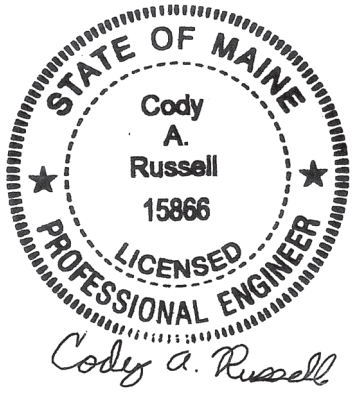
MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of

LARGE CULVERT #1063182
ROUTE 22
BUXTON, MAINE

Prepared by:
Yueh-Ti Lee
Assistant Geotechnical Engineer



Reviewed by:
Cody Russell, P.E.
Senior Geotechnical Engineer

York County
WIN 26380.00

Soils Report 2024-38
November 13, 2024

PROJECT DETAILS

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of an existing large culvert (#1063182) on Route 22 in Buxton. 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 dual 36-inch diameter, approximately 58-foot-long corrugated metal pipe (CMP) culverts. The CMPs are in poor condition and need replacement both from an infrastructure and environmental standpoint. Route 22 is a Highway Corridor Priority 3 road.

The proposed replacement structure will be an approximately 57-inch span by 38-inch rise by 66-foot-long corrugated metal pipe arch culvert. The invert of the proposed culvert is approximately 9 feet below the existing road grade at the roadway centerline. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V to protect against erosion.

SUBSURFACE INVESTIGATION

One (1) boring (HB-BUXT-101) and one (1) probe (HB-BUXT-102) were drilled for this project on September 8, 2022 by the MaineDOT drill crew using a trailer mounted drill rig. Exploration locations are shown on the attached Boring Location Plan. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on the attached Boring Logs.

Boring HB-BUXT-101 was drilled using solid stem auger, cased wash boring, open hole, and hydraulic push techniques. Soil samples were obtained in the upper approximately 22 feet of the boring 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 62 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 0.974 to the raw field N-values. Probe HB-BUXT-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 Northeast Transportation Training and Certification Program (NETTCP) certified subsurface inspector logged the subsurface conditions encountered. The boring and probes were located in the field by taping to surveyed site features after completion of the drilling program.

LABORATORY TESTING

A laboratory testing program was conducted to assist in soil classification, evaluation of engineering properties of the soils and geologic assessment of the project site. Laboratory testing consisted of one (1) standard grain size analyses with natural water content, four (4) standard grain size analyses with hydrometer and natural water content, and two (2) Atterberg Limits tests. The results of the laboratory testing program are discussed in the following section and are shown in the attached Boring Logs, Laboratory Testing Summary Sheet, Grain Size Distribution Curve Sheet, and Atterberg Limits Plots.

SUBSURFACE CONDITIONS

Subsurface conditions encountered in the test boring and probe generally consisted of sand fill underlain by Presumpscot Formation consisting of silty clay, clay, and clayey silt. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on the attached Interpretive Subsurface Profile.

Boring HB-BUXT-101 was drilled to a depth of approximately 72.7 feet below ground surface (bgs), where it encountered a refusal surface. The exact nature of the refusal surface was not determined in the boring. Probe HB-BUXT-102 was drilled to depth of approximately 15.5 feet bgs without encountering a refusal surface.

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

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 3.5	Fill: Brown, moist, fine to coarse sand, little gravel, little silt.	A-1-b	SM	5.3
3.5 – 4.0	Cobbles	--	--	--
4.0 – 72.7	Presumpscot Formation: Brown, moist, clayey silt, trace fine to coarse sand, trace gravel, trace organics. Grey, wet, clay, some silt, trace fine to medium sand. Grey, wet, silty clay, trace fine to coarse sand, trace gravel.	A-4 or A-6	CL	21.9 to 49.9

[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

One (1) N_{60}-value obtained in the fill was 32 blows per foot (bpf), indicating that the fill is dense in consistency. Four (4) N_{60}-values obtained in the Presumpscot Formation ranged from Weight of

Hammer (WOH) to 19 bpf, indicating that the Presumpscot Formation is very soft to very stiff in consistency. Two (2) vane shear tests conducted within the Presumpscot Formation showed measured undrained shear strength of 670 pounds per square foot (psf) and 491 psf with remolded shear strengths of 45 psf for both tests. Based on the ratio of undrained to remolded shear strength from the vane shear test, the Presumpscot Formation was determined to have sensitivities of 10.9 and 14.9 and are classified as very sensitive.

The following table summarizes the results of Atterberg Limits tests done on two (2) samples of the clay and silty clay:

Boring No. and Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
HB-BUXT-101 3D	34.1	40	21	19	0.69
HB-BUXT-101 5D	48.0	34	21	13	2.08

Interpretation of these results indicate that the clay and silty clay have medium plasticity. The clay in sample 3D from boring HB-BUXT-101 is overconsolidated. The silty clay in sample 5D from boring HB-BUXT-101 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 depth 5.0 feet bgs in boring HB-BUXT-101. Groundwater levels can be expected to fluctuate subject to seasonal variations, local soil conditions, topography, precipitation, and construction activity.

GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

The proposed replacement structure will consist of an approximately 57-inch span by 38-inch rise by 66-foot-long corrugated metal pipe arch culvert. The proposed structure inlet and outlet slopes shall be riprapped with slopes no steeper than 2H:1V on the inlet end to protect against erosion. The following sections discuss geotechnical recommendations for the design and construction of the proposed culvert.

Corrugated Metal Pipe Arch Culvert Design and Construction – The proposed replacement structure will be a 57-inch span by 38-inch rise by 66-foot-long corrugated metal pipe arch culvert. The proposed corrugated metal arch pipe culvert shall be furnished and installed in accordance with MaineDOT Standard Specification 603. The invert of the proposed corrugated metal pipe arch culvert ranges from approximately 169.5 feet at the inlet end to approximately 168.8 feet at the outlet end with a 1.3% slope.

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.

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 corrugated metal pipe arch culvert is larger than the existing culvert 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 structure 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.

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

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.

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 corrugated metal pipe arch culvert will require soil excavation. Earth support systems shall be implemented if laying back slopes is not feasible. It is likely that the use of complex (four-sided) braced excavations with dewatering will be necessary due to the depth of the excavation. If this is the case, adequate embedment into the native soils 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.

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 (#1063182) under Route 22 in Buxton, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

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

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

Attachments:

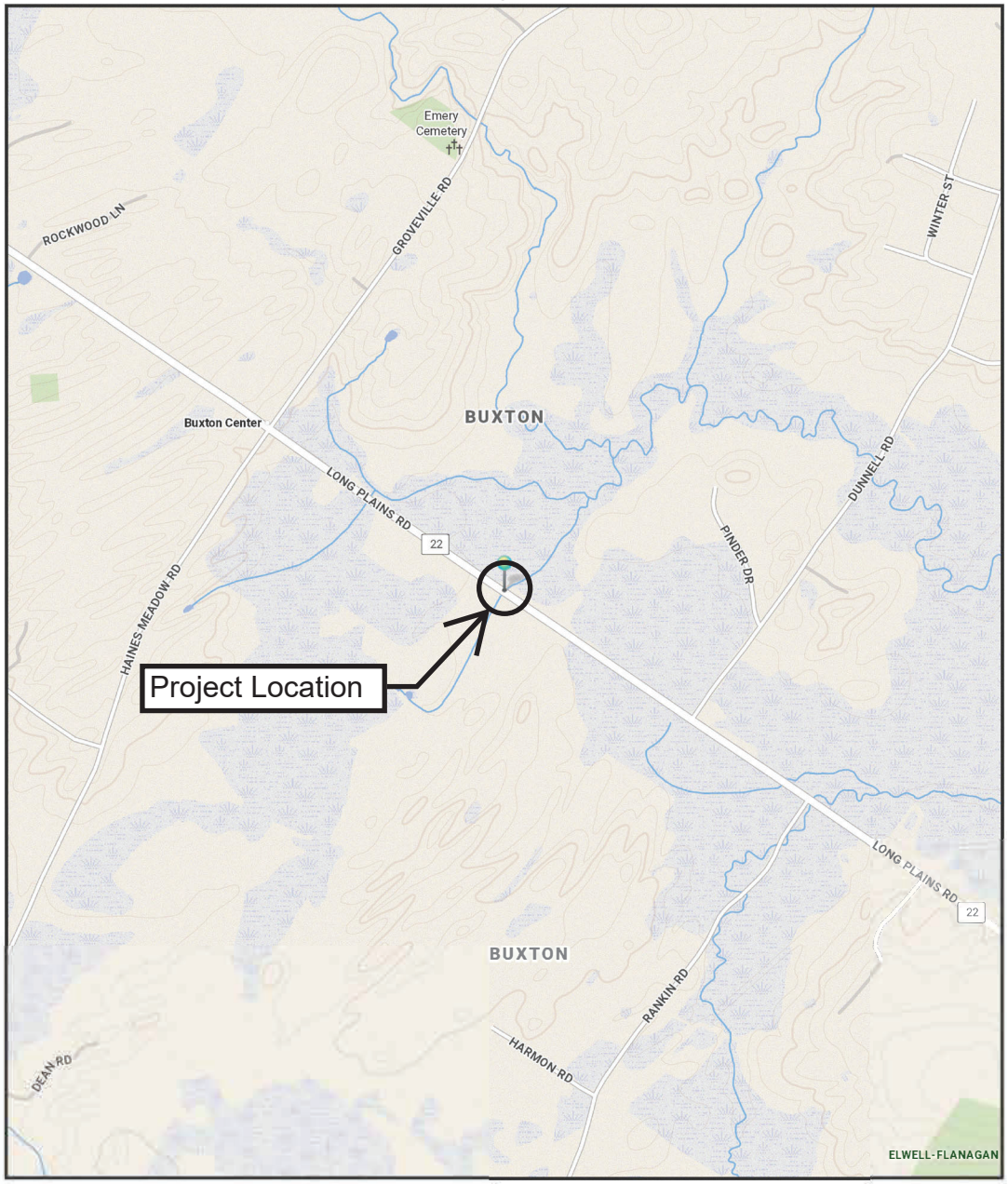
Location Map
Boring Location Plan
Interpretive Subsurface Profile
Key to Soil and Rock Descriptions and Terms
Boring Logs
Laboratory Testing Summary Sheet
Grain Size Distribution Curve Sheet
Atterberg Limits Plots
Special Provision 620 – Geotextile (Reinforcement Geogrid)

Date: 12/30/2024

Division: GEOTECH

Username: Cody.A.Russell

BUXTON, MAINE



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0.25 Miles

1 inch = 0.28 miles

Date: 10/10/2024
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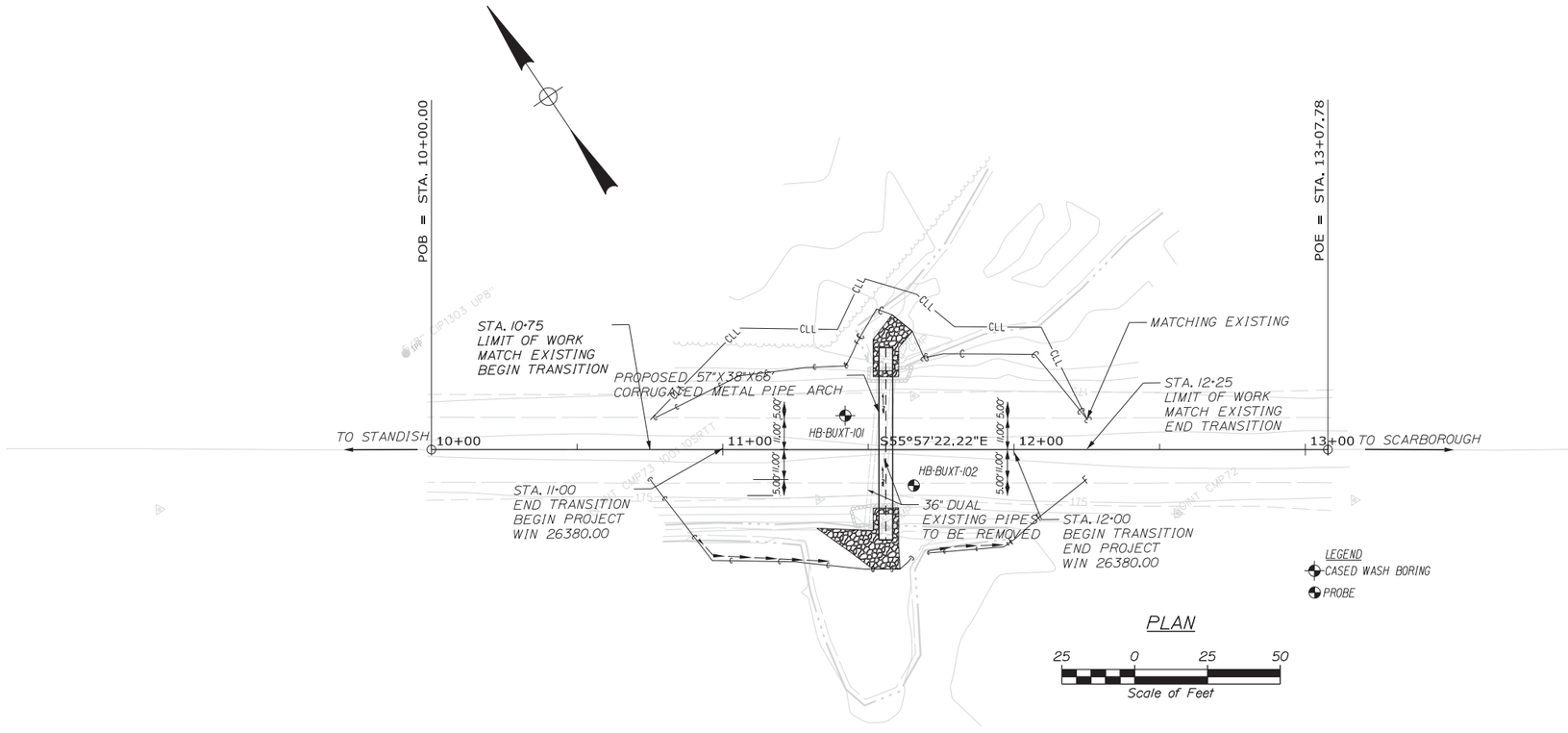
SHEET NUMBER		STATE OF MAINE DEPARTMENT OF TRANSPORTATION
1	BUXTON ROUTE 22	26380.00
OF 3	LOCATION MAP	WIN 26380.00 HIGHWAY PLANS



