MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

BOG BROOK BRIDGE
OVER BOG BROOK
STATE ROUTE 140
CANTON, MAINE

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Oxford County
WIN 19292.00

Soils Report No. 2012-12
Bridge No. 0645

May 31, 2012

Table of Contents

Tables

Sheets

Appendices

GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of Bog Brook Bridge which carries State Route 140 (School Street) over Bog Brook in Canton, Maine. Bog Brook Bridge was built in 1940 and consists of a steel girder superstructure with a concrete deck supported on mass concrete abutments presumed to be constructed in front of older stacked granite abutment walls. The wingwalls are flared dry stacked granite masonry walls. The proposed replacement structure will be a precast concrete box culvert. The proposed structure will have an overall length of approximately 68 feet and will be constructed on a 15 degree skew. Bog Brook will be realigned to flow through the new structure approximately 20 feet southwest of the existing bridge. The following design recommendations are discussed in detail in Section 7.0 of this report.

Precast Concrete Box Culvert Design and Construction– The precast concrete box culvert shall be designed by the Manufacturer in accordance with Special Provision 534 and AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD) specifications. The loading specified for the structure should be Modified HL-93 Strength I in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The precast concrete box culverts shall be designed for all relevant strength and service limit states and load combinations. The box culverts shall be constructed with concrete inlet and outlet toe walls.

Precast Concrete Box Culvert Headwall Design – Concrete headwalls should be specified to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. A minimum 1 foot by 1 foot concrete headwall is recommended. Precast concrete box culvert headwalls that are any larger than the nominal 1 foot by 1 foot shall be designed for all relevant strength and service limit states and load combinations. The headwalls shall be designed to resist and/or absorb lateral earth loads, vehicular loads, creep, and temperature and shrinkage deformations of the concrete box culvert. The headwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}).

Bearing Resistance - The factored bearing resistance for the strength limit state for the box culvert on compacted fill shall not exceed 8 ksf, however, the service limit state will control. A factored bearing resistance of 3 ksf shall be used to control settlement when analyzing the service limit state. In no instance shall the bearing stress exceed the nominal resistance of the structural concrete which may be taken as $0.3f'_c$.

Settlement - Settlement along the new alignment at the location of the replacement structure is anticipated to be minimal. The installation of the proposed box culvert will result in a net unloading of the site soils at the 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. No settlement issues are anticipated at the site.

Scour and Riprap – The box culverts shall be fitted with integral concrete headwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway and with inlet and outlet cutoff walls that extend below the maximum depth of scour. The slopes shall be armored with a 3-foot thick layer of riprap. The riprap shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of bedding material. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation. The riprap slopes shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface.

Frost Protection - Any foundation placed on granular subgrade soils should be founded a minimum of 6.0 feet below finished exterior grade for frost protection.

Seismic Design Considerations – 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 of the proposed precast concrete box culverts will require soil excavation. Earth support systems will be required. The fill and native soils at the site will be susceptible to disturbance and rutting as a result of exposure to water and construction traffic. All subgrade surfaces should be protected from any unnecessary construction traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted gravel borrow. Any cobbles or boulder encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow.

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.

1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present geotechnical recommendations for the replacement of Bog Brook Bridge which carries State Route 140 (School Street) over Bog Brook, in Canton, Maine. A subsurface investigation has been completed at the site. The purpose of the investigation was to explore subsurface conditions at the site in order to develop geotechnical recommendations for the bridge replacement. This report presents the soils information obtained at the site during the subsurface investigation, foundation design recommendations and geotechnical design parameters for the bridge replacement.

Bog Brook Bridge was built in 1940 and consists of a 14-foot, single-span, riveted steel girder superstructure with a concrete deck founded on mass concrete abutments presumed to be constructed in front of older stacked granite abutment walls. The wingwalls are flared dry stacked masonry walls. Maine Department of Transportation (MaineDOT) Bridge Maintenance inspection report for the bridge indicates the structure is in poor but serviceable condition. The existing stream alignment is poor at the bridge crossing with a sharp bend in the stream immediately upstream of the bridge. There is a large scour hole immediately downstream of the bridge. Undermining of both abutments is noted in the inspection reports. Settlement of the northeast granite retaining wall is noted due to the undermining. The 2009 MaineDOT Bridge Maintenance inspection reports assign both the bridge deck and superstructure a condition rating of 6 – satisfactory and the substructure a rating of 4 – poor. The channel protection is given a rating of 4 – protection undermined. The structure has a scour critical rating of "6 – scour calculation/evaluation has not been made". The bridge has a Bridge Sufficiency Rating of 52.1.

The MaineDOT Bridge Program and their structural consultant Stantec Consulting Services, Inc. (Stantec) are proposing a replacement structure consisting of a precast concrete box culvert skewed at approximately 15 degrees. The proposed box culvert will have inlet and outlet toe walls and beveled ends which will eliminate the need for wingwalls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. The overall length of the culvert will be approximately 68 feet. The existing roadway horizontal and vertical profiles will be maintained in the replacement. Bog Brook will be realigned to flow through the new structure approximately 20 feet southwest of the existing bridge. Staged construction with alternating two-way traffic using traffic signals will be utilized in the replacement of the structure.

