as directed by the Resident.

5. Fill shall not be dumped directly onto the Reinforcement Geogrid. It shall be dumped at the edge of the Reinforcement Geogrid or on a previous course of fill with a minimum compacted depth of 8 inches.

6. The Reinforcement Geogrid shall be covered with fill materials within 7 days of placement to protect against unnecessary exposure.

7. Fill may then be pushed onto the Reinforcement Geogrid using a track mounted bulldozer. At no time shall construction equipment be allowed directly onto the Reinforcement Geogrid. Track mounted equipment shall be allowed on previous courses of fill with a minimum compacted depth of 8 inches. Smooth drum roller compaction equipment shall be allowed on previous courses of fill with a minimum compacted depth of 8 inches and spread fill with a minimum depth of 12 inches, loose measure. At no time shall rubber tired or sheeps-foot rollers be allowed onto the reinforced fill. Turning of vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the Reinforcement Geogrid. Sudden breaking and sharp turning shall be avoided. Equipment speeds over 10 MPH shall not be allowed.

8. Placement, spreading, and compaction of soil on top of the Reinforcement Geogrid shall advance from one end of the Reinforcement Geogrid and move towards the other. Care shall be taken to minimize the development of wrinkles and to ensure that the Reinforcement Geogrid doesn't move from its position during fill placement. A spotter shall observe all fill placement operations to ensure the Reinforcement Geogrid does not slip, achieves the minimum coverage specified on the Plans, and is not damaged by the work.

9. Fill shall be compacted as specified in (1) the Standard Specifications or (2) to at least 90 percent of the maximum dry density determined in accordance with AASHTO T-180, whichever is greater. Density testing shall be made at a minimum frequency of one (1) test per lift or as otherwise specified in the Standard Specifications. Care shall be taken not to drive test apparatus through the Reinforcement Geogrid tensile elements.

10. All rutting formed during construction shall be filled with new Culvert Bedding Stone. In no case shall rutting be filled by blading down

620.04 Overlap Adjacent rolls of Reinforcement Geogrid shall be overlapped a minimum of 1 foot.

620.05 Seams Seams along adjacent lengths of Reinforcement Geogrid shall be tied together with hog rings or cable ties every 3 to 6 feet.

620.06 Certification Prior to construction the Contractor shall submit to the Resident the Manufacturer's certification that the Reinforcement Geogrid supplied has been evaluated in full compliance with this Specification and is fit for long-term, critical soil reinforcement applications.

The Contractor’s submittal package shall include, but not be limited to, actual tests for tension/creep, durability/aging, construction damage, and quality control tensile testing.

620.08 Shipment, Storage, Protection, and Repair of Fabric The Contractor shall check the Reinforcement Geogrid upon delivery to ensure that the proper material has been received. Each Reinforcement Geogrid roll shall be shipped in a protective bag and clearly marked with roll number, lot number, geogrid style and principle strength direction. During all periods of shipment and storage, the Reinforcement Geogrid shall be protected from temperatures greater than 140°F and all deleterious materials that might otherwise become affixed to the Reinforcement Geogrid and effect its performance. The manufacturer’s recommendations shall be followed with regard to protection from direct sunlight. The Reinforcement Geogrid shall be stored off the ground in a clean, dry environment out of the pathway of construction equipment.

Any Reinforcement Geogrid damage shall be repaired or replaced in accordance with the manufacturer’s recommendations. The Contractor shall replace any Reinforcement Geogrid damaged during installation at no additional cost to the Department.

620.09 Method of Measurement Reinforcement Geogrid will be measured by the number of Square Yards of surface area installed. Overlaps for connections, splices, patches, and repairs of damaged Reinforcement Geogrid, etc. are incidental to this Pay Item.

620.10 Basis of Payment Reinforcement Geogrid placement will be paid for per Square Yard in-place which shall be full compensation for all off-loading, inspection, storage, labor, materials, equipment, tools and any incidentals to complete the installation.

Payment will be made under:

Pay Item	Pay Unit
620.65 Reinforcement Geogrid	Square Yard