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

26380.00

WIN
26380.00

HIGHWAY PLANS

	BY	DATE
PROJ. MANAGER	------	---
DESIGN-DETAILED	------	-----
CHECKED-REVIEWED	-----	-----
DESIGN2-DETAILED2	Y.T.LEE	NOV 2024
DESIGN3-DETAILED3	T.WHITE	NOV 2024
REVISIONS 1	------	------
REVISIONS 2	------	------
REVISIONS 3	------	------
REVISIONS 4	------	------
FIELD CHANGES	------	------

SIGNATURE

P.E. NUMBER

DATE

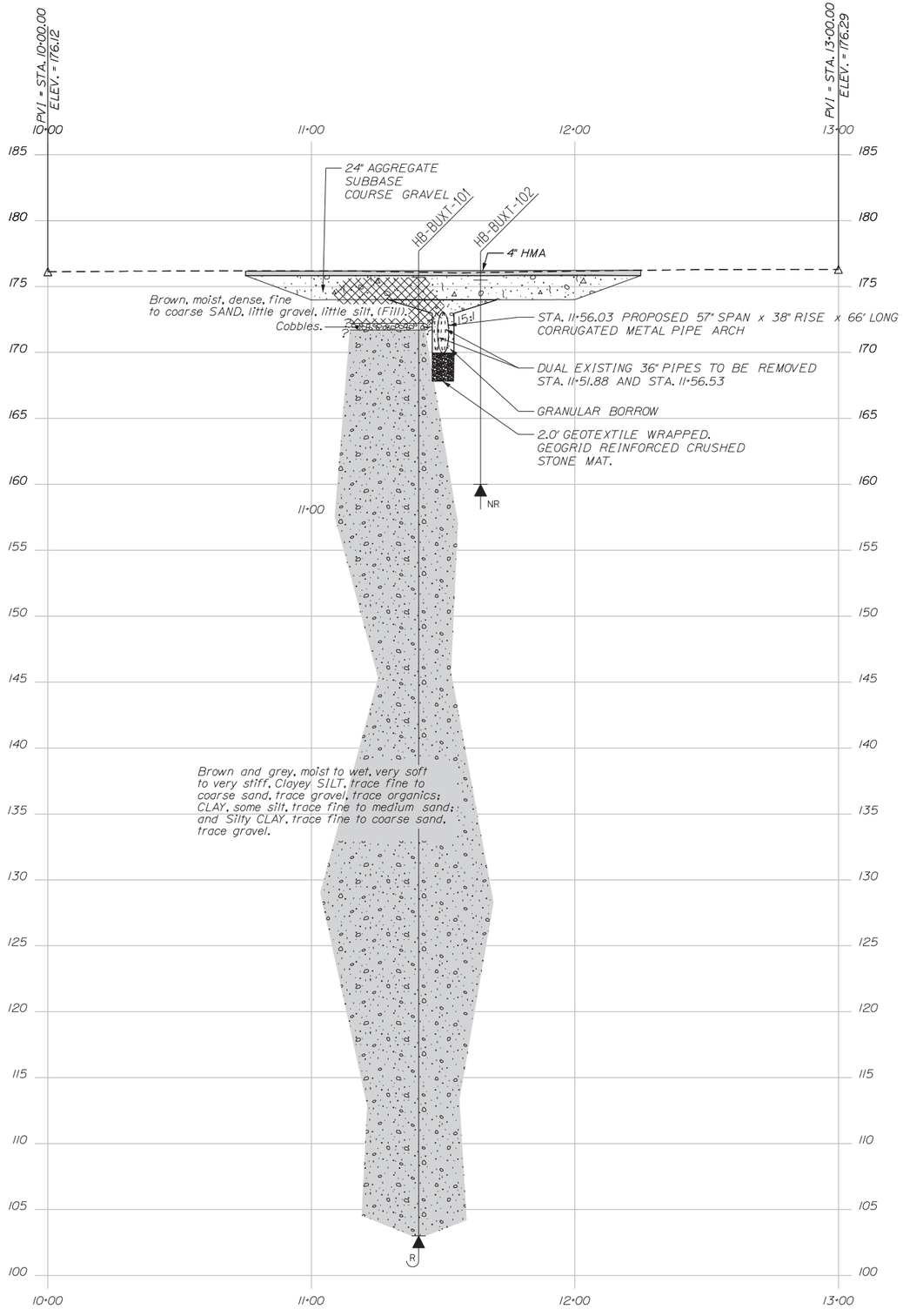
BUXTON
ROUTE 22

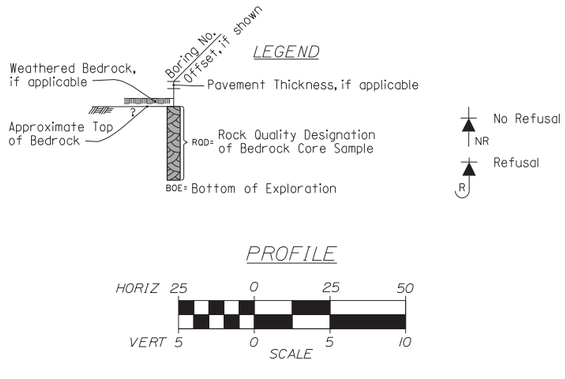
BORING LOCATION PLAN

SHEET NUMBER

2

OF 3





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

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

26380.00

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HIGHWAY PLANS

	BY	DATE
PROJ. MANAGER	---	---
DESIGN-DETAILED	---	---
CHECKED-REVIEWED	T. WHITE	NOV 2024
DESIGN2-DETAILED2	Y.T.LEE	---
DESIGN3-DETAILED3	---	---
REVISIONS 1	---	---
REVISIONS 2	---	---
REVISIONS 3	---	---
REVISIONS 4	---	---
FIELD CHANGES	---	---

SIGNATURE

P.E. NUMBER

DATE

BUXTON
ROUTE 22

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF 3

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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):

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

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

Rock Quality Based on RQD

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

Desired Rock Observations (in this order, if applicable):

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
-dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
-spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
-tightness (tight, open, or healed)
-infilling (grain size, color, etc.)
Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Sample Container Labeling Requirements:

WIN
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: Large Culvert #1063182 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXT-101
WIN: 26380.00

Driller:	MaineDOT	**Elevation (ft.)**	175.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/8/2022; 13:00-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	11+40.7, 12.2 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	5.0 ft bgs.
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/16	0.00 - 2.00	5/10/10/8	20	32	SSA			Brown, moist, dense, fine to coarse SAND, little gravel, little silt, (Fill).	G#379800 A-1-b, SM WC=5.3%
								172.2		3.5	
								171.7		Layer of Cobbles from 3.5-4.0 ft bgs.	
5										4.0	
	2D	24/20	5.00 - 7.00	4/5/7/14	12	19	20			Brown, moist, very stiff, Clayey SILT, trace fine to coarse sand, trace gravel, trace organics.	G#379855 A-4, CL WC=21.9%
							26				
							37				
							42	167.7		8.0	
							52				
10	3D	24/24	10.00 - 12.00	3/3/3/3	6	10	39			Grey, wet, stiff, CLAY, some silt, trace fine to medium sand.	G#379856 A-6, CL WC=34.1% LL=40 PL=21 PI=19
							44				
							42				
							38				
							36	161.7		14.0	
15	4D	24/10	15.00 - 17.00	WOH/WOH/WOH/ WOH	---		OPEN HOLE			Grey, wet, very soft, Silty CLAY, trace fine to coarse sand, trace gravel.	G#379857 A-6, CL WC=49.9%
	V1		15.63 - 16.00	Su=670/45 psf						55x110 mm vane raw torque readings: V1: 15.0/1.0 ft-lbs	
	V2		16.63 - 17.00	Su=491/45 psf						V2: 11.0/1.0 ft-lbs	
20	5D	24/18	20.00 - 22.00	WOH/WOH/WOH/ WOH	---		HP			Grey, wet, very soft, Silty CLAY, trace fine sand. Hydraulic Pushed drill rods to 72.7 ft bgs.	G#379858 A-6, CL WC=48.0% LL=34 PL=21 PI=13
										No samples taken after 5D, Hydraulic Push through soft soils after 22.0 ft bgs.	
25											

Remarks:

HP = Hydraulic Push

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: Large Culvert #1063182 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXT-101
WIN: 26380.00

Driller:	MaineDOT	**Elevation (ft.)**	175.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/8/2022; 13:00-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	11+40.7, 12.2 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	5.0 ft bgs.
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25											
30											
							HP			Hyraulic Push to Refusal through soft soils	
35											
40											
45											
50											

Remarks:

HP = Hydraulic Push

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: Large Culvert #1063182 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXT-101
WIN: 26380.00

Driller:	MaineDOT	**Elevation (ft.)**	175.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/8/2022; 13:00-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	11+40.7, 12.2 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	5.0 ft bgs.
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50											
55											
60											
							HP			Hyraulic Push to Refusal through soft soils	
65											
70											
								103.0		72.7 **Bottom of Exploration at 72.7 feet below ground surface.** VERY HARD REFUSAL	
75											

Remarks:

HP = Hydraulic Push

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: Large Culvert #1063182 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXT-102
WIN: 26380.00

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	175.5	**Auger ID/OD:**	5" Dia.
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	9/8/2022; 12:30-13:00	**Drilling Method:**	Soild Stem Auger	**Core Barrel:**	N/A
Boring Location:	11+64.2, 12.0 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 material samples taken.	
5										
10										
15							160.0		15.5 **Bottom of Exploration at 15.5 feet below ground surface.** NO 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.

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Buxton Work Number: 26380.00

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-BUXT-101, 1D	11+40.7	12.2 Lt.	0.0-2.0	379800	1	5.3			SM	A-1-b	II
HB-BUXT-101, 2D	11+40.7	12.2 Lt.	5.0-7.0	379855	1	21.9			CL	A-4	IV
HB-BUXT-101, 3D	11+40.7	12.2 Lt.	10.0-12.0	379856	1	34.1	40	19	CL	A-6	III
HB-BUXT-101, 4D	11+40.7	12.2 Lt.	15.0-17.0	379857	1	49.9			CL	A-6	III
HB-BUXT-101, 5D	11+40.7	12.2 Lt.	20.0-22.0	379858	1	48.0	34	13	CL	A-6	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.