2.0 GEOLOGIC SETTING

Bog Brook Bridge is located on State Route 140 (School Street) in Canton, Maine and crosses Bog Brook approximately 1.3 miles east of the Hartford/Canton town line as shown on Sheet 1 - Location Map presented at the end of this report.

According to the Surficial Geologic Map Canton Quadrangle, Maine Open File No. 08-82 2008 published by the Maine Geological Survey the surficial soils in the vicinity of the Bog

Brook Bridge site consist stream alluvium made up of sand, silt, gravel and organic sediment with local contacts to Glacial Lake Canton deposits. Stream alluvium soils were deposits on the flood plain of the Androscoggin River and other modern streams. The unit includes some wetland areas.

According to the Bedrock Geologic Map of Maine, Maine Geologic Survey, 1985, the site is underlain by interbedded pelite and sandstone. The formation is identified as the Anasagunticook Member of the Sangerville Formation.

3.0 SUBSURFACE INVESTIGATION

Subsurface conditions at the site were explored by drilling two (2) test borings. Test borings BB-CBB-101 and BB-CBB-102 were drilled on either side of the existing structure. The borings were drilled on January 9 and 10, 2012 by Northern Test Boring, Inc. (NTB) of Gorham, Maine. The boring locations are shown on Sheet 2 - Boring Location Plan found at the end of this report. An interpretive subsurface profile depicting the generalized soil stratigraphy across the site is shown on Sheet 3 - Interpretive Subsurface Profile found at the end of this report. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided in Appendix A - Boring Logs and on Sheet 4 - Boring Logs found end of this report.

The borings were drilled using solid stem auger and cased wash boring techniques. Soil samples were typically obtained at 5-foot intervals using Standard Penetration Test (SPT) methods. During SPT sampling, the sampler is driven 24 inches and the hammer blows for each 6 inch interval of penetration are recorded. The sum of the blows for the second and third intervals is the N-value, or standard penetration resistance. The NTB drill rig is equipped with an automatic hammer to drive the spilt spoon. The hammer was calibrated in October of 2011 and was found to deliver approximately 28 percent more energy during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values computed by applying an average energy transfer factor of 0.768 to the raw field N-values. This hammer efficiency factor, 0.768, and both the raw field N-value and the corrected N-value are shown on the boring logs. The bedrock was cored both borings using an NQ-2 inch core barrel and the Rock Quality Designation (RQD) of the core was calculated for the NQ cores.

The MaineDOT Geotechnical Team member selected the boring locations and drilling methods, designated type and depth of sampling techniques, reviewed field logs for accuracy and identified field and laboratory testing requirements. A New England Transportation Technician Certification Program (NETTCP) Certified Subsurface Inspector logged the subsurface conditions encountered. The borings were located in the field by taping to site features after completion of the drilling program.

4.0 LABORATORY TESTING

Laboratory testing for samples obtained in the borings consisted of twelve (12) standard grain size analyses with natural water contents. The results of soil laboratory tests are included as Appendix B - Laboratory Test Results at the end of this report. Laboratory test information is also shown on the boring logs provided in Appendix A – Boring Logs and on Sheet 4 – Boring Logs at the end of this report.

5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered at test borings generally consisted of granular fill underlain by interbedded sand and silt all underlain by bedrock. An interpretive subsurface profile depicting the generalized soil stratigraphy across the site is shown on Sheet 3 – Interpretive Subsurface Profile found at the end of this report. The boring logs are provided in Appendix A – Boring Logs at the end of this report. A brief summary description of the strata encountered follows:

5.1 Granular Fill

A layer of granular fill was encountered below the pavement in both of the borings. The layer ranged from approximately 4.5 feet to 4.6 feet thick. The deposit generally consisted of:

- Brown, moist, sandy gravel, trace silt and
- Brown, moist, fine to coarse sand, little silt, trace to little gravel.

Within the granular fill, an isolated cobble was encountered in boring BB-CBB-101 at a depth of approximately 1.2 to 1.7 feet below ground surface (bgs).

One corrected SPT N-value obtained in the granular fill unit was 32 blows per foot (bpf), indicating a soil that is dense in consistency. Grain size analyses were conducted on three (3) samples from the granular fill unit. Grain size analyses resulted in the soil being classified as an A-1-a or A-2-4 under the AASHTO Soil Classification System and an SM or GW-GM under the Unified Soil Classification System. The measured natural water contents of the samples tested ranged from approximately 2 to 14 percent.

5.2 Alluvial Sand

A layer of alluvial sand was encountered below the granular fill in both borings. The alluvial sand ranged from approximately 12.9 to 24.5 feet thick. The alluvial sand consisted of:

- Brown, wet, fine to medium sand, little silt, little gravel, trace coarse sand,
- Brown, wet, fine sand, trace silt, trace medium to coarse sand, trace gravel,
- Grey, wet, fine sand, trace silt, trace medium sand, and
- Grey, wet silty fine sand trace medium sand.