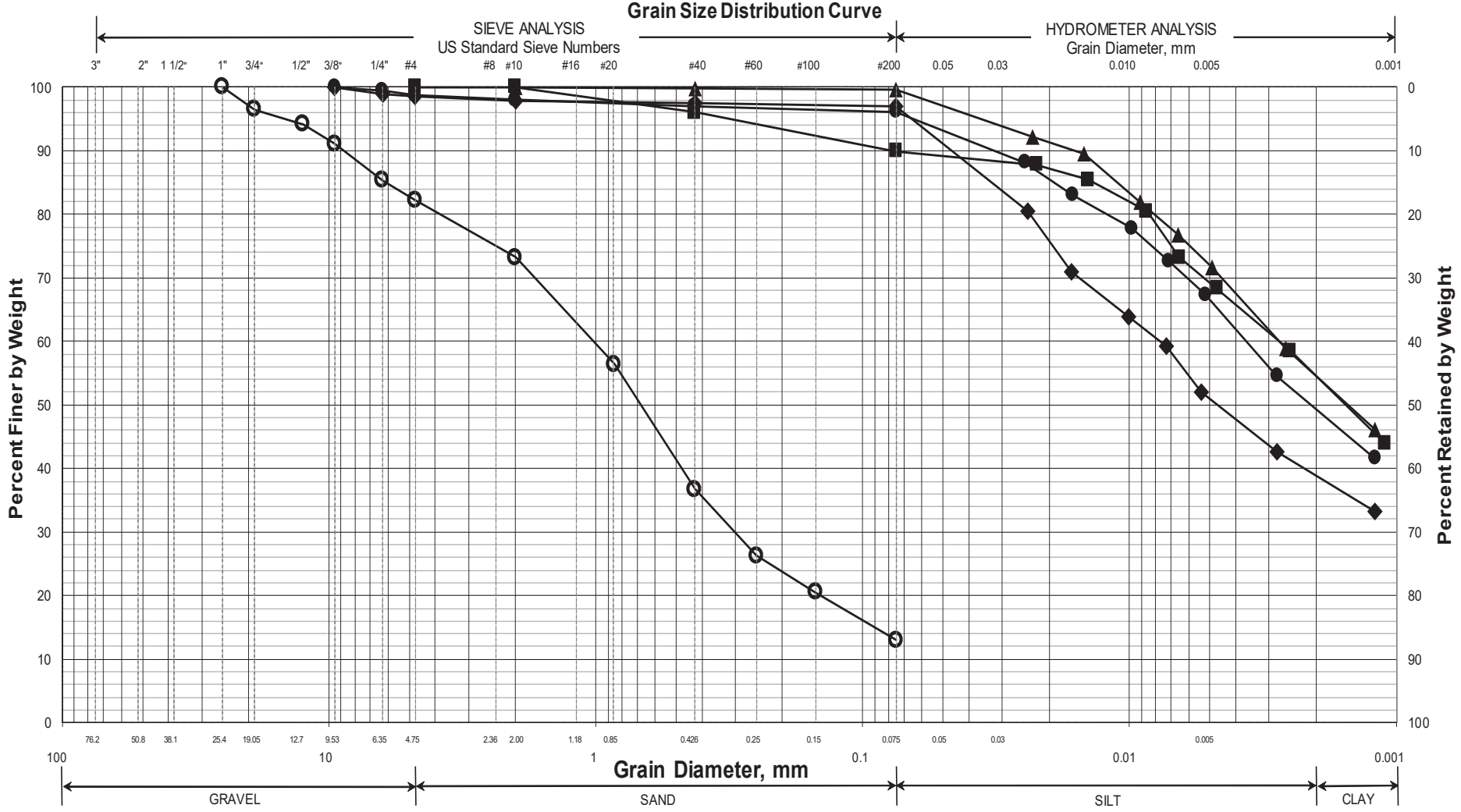
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

Maine Department of Transportation
Grain Size Distribution Curve

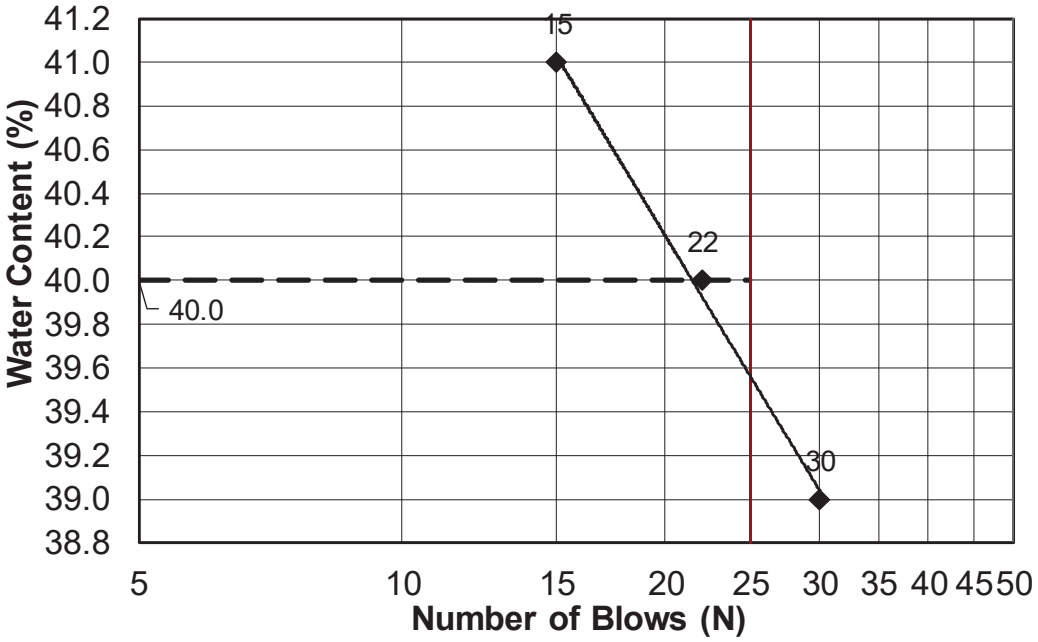


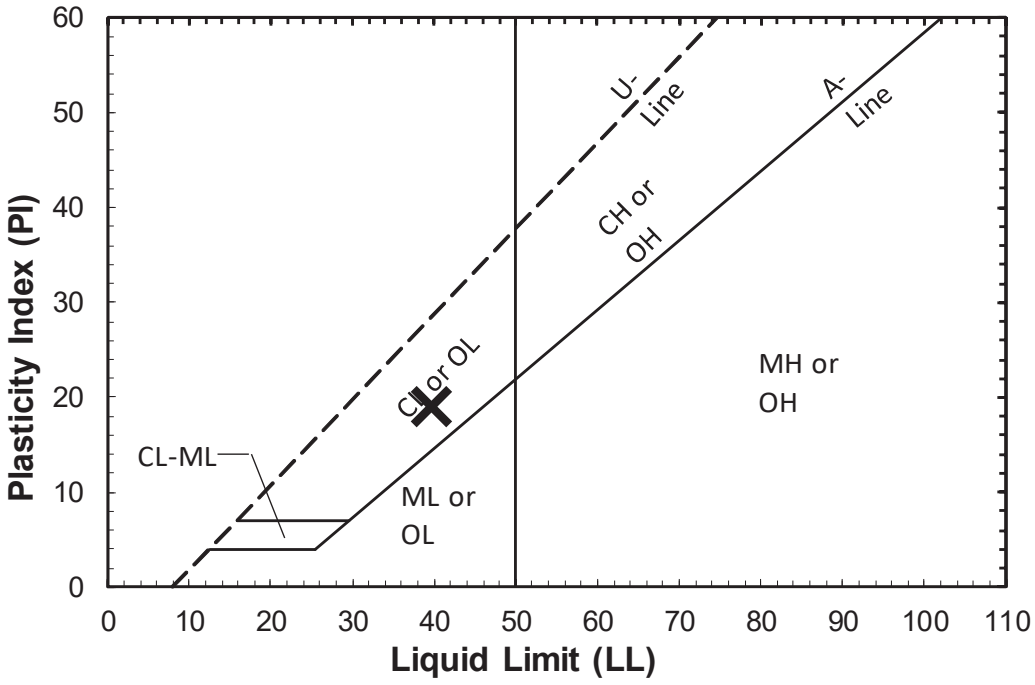
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-BUXT-101/1D	11+40.7	12.2 LT	0.0-2.0	SAND, little gravel, little silt.	5.3			
◆	HB-BUXT-101/2D	11+40.7	12.2 LT	5.0-7.0	Clayey SILT, trace sand, trace gravel.	21.9			
■	HB-BUXT-101/3D	11+40.7	12.2 LT	10.0-12.0	CLAY, some silt, trace sand.	34.1	40	21	19
●	HB-BUXT-101/4D	11+40.7	12.2 LT	15.0-17.0	Silty CLAY, trace sand, trace gravel.	49.9			
▲	HB-BUXT-101/5D	11+40.7	12.2 LT	20.0-22.0	Silty CLAY, trace sand.	48.0	34	21	13
×									

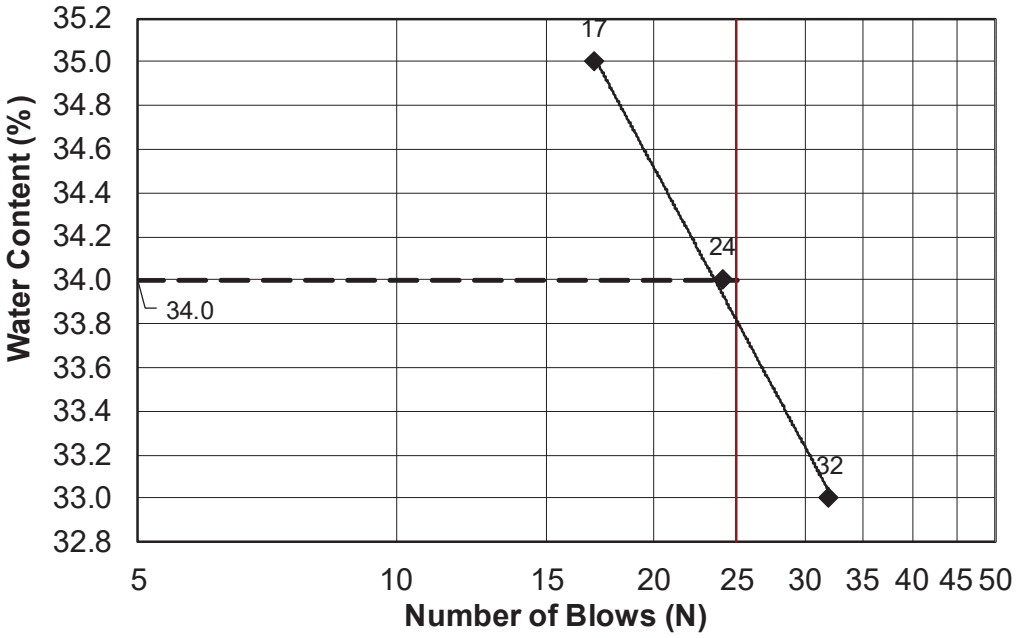
WIN	
026380.00	
Town	
Buxton	
Reported by/Date	
WHITE, TERRY A	10/17/2022

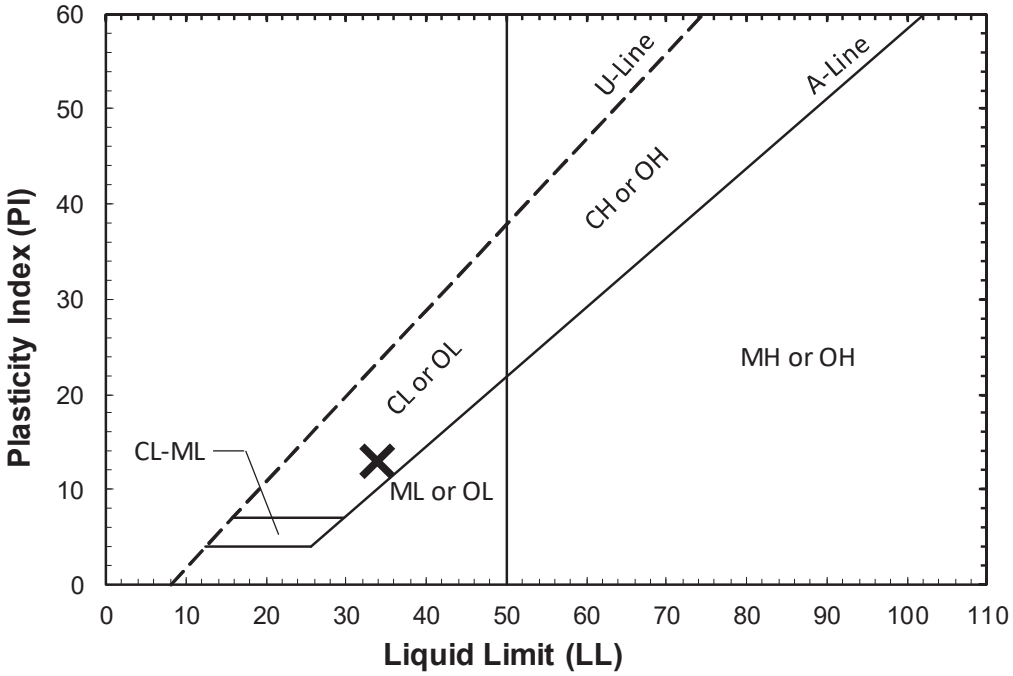
TOWN	Buxton	Reference No.	379856
WIN	026380.00	Water Content, %	34.1
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	40
Boring No./Sample No.	HB-BUXT-101/3D	Plastic Limit (T 90), %	21
Station	11+40.7	Plasticity Index (T 90), %	19
Depth	10.0-12.0	Tested By	BBURR





TOWN	Buxton	Reference No.	379858
WIN	026380.00	Water Content, %	48
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	34
Boring No./Sample No.	HB-BUXT-101/5D	Plastic Limit (T 90), %	21
Station	11+40.7	Plasticity Index (T 90), %	13
Depth	20.0-22.0	Tested By	BBURR





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

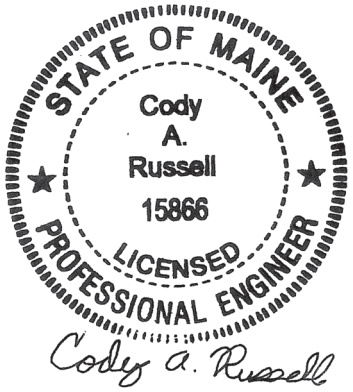
MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Construction of

LONG PLAINS BRIDGE
ROUTE 22
BUXTON, MAINE

Prepared by:
Yueh-Ti Lee
Assistant Geotechnical Engineer



Reviewed by:
Cody Russell, P.E.
Senior Geotechnical Engineer

York County
WIN 26382.00

Soils Report 2024-40
Bridge No. 6698

November 18, 2024

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Sheets

Appendices

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 (#1063141) on Route 22 in Buxton. 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 a dual 48-inch diameter, approximately 56-foot-long corrugated metal pipe (CMP) culverts. The CMPs are in poor condition and need replacement both from an infrastructure and environmental standpoint. Route 22 is a Highway Corridor Priority 3 road.

The proposed replacement structure will be an approximately 11-foot span by 5-foot rise by 72-foot-long precast concrete box culvert. The invert of the proposed culvert is approximately 9.5 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 an unnamed stream under Route 22 in Buxton and is located approximately 0.01 of a mile southeast of Rankin Road as shown on Sheet 1 – Location Map.

According to the Maine Geological Survey (MGS) map titled Surficial Geology of the Standish Quadrangle, Maine, Open File 99-101 (1999) the surficial soils at the site consist of Marine Regressive Sand Deposits. Marine Regressive Sand Deposits consist of sand and typically overlie Presumpscot Formation silt and clay.

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 interbedded pelite and sandstone of the Waterville Formation.

3.0 SUBSURFACE INVESTIGATION

One (1) boring (HB-BUXN-101) and one (1) probe (HB-BUXN-102) were drilled for this project on September 8, 2022 by the MaineDOT drill crew using a trailer-mounted drill rig. Exploration locations are shown on Sheet 2 – Boring Location Plan. 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-BUXN-101 was drilled using solid stem auger, cased wash boring, open hole, and hydraulic push techniques. Soil samples were obtained in the upper approximately 25 feet of the boring 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 62 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 0.974 to the raw field N-values. Probe HB-BUXN-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 (NETTCP) certified Subsurface Investigator logged the subsurface conditions encountered. 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 one (1) standard grain size analyses with natural water content, six (6) standard grain size analyses with hydrometer and natural water content, and five (5) Atterberg Limits tests. 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 sand fill underlain by Presumpscot Formation consisting of silt and silty clay underlain by sand. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on Sheet 3 – Interpretive Subsurface Profile.

Boring HB-BUXN-101 was drilled to depth of approximately 64.3 feet below ground surface (bgs) without encountering a refusal surface. Probe HB-BUXN-102 was drilled to depth of approximately 20.0 feet bgs without encountering a refusal surface.

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

Approx. Depth BGS[1] (feet)	Soil Description	AASHTO[2] Classification	USCS[3]	WC%[4]
0.0 – 5.0	Fill: Brown, damp, fine to coarse sand, some gravel, trace silt.	A-1-b	SW-SM	4.1
5.0 – 60.0	Presumpscot Formation:	A-4 or	CL	32.4 to

	Grey, wet, silt, some clay, trace fine to coarse sand, trace gravel, trace organics. Olive and grey, wet, silty clay, trace fine sand.	A-6		45.1
60.0 – 64.3	Sand.	--	--	--

[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

One (1) N_{60}-value obtained in the fill was 28 blows per foot (bpf) indicating that the fill is medium dense in consistency. Seven (7) N_{60}-values obtained in the Presumpscot Formation ranged from Weight of Hammer (WOH) to 8 bpf, indicating that the Presumpscot Formation is very soft to medium stiff in consistency. Ten (10) vane shear tests conducted within the Presumpscot Formation showed measured undrained shear strengths ranging from approximately 179 pounds per square foot (psf) to 491 psf with remolded shear strengths ranging from approximately 22 psf to 134 psf. Based on the ratio of undrained to remolded shear strength from the vane shear test, the Presumpscot Formation was determined to have sensitivities of ranging from 3.3 to 12.2 and are classified as moderately sensitive to very sensitive.

The following table summarizes the results of Atterberg Limits tests done on five (5) samples of the silt and silty clay:

Boring No. and Sample No.	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
HB-BUXN-101 2D	32.4	29	21	8	1.43
HB-BUXN-101 3D	34.7	39	21	18	0.76
HB-BUXN-101 4D	44.7	35	20	15	1.65
HB-BUXN-101 6D	45.1	39	20	19	1.32
HB-BUXN-101 7D	41.8	35	21	14	1.49

Interpretation of these results indicate that the silt and silty clay have low to medium plasticity. The silty clay in sample 3D from boring HB-BUXN-101 is overconsolidated. The silt and silty clay in samples 2D, 4D, 6D and 7D from boring HB-BUXN-101 are 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 depth 8.0 feet bgs in boring HB-BUXN-101. 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 culvert.

6.1 Precast Concrete Box Culvert Culvert Design and Construction

The proposed replacement structure will consist of a 11-foot span by 5-foot rise by 72-foot-long precast concrete box culvert. The proposed box culvert shall be designed and constructed in accordance with MaineDOT Standard Specification 534.

The approximate invert of the proposed box culvert will be set at an elevation of 165.00 feet with a 0% slope. To facilitate fish passage, Habitat Connectivity Design elements will be used inside the precast concrete box culvert as shown on the Streambed Details Sheet 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 proof rolled using a static roller to visually confirm the prepared subgrade is firm and stable. The exposed subgrade shall be free of ponded water so that bedding material placement and compaction can be completed in the dry.

The proposed structure shall be bedded on a 2-foot thick, geotextile wrapped, geogrid reinforced, crushed stone mat (Culvert Bedding Stone; Pay Item 203.55). The geogrid reinforcement shall meet the requirements shown on Appendix C – Special Provision 620 – Geotextile (Reinforcement Geogrid). 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 precast concrete box culvert will be constructed at a new location east (up station) of the existing culvert. The proposed precast concrete box culvert

is larger than the existing culvert 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 structure 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 and/or bedrock 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 D – Calculations.

Limit State	Resistance Factor φ_b	AASHTO LRFD Reference	Factored Bearing Resistance (ksf)
Service	1.0	Article 10.5.5.1	3.0
Strength	0.45	Table 10.5.5.2.2-1	8.5

6.4 Modulus of Subgrade Reaction

A modulus of subgrade reaction (k_s) equal to 35 pounds per cubic inch shall be used for the structural design of the box culvert's base slab. Calculations are included in Appendix D – 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 on the inlet and outlet end. No specific scour protection recommendations are needed other than armoring with riprap. The riprap on the slopes shall be underlain by a 1-foot layer of protective aggregate cushion consisting of Granular Borrow Material for Underwater Backfill (703.19) that is underlain by a non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03. 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 sand or 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 for specific application to the proposed replacement of an existing large culvert (#1063141) under Route 22 in Buxton, 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.