Corrected SPT N-values in the alluvial sand ranged from weight of hammer to 12 bpf indicating that the soil deposit is very loose to medium dense in consistency. Grain size analyses conducted on six (6) samples from the alluvial sand resulted in the soil being classified as an A-2-4, A-3 or A-4 under the AASHTO Soil Classification System and an SM or SP-SM under the Unified Soil Classification System. The measured natural water contents of samples tested ranged from approximately 24 to 32 percent.

5.3 Glacial Lake Deposits

Silts and sands which were deposited in Glacial Lake Canton were encountered below the alluvial sand fill in both borings. The silt ranged from approximately 4.9 to 15.5 feet thick. The silt consisted of:

- Grey, wet, fine sandy silt, trace medium sand and
- Grey, wet, silt, little fine sand.

Corrected SPT N-values in the silt were all 5 bpf indicating that the soil deposit is medium stiff in consistency. Grain size analyses conducted on three (3) samples from the silt resulted in the soil being classified as an A-4 under the AASHTO Soil Classification System and an ML under the Unified Soil Classification System. The measured natural water contents of samples tested ranged from approximately 29 percent.

A lower layer of sand was encountered below the silt in boring BB-CBB-101. The lower sand was approximately 4.5 feet thick and consisted of:

- Grey, wet, fine to coarse sand, little silt, little gravel.

One (1) corrected SPT N-value in lower sand was 10 bpf indicating that the layer is loose in consistency. No laboratory testing was conducted on the lower sand samples.

5.4 Bedrock

The bedrock at the site is identified as dark grey, fine grained, highly metamorphosed, slightly banded gneiss and granodiorite, with feldspar, biotite and muscovite mica, amphibole, quartz and garnet, with joints dipping at 5 to 40 degrees and 0 to 20 degrees. The RQD of the bedrock was determined to range from 72 to 100 percent, correlating to a rock mass quality of fair to excellent.

Table 1 summarizes approximate top of bedrock elevations at the exploration locations.

Boring	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock Surface (feet)
BB-CBB-101	37.5	349.3
BB-CBB-102	33.9	352.7

Table 1 - Approximate Depth to Bedrock and Elevation of Bedrock Surface at Exploration Locations

5.5 Groundwater

The measured groundwater levels in the borings ranged from approximately 6.0 feet bgs in boring BB-CBB-101 to approximately 5.0 feet bgs in boring BB-CBB-102. The water levels measured upon completion of drilling are indicated on the boring logs in Appendix A. Note that water was introduced into the boreholes during the drilling operations. It is likely that the water levels indicated on the boring logs do not represent stabilized groundwater conditions. Groundwater levels will fluctuate with seasonal changes, runoff and adjacent construction activities.

6.0 FOUNDATION ALTERNATIVES

Two (2) potential replacement alternative structures types were considered for this site:

- Corrugated metal pipe arch with buried invert to create a natural streambed crossing, and
- Precast concrete box culvert structure with a buried invert to create a natural streambed crossing.

Open bottom structures were ruled out for the site due to the scour susceptibility of the site soils. Additionally, the bottom of footing elevation for an open bottom structure was determined to be at an impractical depth for the site.

Staged construction with alternating two-way traffic using traffic signals will be utilized in the replacement of the structure. Closure of the bridge/road during construction was ruled out due to the detour length and the lack of maneuverability for truck traffic along the potential detour route. A temporary detour bridge was ruled out due to utility and property impacts.

The corrugated metal pipe arch was ruled out as constructing a pipe arch under staged construction loading can create problems with the second phase connection due to deflection of the arch.

The Preliminary Design Report (PDR) for this project prepared by Stantec recommends that the replacement structure be a precast concrete box culvert skewed at approximately 15 degrees. The proposed box culvert will have inlet and outlet toe walls and beveled ends which will eliminate the need for wingwalls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. Bog Brook will be realigned to flow through the new structure approximately 20 feet southwest of the existing bridge. This report addresses only this replacement structure.

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

The proposed replacement structure will consist of a 14-foot wide by 7-foot high precast concrete box culvert on a 15 degree skew with a stream realignment. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. The following sections will discuss geotechnical design recommendations for design of a precast concrete box culvert.

7.1 Precast Concrete Box Culvert Design and Construction

Precast concrete box culverts are typically detailed on the contract plans with only the basic layout and required hydraulic opening so that the Contractor may choose the appropriate structure. The manufacturer is responsible for the design of the structure including determination of the wall thickness, haunch thickness and reinforcement in accordance with Special Provision 534 Precast Concrete Arches, Box Culverts, which is included in Appendix D of this report. The loading specified for the structure should be Modified HL-93 Strength I in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The designer should use Soil Type 4 as presented in the MaineDOT Bridge Design Guide (BDG) Section 3.6 to design earth loads from the soil envelope. The backfill properties are as follows: $\phi = 32$ degrees, $\gamma = 125$ pcf.

The precast concrete box shall include accommodations for toe walls at both the inlet and outlet ends to prevent undermining per MaineDOT BDG Section 8.3.1. The cutoff walls should extend below the maximum depth of scour.

The precast concrete box culverts will be supplier-designed in accordance with AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD) specifications. The precast concrete box culverts shall be designed for all relevant strength and service limit states and load combinations specified in LRFD Article 3.4.1 and LRFD Section 12. The precast concrete box culvert shall be constructed in conformance with MaineDOT BDG Section 8 and Special Provision 534.

The box culvert will be bedded on a 2-foot thick layer of 3/4–inch crushed stone (see Special Provision 203 in Appendix D) reinforced with geogrid and wrapped with geotextile fabric. The soil envelop and backfill shall consist of Standard Specification 703.19 - Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches. The crushed stone bedding should be placed in 12 inch maximum thick lifts and compacted with a minimum of four passes of a large walk behind compactor. The granular borrow backfill should be placed in lifts of 6 to 8 inches thick loose measure and compacted to the manufacturer's specifications. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

7.2 Precast Concrete Box Culvert Headwall Design

Concrete headwalls should be included in the culvert design to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. A nominal 1 foot by 1 foot concrete headwall is recommended.

Larger precast or cast-in-place concrete box culvert headwalls are essentially retaining walls and shall be designed for all relevant strength and service limit states and load combinations specified in LRFD Articles 3.4.1, 11.5.5 and 11.6. The head walls shall be designed to resist and/or absorb lateral earth loads, vehicular loads, creep, and temperature and shrinkage deformations of the concrete box culvert. The headwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) taken from Table 2 below:

Wall Height (feet)	h_{eq} (feet)	
	Distance from wall pressure surface to edge of traffic = 0 feet	Distance from wall pressure surface to edge of traffic ≥ 1 foot
5	5.0	2.0
10	3.5	2.0
≥20	2.0	2.0

Table 2 – Equivalent Height of Soil for Vehicular Loading on Retaining Walls

Culvert headwall sections that are fixed to the box culverts to resist movement should be designed using an at-rest earth pressure coefficient, K_o, of 0.5. Headwall sections that are independent of the box culvert should be designed using the Rankine active earth pressure coefficient, K_a, of 0.31 assuming a level back slope. The active earth pressure coefficient may change if the back slope conditions are different. See Appendix C - Calculations for supporting documentation.

Footings for any headwall or wingwall constructed independently of the box culvert should be placed no less than 2.0 feet below the maximum anticipated scour depth.

7.3 Bearing Resistance

The factored bearing resistance for at the strength limit state for the box culvert on compacted fill shall not exceed 8 kips per square foot (ksf), however, the service limit state bearing resistance will govern. A factored bearing resistance of 3 ksf shall be used to control settlement when analyzing the service limit state as allowed in LRFD C10.6.2.6.1. In no instance shall the bearing stress exceed the nominal resistance of the structural concrete which may be taken as $0.3f'_c$. See Appendix C - Calculations for supporting documentation.

7.4 Scour and Riprap

The box culverts shall be fitted with integral concrete headwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway and with inlet and outlet cutoff walls that extend below the maximum depth of scour. The slopes shall be armored with a 3-foot thick layer of riprap conforming to MaineDOT Supplemental Specification Section 703.26 Plain and Hand Laid Riprap. The riprap shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of bedding material conforming to MaineDOT Standard Specification 703.19 Granular Borrow Material for Underwater Backfill. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation. The riprap slopes should also be constructed in accordance with MaineDOT Supplemental Specification Section 610 – Stone Fill, Riprap, Stone Blanket and Stone Ditch Protection and shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface.

7.5 Settlement

Settlement along the new alignment at the location of the replacement structure is anticipated to be minimal. The installation of the proposed box culvert will result in a net unloading of the site soils at the 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. No settlement issues are anticipated at the site.

7.6 Frost Protection

Any foundation placed on granular subgrade soils should be designed with an appropriate embedment for frost protection. Based on the State of Maine frost depth map found in Maine DOT BDG (Figure 5-1), the site has an air design-freezing index of approximately 1600 F-degree days. Considering the site soils and natural water contents determined in the laboratory, this correlates to a frost depth of approximately 6.0 feet. Therefore, any foundations placed on granular soils should be founded a minimum of 6.0 feet below finished exterior grade for frost protection. See Appendix C- Calculations at the end of this report for supporting documentation.

7.7 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.

7.8 Construction Considerations

Construction of the proposed precast concrete box culverts will require soil excavation. Earth support systems will be required. The fill and native soils at the site will be susceptible to disturbance and rutting as a result of exposure to water and construction traffic. All subgrade surfaces should be protected from any unnecessary construction traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted gravel borrow. Any cobbles or boulder encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow.

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.