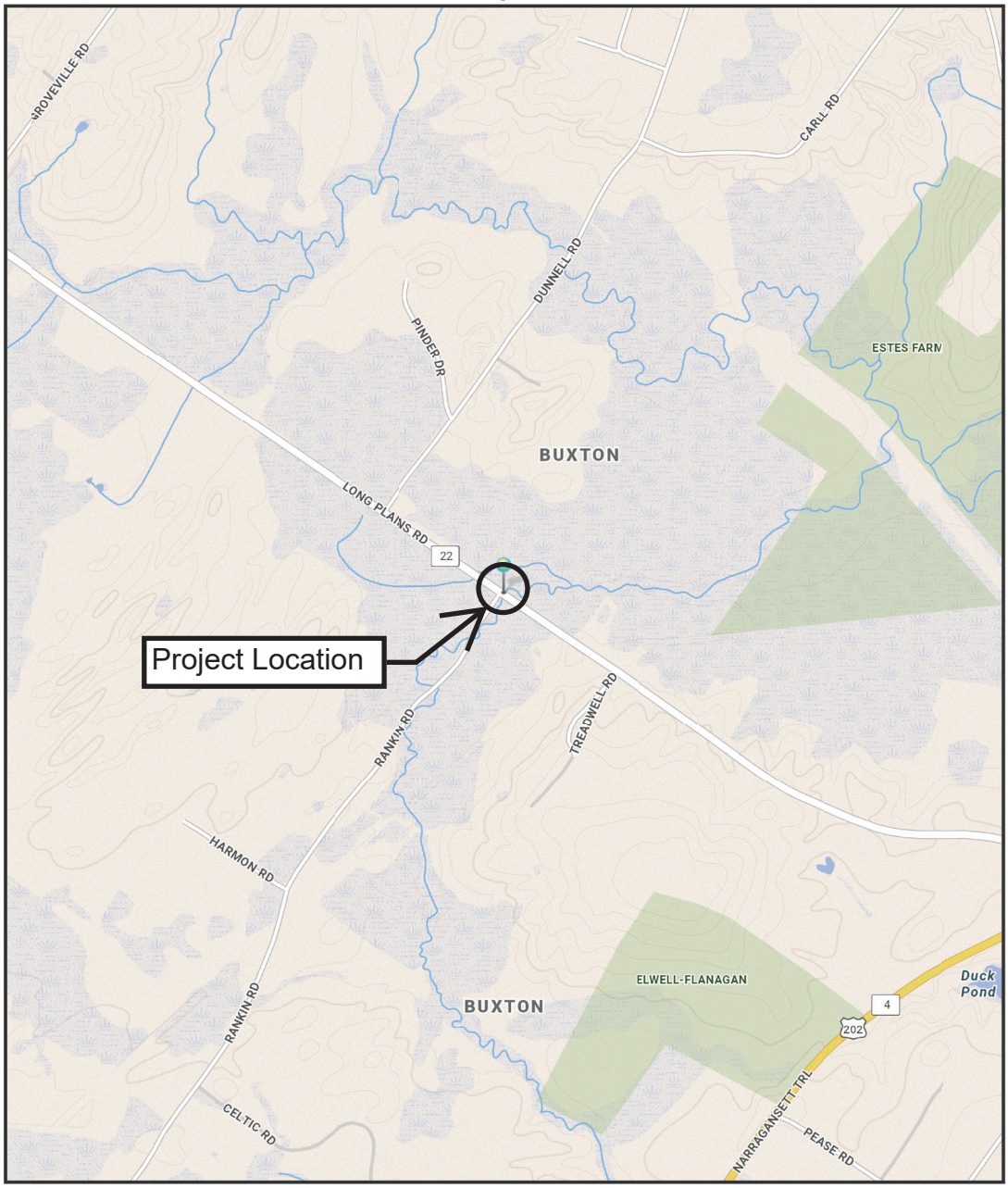
Sheets

Date:12/30/2024

Division: GEOTECH

Username: Cody.A.Russell

BUXTON, MAINE



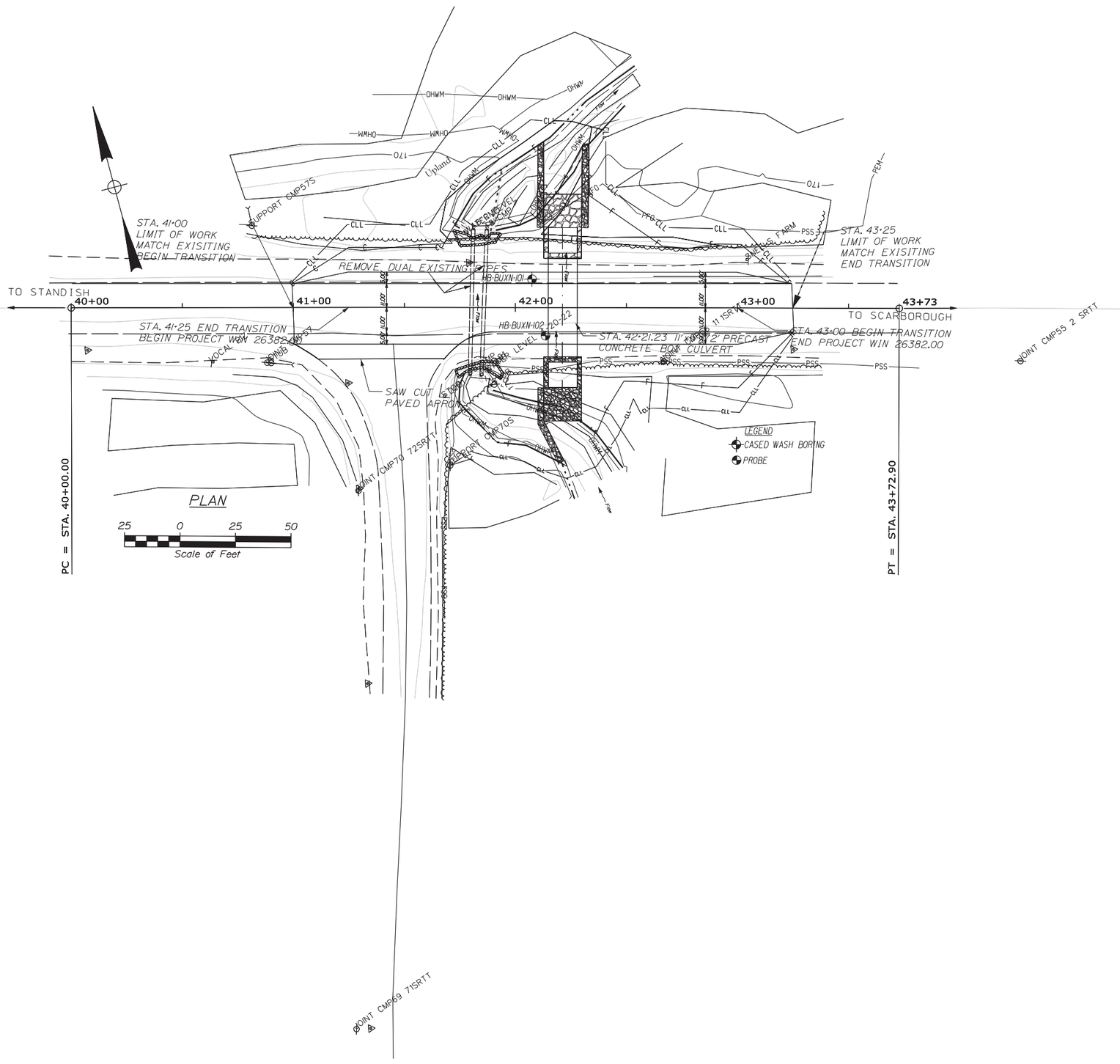
The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information.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

0.25 Miles

1 inch = 0.28 miles

Date: 10/15/2024
Time: 2:17:07 PM

SHEET NUMBER 1 OF 3	BUXTON ROUTE 22 LOCATION MAP	STATE OF MAINE DEPARTMENT OF TRANSPORTATION 26382.00 WIN 26382.00 HIGHWAY PLANS



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STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

26382.00

WIN
26382.00

HIGHWAY PLANS

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

SIGNATURE

P.E. NUMBER

DATE

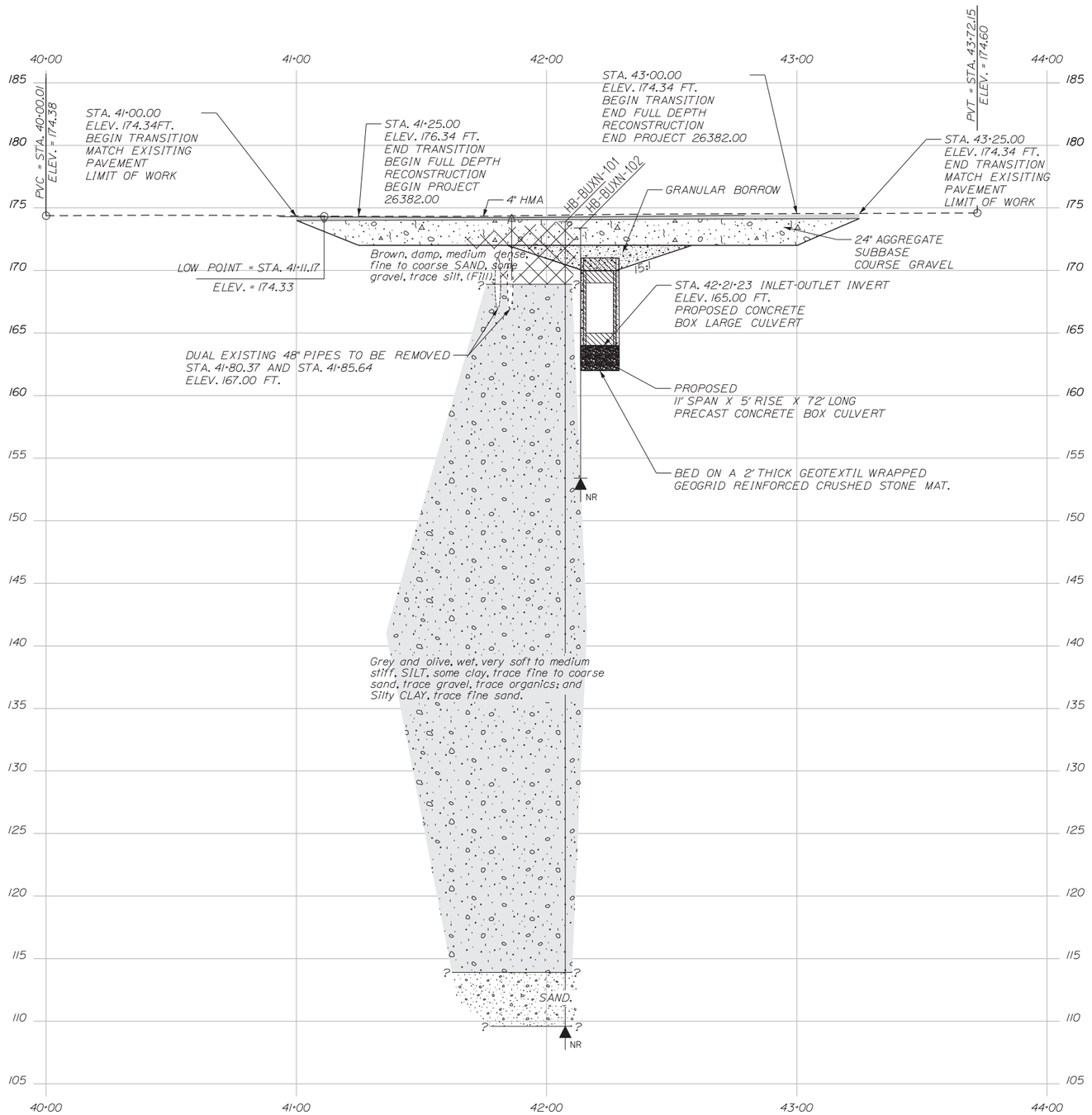
BUXTON
ROUTE 22

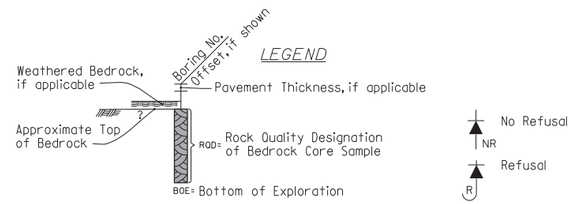
BORING LOCATION PLAN

SHEET NUMBER

2

OF 3





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

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

26382.00

WIN
26382.00

HIGHWAY PLANS

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

SIGNATURE

P.E. NUMBER

DATE

BUXTON
ROUTE 22

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF 3

Appendix A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

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

Desired Soil Observations (in this order, if applicable):

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

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	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: Large Culvert #1063141 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXN-101
WIN: 26382.00

Driller:	MaineDOT	**Elevation (ft.)**	173.9	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/8/2022; 09:00-12:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	42+07.5, 12.7 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/17	0.00 - 2.00	3/8/9/7	17	28	SSA			Brown, damp, medium dense, fine to coarse SAND, some gravel, trace silt, (Fill).	G#379859 A-1-b, SW-SM WC=4.1%
5	2D	24/20	5.00 - 7.00	1/2/2/3	4	6	7	168.9		5.0	
							8			Grey, wet, medium stiff, SILT, some clay, trace fine to coarse sand, trace gravel, trace organics.	G#379860 A-4, CL WC=32.4% LL=29 PL=21 PI=8
							9				
							18				
							39	164.9		9.0	
10	3D	24/24	10.00 - 12.00	2/2/3/3	5	8	41			Olive, wet, medium stiff, Silty CLAY, trace fine sand.	G#379861 A-6, CL WC=34.7% LL=39 PL=21 PI=18
							36				
							32				
							34				
							31				
15	4D	24/24	15.00 - 17.00	Hydraulic Push	---		24			Grey, wet, very soft, Silty CLAY, trace fine sand.	G#379862 A-6, CL WC=44.7% LL=35 PL=20 PI=15
	V1		15.63 - 16.00	Su=402/89 psf						55x110 mm vane raw torque readings: V1: 9.0/2.0 ft-lbs V2: 8.0/2.0 ft-lbs	
	V2		16.63 - 17.00	Su=357/89 psf			26				
							27				
							23				
							24				
20	5D	24/24	20.00 - 22.00	WOH/WOH/WOH/ WOH	---		OPEN HOLE			Grey, wet, very soft, Silty CLAY, trace fine sand.	G#379863 A-6, CL WC=40.8%
	V3		20.63 - 21.00	Su=402/45 psf						55x110 mm vane raw torque readings: V3: 9.0/1.0 ft-lbs V4: 9.0/1.5 ft-lbs	
	V4		21.63 - 22.00	Su=402/67 psf							
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: Large Culvert #1063141 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXN-101
WIN: 26382.00

Driller:	MaineDOT	**Elevation (ft.)**	173.9	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/8/2022; 09:00-12:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	42+07.5, 12.7 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	8.0 ft bgs.
Hammer Efficiency Factor: 0.974		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
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$S_{u(lab)}$ = 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
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T_V = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D	24/24	25.00 - 27.00	WOR/WOR/WOR/ WOR	---					Grey, wet, very soft, Silty CLAY, trace fine sand.	G#379864
	V5		25.63 - 26.00	Su=446/45 psf						55x110 mm vane raw torque readings:	A-6, CL
	V6		26.63 - 27.00	Su=446/45 psf						V5: 10.0/1.0 ft-lbs	WC=45.1%
										V6: 10.0/1.0 ft-lbs	LL=39
											PL=20
											PI=19
30	7D	24/24	30.00 - 32.00	WOR/WOR/WOR/ WOR	---					Grey, wet, very soft, Silty CLAY, trace fine sand.	G#379865
	V7		30.63 - 31.00	Su=179/45 psf						55x110 mm vane raw torque readings:	A-6, CL
	V8		31.63 - 32.00	Su=268/22 psf						V7: 4.0/1.0 ft-lbs	WC=41.8%
										V8: 6.0/0.5 ft-lbs	LL=35
											PL=21
											PI=14
35	8D	24/15	35.00 - 37.00	WOR/WOR/WOR/ WOR	---					Grey, wet, very soft, Silty CLAY, trace fine sand.	
	V9		35.63 - 36.00	Su=446/134 psf						55x110 mm vane raw torque readings:	
	V10		36.63 - 37.00	Su=491/45 psf						V9: 10.0/3.0 ft-lbs	
										V10: 11.0/1.0 ft-lbs	
										No samples taken after 8D.	
40							HP			Hydraulic Pushed Drill Rods (450 psi) to 64.3 ft bgs.	
45											
50											

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

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Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/8/2022; 09:00-12:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	42+07.5, 12.7 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	8.0 ft bgs.
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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-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50											
55											
60								113.9		Sand layer at 60.0 ft bgs. (60.0)	
65								109.6		(64.3) **Bottom of Exploration at 64.3 feet below ground surface.** FIRM	
70											
75											

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: Large Culvert #1063141 Replacement on Route 22
Location: Buxton, Maine

Boring No.: HB-BUXN-102
WIN: 26382.00

Drilling Contractor:	MaineDOT	**Elevation (ft.)**	173.4	**Auger ID/OD:**	5" Dia.
Operator:	Daggett	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	9/8/2022-9/8/2022	**Drilling Method:**	Soild Stem Auger	**Core Barrel:**	N/A
Boring Location:	42+13.6, 12.7 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 material samples taken.	
5										
10										
15										
20							153.4		20.0 **Bottom of Exploration at 20.0 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.

Appendix B

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Buxton Work Number: 26382.00

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-BUXN-101, 1D	42+07.5	12.7 Lt.	0.0-2.0	379859	1	4.1			SW-SM	A-1-b	0
HB-BUXN-101, 2D	42+07.5	12.7 Lt.	5.0-7.0	379860	1	32.4	29	8	CL	A-4	IV
HB-BUXN-101, 3D	42+07.5	12.7 Lt.	10.0-12.0	379861	1	34.7	39	18	CL	A-6	III
HB-BUXN-101, 4D	42+07.5	12.7 Lt.	15.0-17.0	379862	1	44.7	35	15	CL	A-6	III
HB-BUXN-101, 5D	42+07.5	12.7 Lt.	20.0-22.0	379863	2	40.8			CL	A-6	III
HB-BUXN-101, 6D	42+07.5	12.7 Lt.	25.0-27.0	379864	2	45.1	39	19	CL	A-6	III
HB-BUXN-101, 7D	42+07.5	12.7 Lt.	30.0-32.0	379865	2	41.8	35	14	CL	A-6	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.