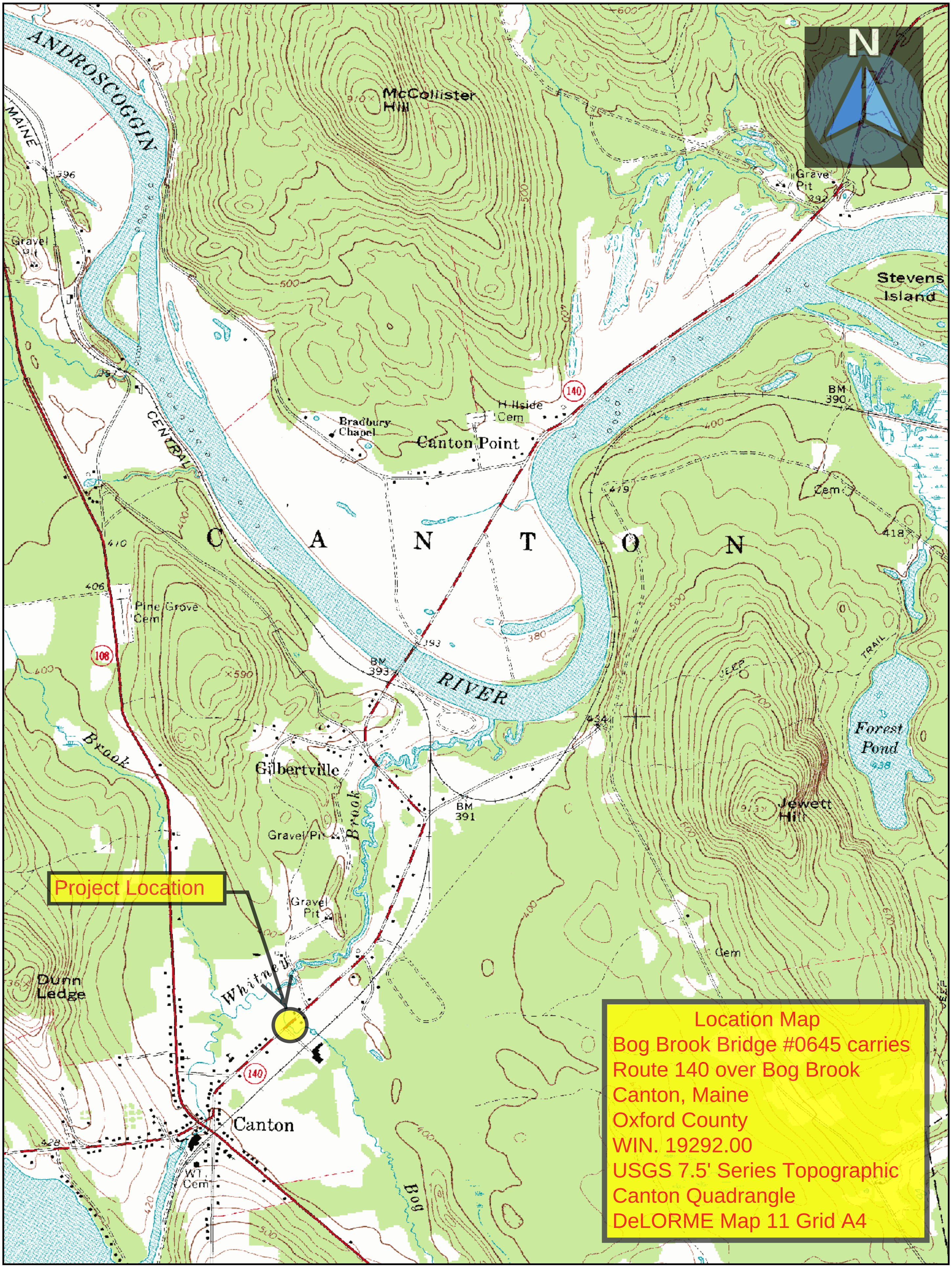
8.0 CLOSURE

This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Bog Brook Bridge in Canton, 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. Further, the analyses and recommendations are based in part upon limited soil explorations at discrete locations 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 also recommend that the geotechnical designer be provided the opportunity for a general review of the final design plans and specifications in order to verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design.

Sheets



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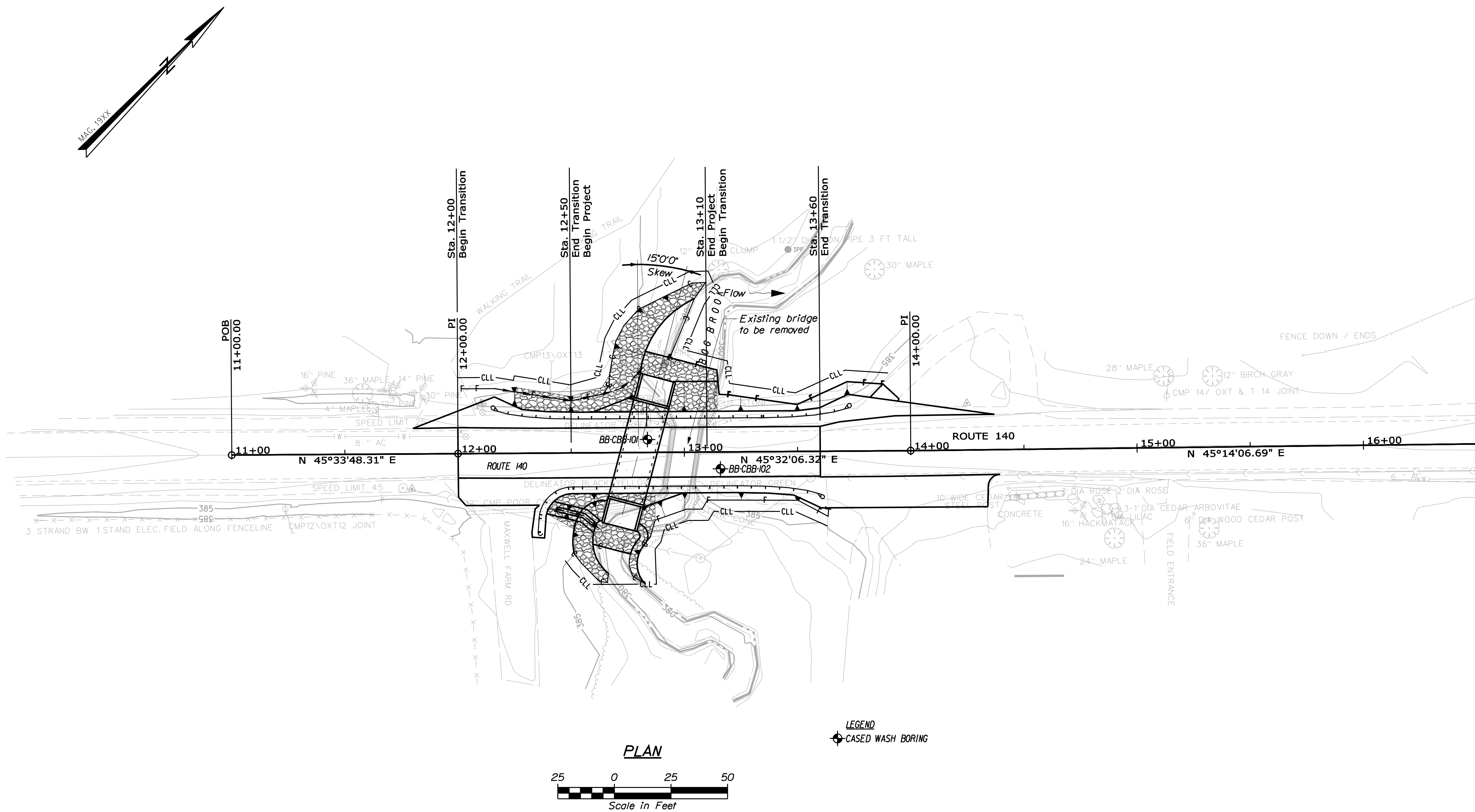


STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19292.00

WIN
19292.00

BRIDGE NO. 0645

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	T. WHITE	JAN 2012
CHECKED-REVIEWED	K. MAGUIRE	
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

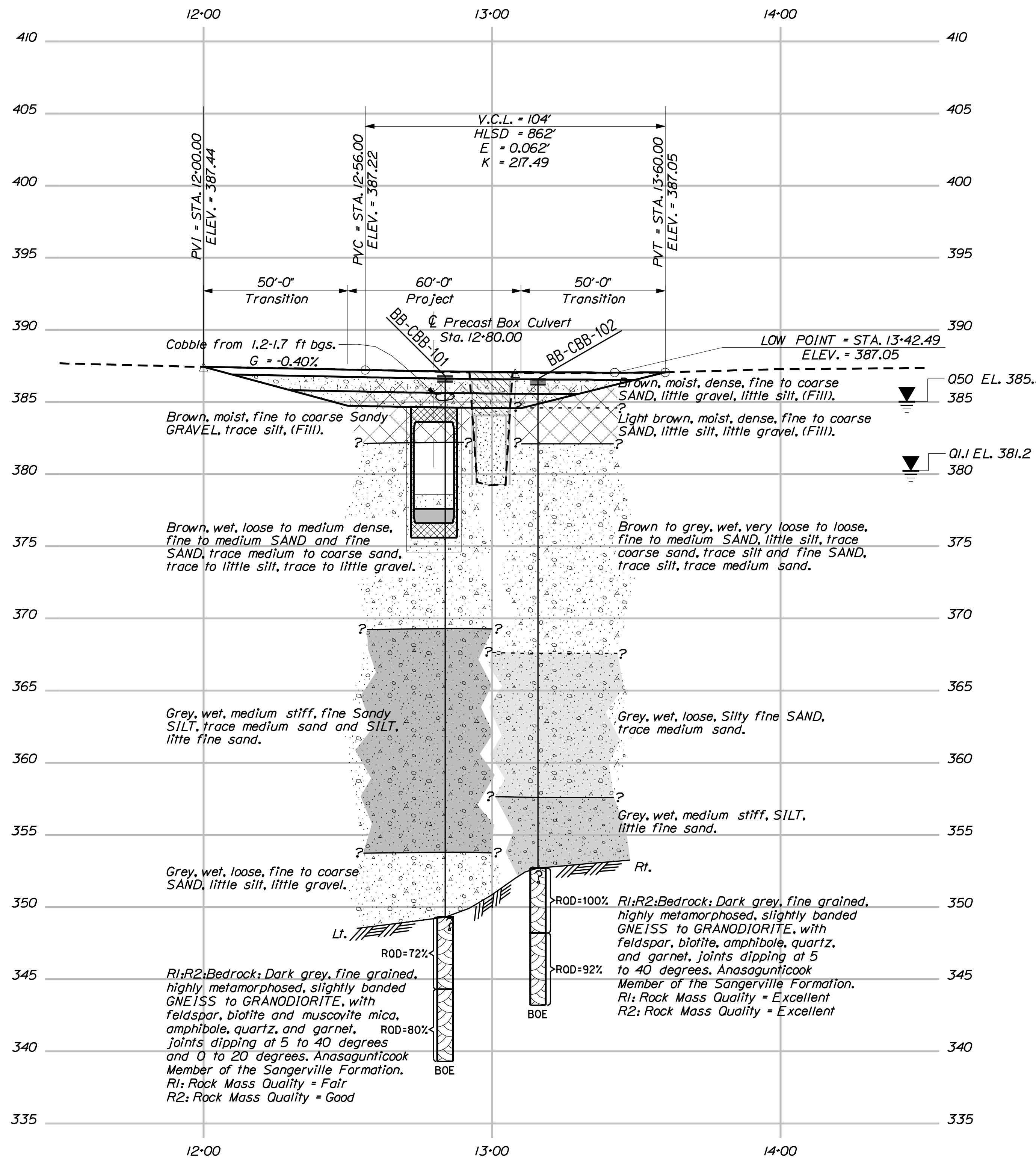
BOG BROOK BRIDGE
BOG BROOK
CANTON OXFORD COUNTY