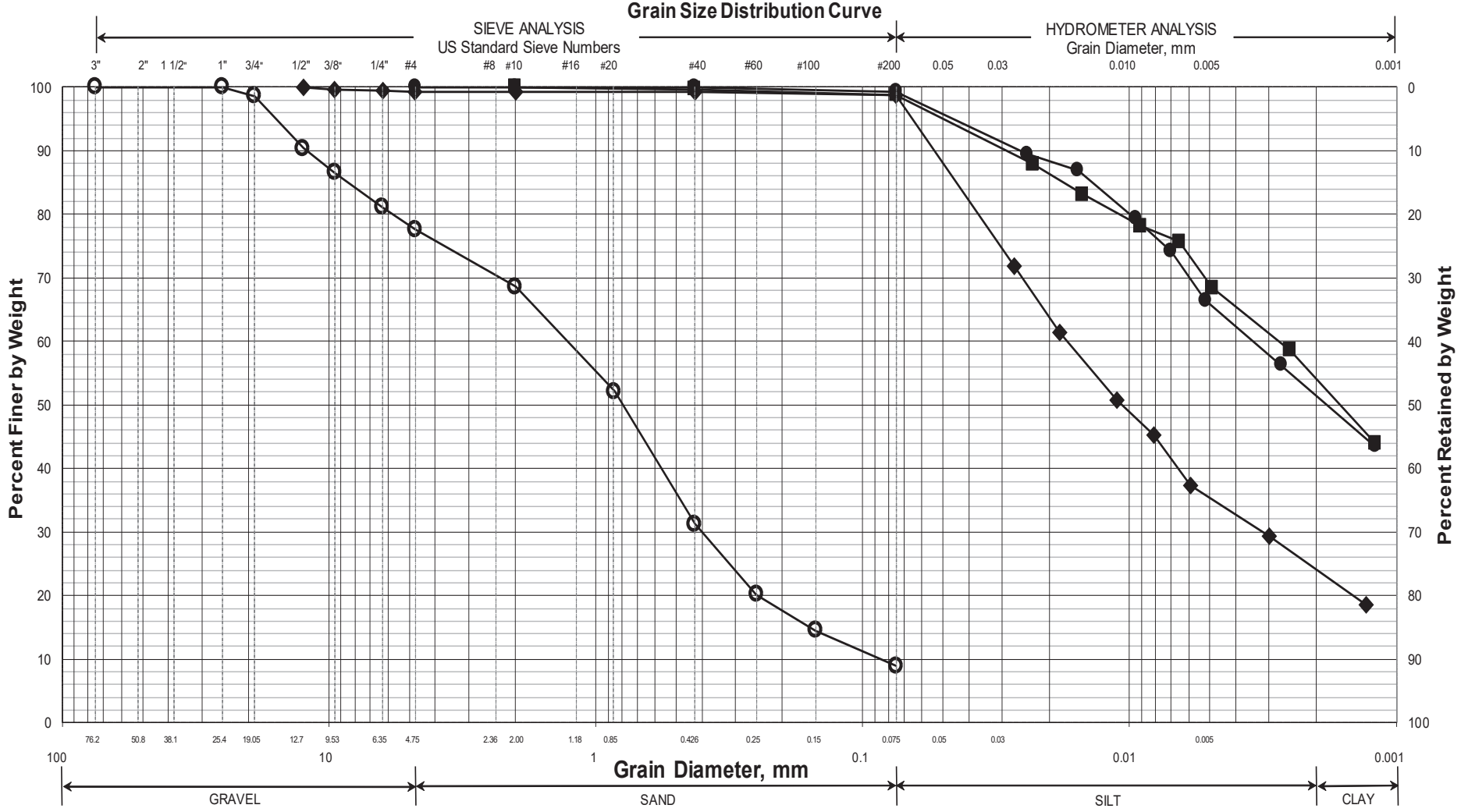
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

Maine Department of Transportation
Grain Size Distribution Curve

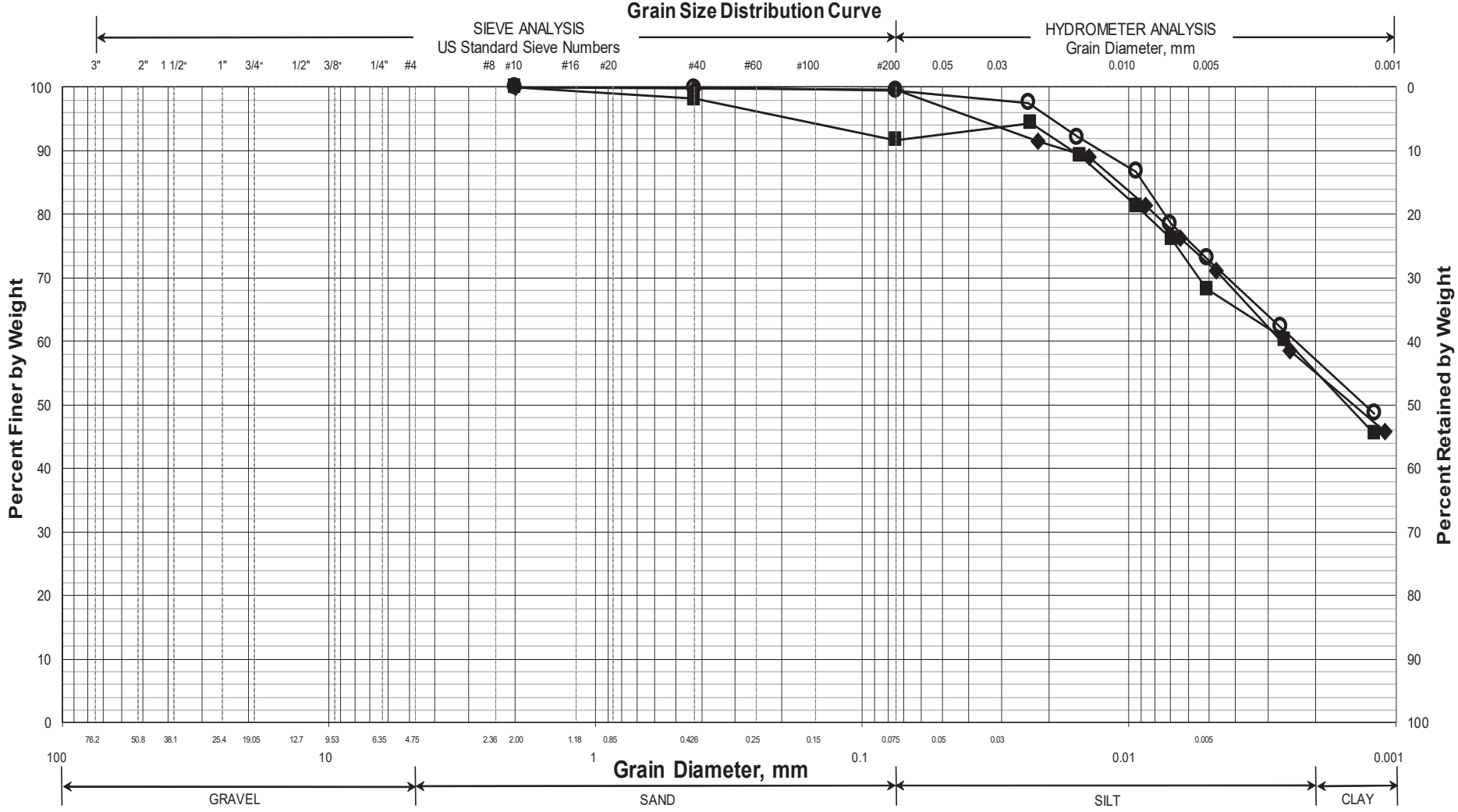


UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-BUXN-101/1D	42+07.5	12.7 LT	0.0-2.0	SAND, some gravel, trace silt.	4.1			
◆	HB-BUXN-101/2D	42+07.5	12.7 LT	5.0-7.0	SILT, some clay, trace sand. trace gravel.	32.4	29	21	8
■	HB-BUXN-101/3D	42+07.5	12.7 LT	10.0-12.0	Silty CLAY, trace sand.	34.7	39	21	18
●	HB-BUXN-101/4D	42+07.5	12.7 LT	15.0-17.0	Silty CLAY, trace sand.	44.7	35	20	15
▲									
×									

WIN
026382.00
Town
Buxton
Reported by/Date
WHITE, TERRY A 10/17/2022

Maine Department of Transportation
Grain Size Distribution Curve

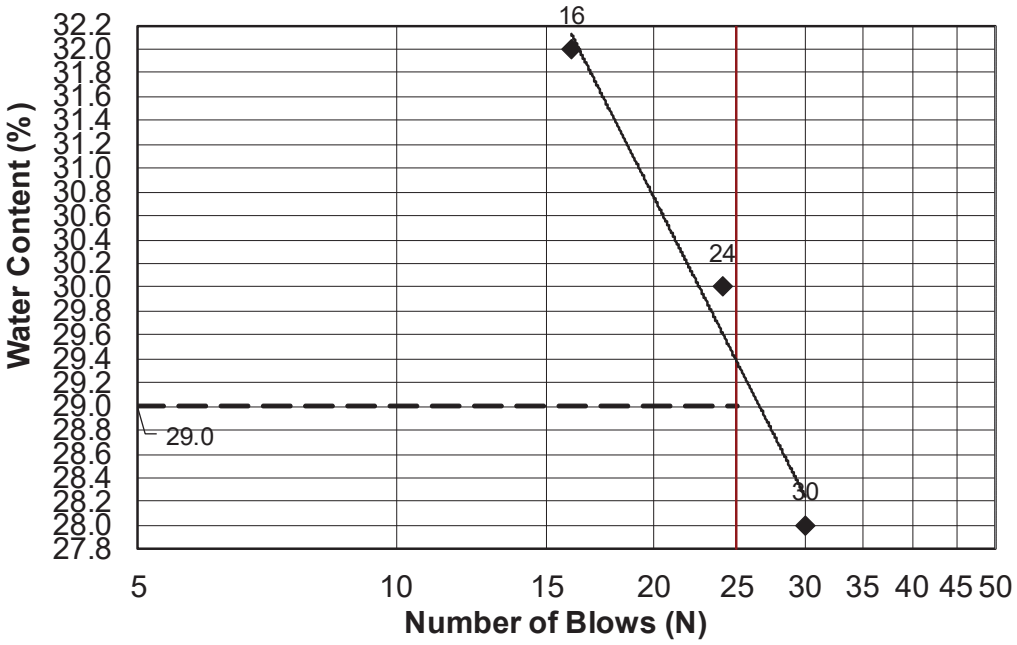


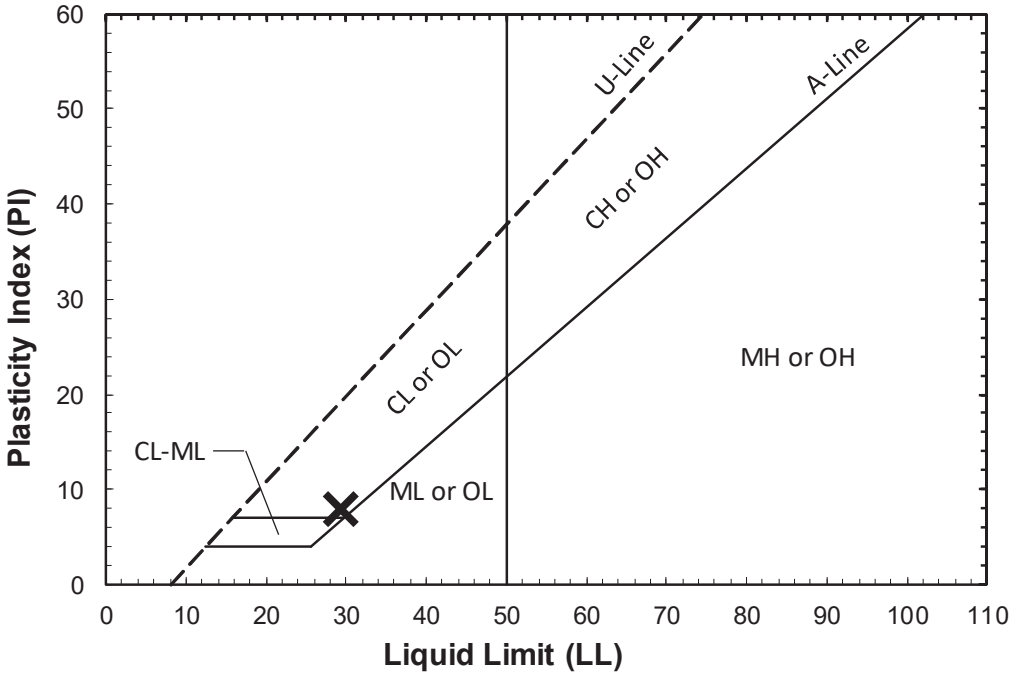
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	HB-BUXN-101/5D	42+07.5	12.7 LT	20.0-22.0	Silty CLAY, trace sand.	40.8			
◆	HB-BUXN-101/6D	42+07.5	12.7 LT	25.0-27.0	Silty CLAY, trace sand.	45.1	39	20	19
■	HB-BUXN-101/7D	42+07.5	12.7 LT	30.0-32.0	Silty CLAY, trace sand.	41.8	35	21	14
●									
▲									
×									