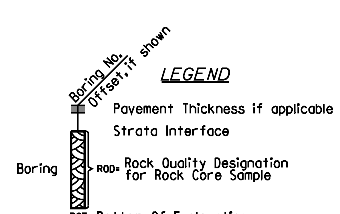
BORING LOCATION PLAN

SHEET NUMBER
2
OF 4

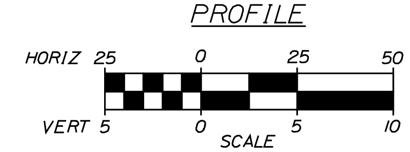
Filename: ...\00\GEOTECH\MSTA\006_BLP1.dgn Division: GEOTECH Username: terry.white Date:6/1/2012

Filename: ...\00\geotech\msta\007_ISP1.dgn Division: GEOTECH Username: terry.white Date:6/1/2012





PROFILE



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 transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19292.00

BRIDGE NO. 0645 | WIN 19292.00 | BRIDGE PLANS

PROJ. MANAGER		BY	DATE
DESIGN-DETAILED	K.MAGUIRE	T.WHITE	MAY 2012
CHECKED-REVIEWED			
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

BOG BROOK BRIDGE
BOG BROOK
CANTON OXFORD COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3
OF 4

Filename: ...\msta\008_BORING LOGS1.dgn Division: GEOTECH Username: terry.white Date:6/1/2012

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Bog Brook Bridge #0645 carries Route 140 over Bog Brook
Location: Canton, Maine

Boring No.: BB-CBB-101
WIN: 19292.00

Driller:	Northern Test Boring	Elevation (ft.)	386.8	Auger ID/OD:	2.75/6.25" HSA
Operator:	Mike/Adam	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	Diedrick D-50 Track	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	1/10/2012; 08:00-15:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2
Boring Location:	12+83.7, 5.7 ft Lt.	Casing ID/OD:	HW	Water Level*:	6.0 ft bgs
Hammer Efficiency Factor: 0.768		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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	S1		0.42 - 4.60				HSA	386.38		5" Pavement ——0.42 Brown, moist, fine to coarse Sandy GRAVEL, trace silt, (Fill). Sample off auger flights. Cobble from 1.2-1.7 ft bgs.	G#244701 A-1-a, GW-GM WC=1.9%
								382.20		——4.60	
5	1D	24/16	5.00 - 7.00	2/2/2/2	4	5				Brown, wet, loose, fine to medium SAND, little silt, little gravel, trace coarse sand, (Alluvium).	G#244702 A-2-4, SM WC=24.3%
10	2D	24/17	10.00 - 12.00	2/2/3/2	5	6	aHP			Brown, wet, loose, fine SAND, trace silt, trace medium to coarse sand, (Alluvium). aHP = Hydraulic Push	G#244703 A-3, SP-SM WC=27.5%
							aHP				
							18				
							37				
	3D	24/14	14.00 - 16.00	4/4/5/6	9	12	22			Brown, wet, medium dense, fine SAND, trace silt, trace gravel, trace medium to coarse sand, (Alluvium).	G#244704 A-3, SP-SM WC=26.5%
15							36				
							40				
							53	369.30		——17.50	
							53				
	4D	24/19	19.00 - 21.00	2/2/2/3	4	5	48			Grey, wet, medium stiff, fine Sandy SILT, trace medium sand, (Glacial Lake Deposits).	
20							52				
							57				
							58				
							57				
	5D	24/18	24.00 - 26.00	1/2/2/2	4	5	62			Grey, wet, medium stiff, fine Sandy SILT, trace medium sand, (Glacial Lake Deposits).	G#244705 A-4, ML WC=28.9%
25							66				
							76				
							83				
							111				
	6D	24/16	29.00 - 31.00	2/2/2/2	4	5	78			Grey, wet, medium stiff, SILT, little fine sand, (Glacial Lake Deposits).	G#244706 A-4, ML WC=29.1%
30							72				
							60				
							67	353.80		——33.00	
							88				
	7D	24/2	34.00 - 36.00	11/4/4/3	8	10	42			Grey, wet, loose, fine to coarse SAND, little silt, little gravel.	
35							40				
							47			Roller Coned ahead from 36.0-37.5 ft bgs. b80 blows for 0.5 ft.	
	R1	60/60	37.50 - 42.50	RQD = 72%			b80 NQ-2	349.30		——37.50 Top of Bedrock at Elev. 349.3 ft. R1:Bedrock: Dark grey, fine grained, highly metamorphosed, slightly banded GNEISS to GRANODIORITE, with feldspar, biotite, amphibole, quartz, and garnet, joints dipping at 5 to 40 degrees. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Fair. R1:Core Times (min:sec) 37.5-38.5 ft (5:30) 38.5-39.5 ft (5:00) 39.5-40.5 ft (5:30) 40.5-41.5 ft (7:30) 41.5-42.5 ft (8:00) 100% Recovery	
40											
	R2	60/60	42.50 - 47.50	RQD = 80%						R2:Bedrock: Similar to R1 with muscovite mica, joints dipping at 0 to 20 degrees. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Good. R2:Core Times (min:sec) 42.5-43.5 ft (5:00) 43.5-44.5 ft (5:30) 44.5-45.5 ft (5:00) 45.5-46.5 ft (4:30) 46.5-47.5 ft (4:30) 100% Recovery	
45											
								339.30		——47.50 Bottom of Exploration at 47.50 feet below ground surface.	
50											