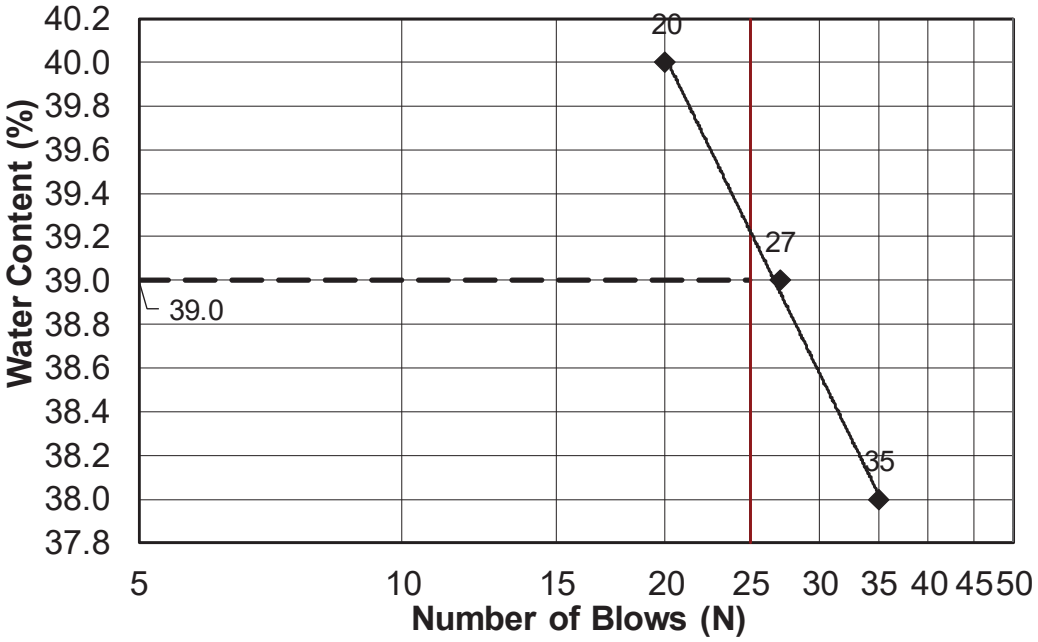
WIN
026382.00
Town
Buxton
Reported by/Date
WHITE, TERRY A 10/17/2022

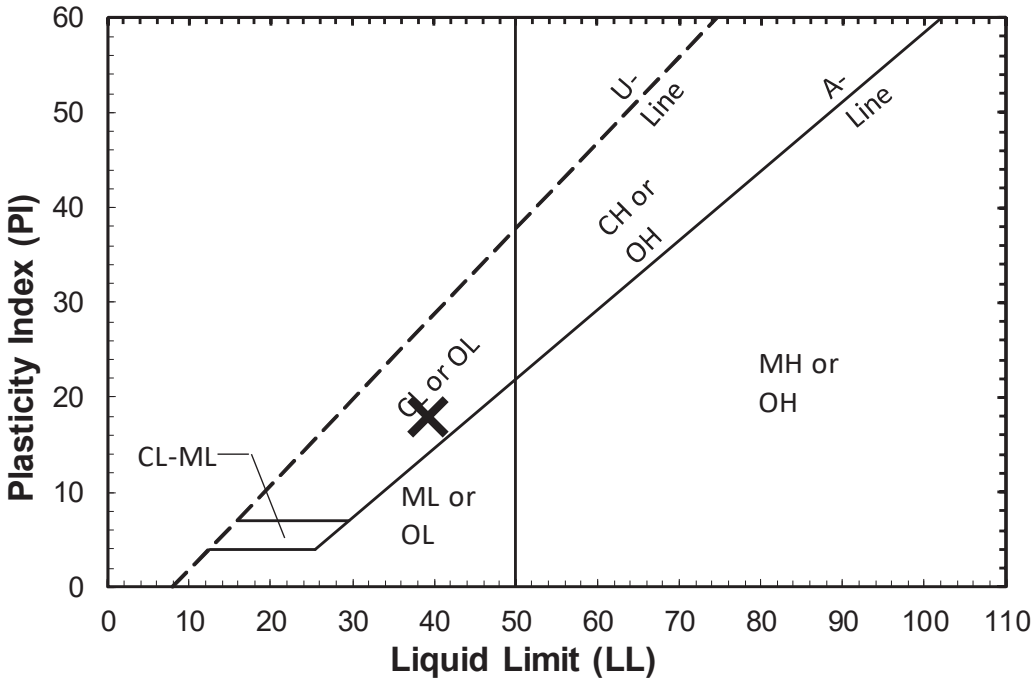
TOWN	Buxton	Reference No.	379860
WIN	026382.00	Water Content, %	32.4
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	29
Boring No./Sample No.	HB-BUXN-101/2D	Plastic Limit (T 90), %	21
Station	42+07.5	Plasticity Index (T 90), %	8
Depth	5.0-7.0	Tested By	BBURR



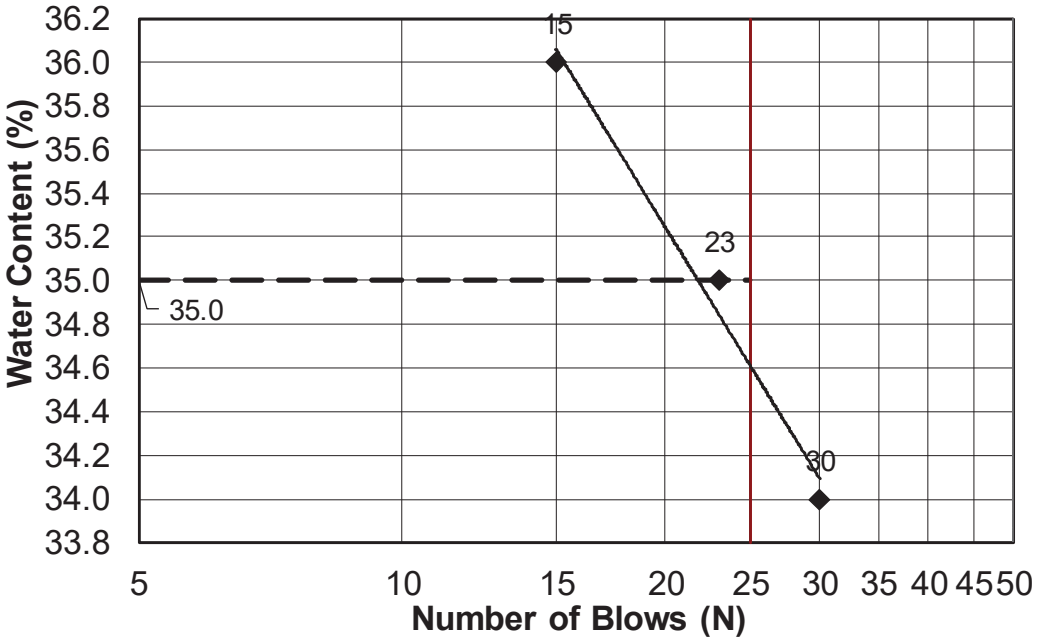


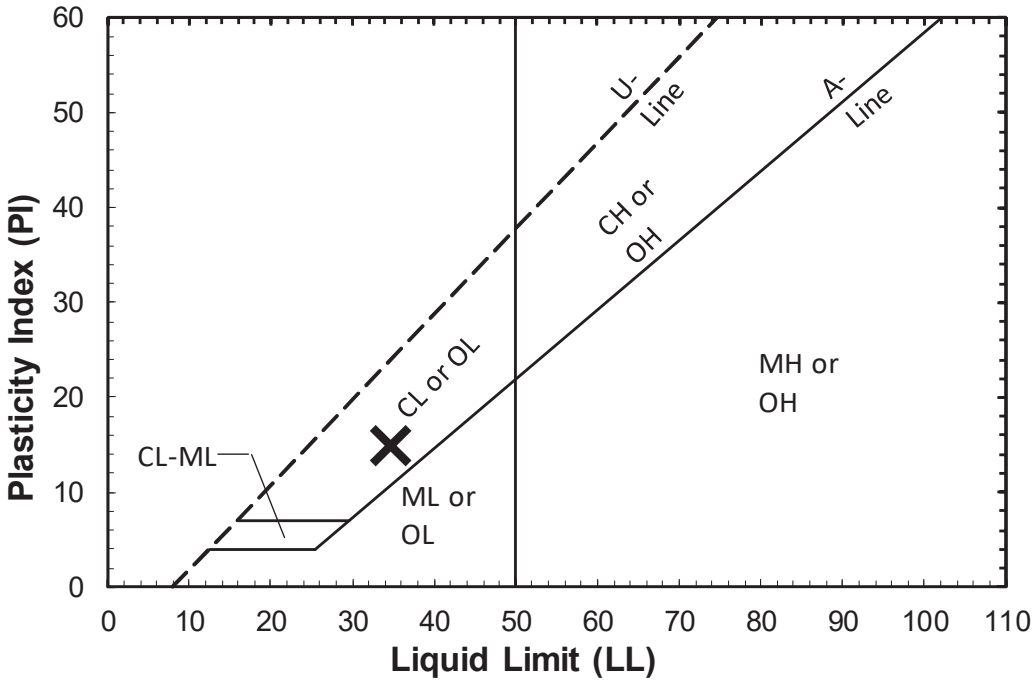
TOWN	Buxton	Reference No.	379861
WIN	026382.00	Water Content, %	34.7
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	39
Boring No./Sample No.	HB-BUXN-101/3D	Plastic Limit (T 90), %	21
Station	42+07.5	Plasticity Index (T 90), %	18
Depth	10.0-12.0	Tested By	BBURR



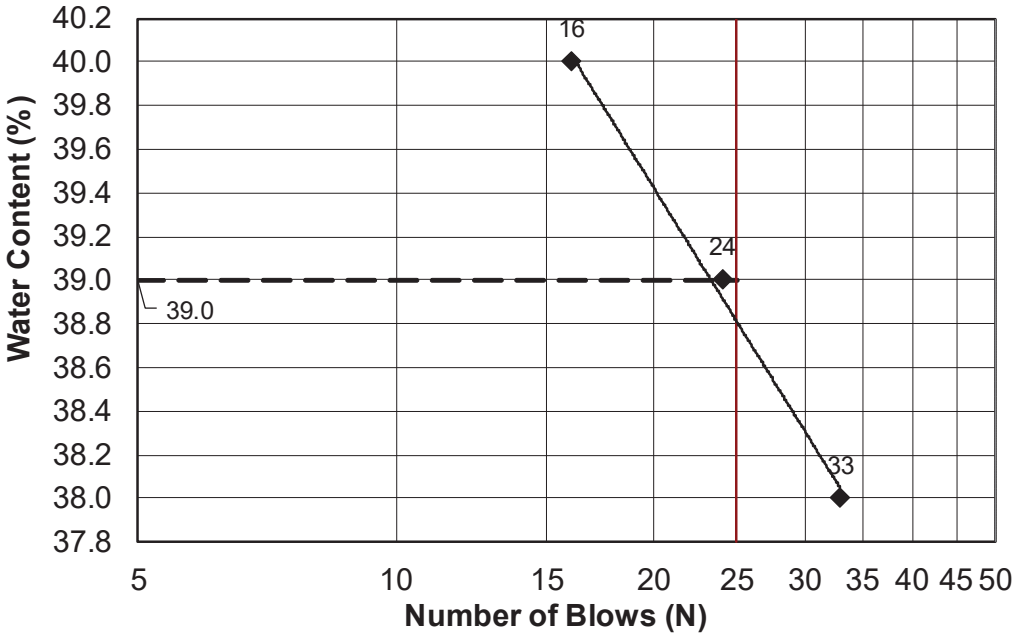


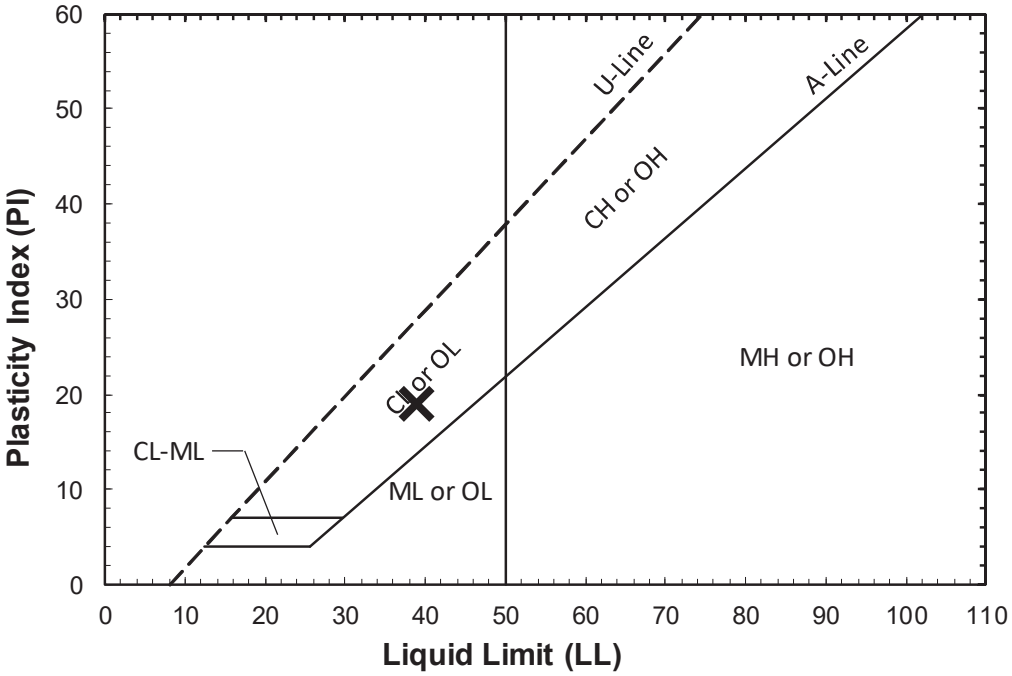
TOWN	Buxton	Reference No.	379862
WIN	026382.00	Water Content, %	44.7
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	35
Boring No./Sample No.	HB-BUXN-101/4D	Plastic Limit (T 90), %	20
Station	42+07.5	Plasticity Index (T 90), %	15
Depth	15.0-17.0	Tested By	BBURR



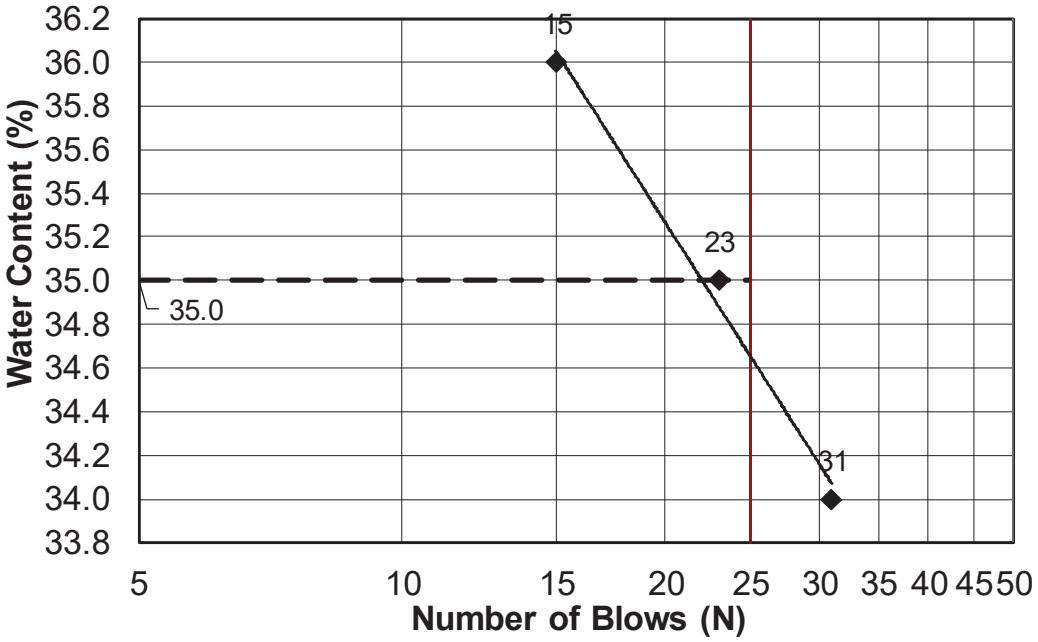


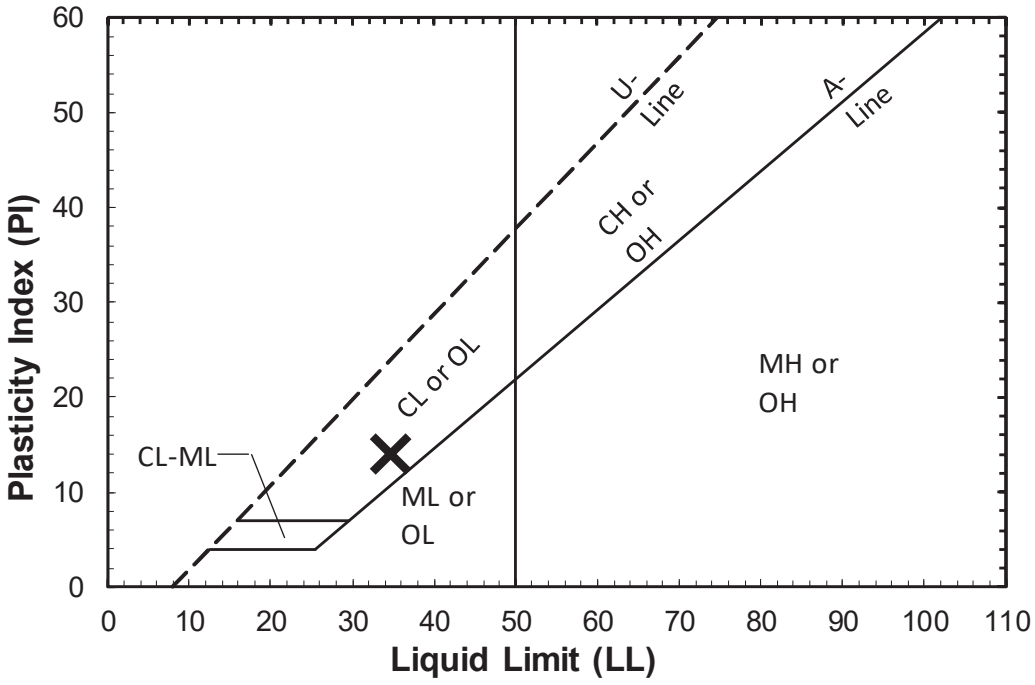
TOWN	Buxton	Reference No.	379864
WIN	026382.00	Water Content, %	45.1
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	39
Boring No./Sample No.	HB-BUXN-101/6D	Plastic Limit (T 90), %	20
Station	42+07.5	Plasticity Index (T 90), %	19
Depth	25.0-27.0	Tested By	BBURR





TOWN	Buxton	Reference No.	379865
WIN	026382.00	Water Content, %	41.8
Sampled	9/8/2022	Liquid Limit @ 25 blows (T 89), %	35
Boring No./Sample No.	HB-BUXN-101/7D	Plastic Limit (T 90), %	21
Station	42+07.5	Plasticity Index (T 90), %	14
Depth	30.0-32.0	Tested By	BBURR





Appendix C

Special Provision 620 – Geotextile (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

Appendix D

Calculations

Bearing Resistance - Existing Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - Box Culvert on Silty Clay

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 9th Edition 2020
Table C10.6.2.6.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Silty Clay (CL)

Based on N-values, soils are medium stiff near the bearing elevation

Density In Place: medium stiff to stiff

Bearing Resistance: Ordinary Range (ksf) 2 to 6

Recommended Value of Use: $q_{nom} := 3 \cdot ksf$

Resistance factor at the **service limit state** = 1.0 (LRFD Article 10.5.5.1) $\phi_{service\_bc} := 1.0$

$q_{factored\_service\_bc} := q_{nom} \cdot \phi_{service\_bc}$ $q_{factored\_service\_bc} = 3 \cdot ksf$

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 Gravel

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

Assumptions:

1. The box will be founded at ~ Elev 165.00 feet

   Bottom of Construction will be 3 feet below box invert $D_{footing} := 3.0 \cdot ft$

2. Assumed parameters for fill soils:

   Saturated unit weight: $\gamma_s := 125 \cdot pcf$

   Internal friction angle: $\phi_{ns} := 32 \cdot deg$

   Undrained shear strength: $c_{ns} := 0 \cdot psf$

3. Box Culvert parameters

   Width of box culvert, B $B_{box} := 11 \cdot ft$

   Length of box culvert, L $L_{box} := 88 \cdot ft$

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 $N_c := 35.5$ $N_q := 23.2$ $N_\gamma := 30.2$

Shape Correction Factors LRFD Table 10.6.3.1.2a.-3

for ϕ=32 degrees

$$s_c := 1 + \left(\frac{B_{box}}{L_{box}}\right)\left(\frac{N_q}{N_c}\right) \qquad s_c = 1.08$$

$$s_\gamma := 1 - 0.4\left(\frac{B_{box}}{L_{box}}\right) \qquad s_\gamma = 0.95$$

$$s_q := 1 + \left(\frac{B_{box}}{L_{box}} \cdot \tan(\phi_{ns})\right) \qquad s_q = 1.08$$

Load Inclination Factors:
Assume all are 1.0 (LRFD Article C10.6.3.1.2a)

$i_c := 1.0$ $i_q := 1.0$ $i_\gamma := 1.0$

Depth Correction Factor $d_q := 1 + 2 \cdot \tan(\phi_{ns}) \cdot (1 - \sin(\phi_{ns}))^2 \cdot \tan\left(\frac{D_{footing}}{B_{box}}\right)^{-1}$ $d_q = 1.9874$ LRFD Eq. 10.6.3.1.2a-10

$N_{cm} := N_c \cdot s_c \cdot i_c$ $N_{cm} = 38.4$ LRFD Eq. 10.6.3.1.2a-2

$N_{qm} := N_q \cdot s_q \cdot d_q \cdot i_q$ $N_{qm} = 49.71$ LRFD Eq. 10.6.3.1.2a-3

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $N_{\gamma m} = 28.69$ LRFD Eq. 10.6.3.1.2a-4

Coefficients for Groundwater Depths LRFD Table 10.6.3.1.2a-2

Depth the water table: $D_w := 8.0 \cdot ft$ $C_{wq} := 0.5$ $C_{w\gamma} := 0.5$

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

$q_{nominal} = 19.2 \cdot ksf$

Factored Bearing Resistance for Strength Limit State

Resistance Factor: $\phi_b := 0.45$ LRFD Table 10.5.5.2.2-1

$q_{factored} := q_{nominal} \cdot \phi_b$

$q_{factored} = 8.6 \cdot ksf$

Recommend a limiting factored bearing resistance of 8.5 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 $B_{box} = 11\ ft$

Length of box culvert, L $L_{box} = 88\ ft$

Thickness of box culvert, t $t_{box} := 12 \cdot in$ assumed

Depth of box, D $D_{box} := 9.5 \cdot ft$

Bearing Resistance: $q_{factored\_service\_bc} = 3 \cdot ksf$ Calculated above

Modulus of Elasticity: Site soils at bearing elevation are Silty Clay. Use values for Clay (medium stiff)
From Bowles Table 2-8 Modulus Es for Clay, ranges from 300 - 1050 ksf

Use Modulus of Elasticity, Es . $E_s := 300 \cdot ksf$

Poisson's Ratio: Site conditions at bearing elevation are Silty Clay. Use values for Clay (unsaturated)
From Bowles Table 2-7 Poisson's Ration μ for Clay ranges from 0.1 - 0.3

Use Possion's Ratio, μ . $\mu := 0.3$

$$E_{prime\_s} := \frac{1 - \mu^2}{E_s} \qquad E_{prime\_s} = 0.003033 \cdot \frac{ft^2}{kip}$$

Analyze corner:

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

$$H_{inf} := \frac{5 \cdot B_{box}}{B_{box}} \qquad H_{inf} = 5$$ N in Table 5-2

$$\frac{L_{box}}{B_{box}} = 8$$ M in Table 5-2

From Table 5-2 for N=5 and M=6.5

$I_1 := 0.546$

$I_2 := 0.124$ by interpolation

Determine Steinbrenner influence factor - Bowles Section 5-6:

$$I_s := I_1 + \left[\frac{1 - (2 \cdot \mu)}{1 - \mu}\right] \cdot I_2 \qquad I_s = 0.6169$$

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

Depth ratio: $\frac{D_{box}}{B_{box}} = 0.8636$ $\frac{L_{box}}{B_{box}} = 8$ $\mu = 0.3$ $I_F := 0.82$

Calculate modulus of subgrade reaction - Bowles Eq. 9-7

$$k_s := \frac{1}{B_{box} \cdot E_{prime\_s} \cdot I_s \cdot I_F}$$ Bowles Eq. 9-7

$k_s = 34 \cdot pci$

Recommend Modulus of Subgrade Reaction of 35 pci