Remarks:

Auto hammer #283

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

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

Page 1 of 1

Boring No.: BB-CBB-101

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Bog Brook Bridge #0645 carries Route 140 over Bog Brook
Location: Canton, Maine

Boring No.: BB-CBB-102
WIN: 19292.00

Driller:	Northern Test Boring	Elevation (ft.)	386.6	Auger ID/OD:	2.75/6.25" HSA
Operator:	Mike/Adam	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	Diedrick D-50 Track	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	1/9/2012; 09:00-15:00	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2
Boring Location:	13+15.9, 7.5 ft Rt.	Casing ID/OD:	HW	Water Level*:	5.0 ft bgs
Hammer Efficiency Factor: 0.768		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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in. Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							HSA	386.18		5" Pavement ——0.42	
	1D/A	24/18	1.00 - 3.00	40/17/8/7	25	32				1D (1.0-2.0 ft bgs) Brown, moist, dense, fine to coarse SAND, little gravel, little silt, (Fill).	G#244707 A-2-4, SM WC=6.6%
								384.60		- - -2.00 1D/A (2.0-3.0 ft bgs) Light brown, moist, dense, fine to coarse SAND, little silt, trace gravel, (Fill).	G#244708 A-2-4, SM WC=13.5%
								382.10		——4.50	
5	2D	24/20	5.00 - 7.00	1/1/1/2	2	3				Brown, wet, very loose, fine to medium SAND, little silt, trace coarse sand, (Alluvium).	G#244709 A-2-4, SM WC=31.7%
10	3D	24/17	10.00 - 12.00	1/WOH/WOH/1	---		aHP			aHP = Hydraulic Push Grey, wet, very loose, fine SAND, trace silt, trace medium sand, (Alluvium).	G#244710 A-3, SP-SM WC=30.7%
							12				
							22				
							37				
	4D	24/16	14.00 - 16.00	2/2/2/2	4	5	19			Similar to above, loose.	
15							12				
							29				
							65				
							81	367.60		- - -19.00	
	5D	24/17	19.00 - 21.00	2/2/2/2	4	5	62			Grey, wet, loose, Silty fine SAND, trace medium sand, (Alluvium).	G#244711 A-4, SM WC=25.8%
20							52				
							55				
							71				
							93				
	6D	24/18	24.00 - 26.00	1/1/1/2	2	3	70			Similar to above, very loose.	
25							59				
							56				
							65				
							78	357.60		——29.00	
	7D	24/20	29.00 - 31.00	1/2/2/2	4	5	68			Grey, wet, medium stiff, SILT, little fine sand, (Glacial Lake Deposits).	G#244712 A-4, ML WC=29.6%
30							77				
							128				
							155			b202 blows for 0.9 ft.	
	R1	54/54	33.90 - 38.40	RQD = 100%			b202 NQ-2	352.70		——33.90 Top of Bedrock at Elev. 352.7 ft. R1:Bedrock: Dark grey, fine grained, highly metamorphosed, slightly banded GNEISS to GRANODIORITE, with feldspar, biotite, amphibole, quartz, and garnet, joints dipping at 5 to 40 degrees. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Excellent. R1:Core Times (min:sec) 33.9-34.9 ft (6:0) 34.9-35.9 ft (5:00) No water return 35.9-36.9 ft (5:30) 36.9-37.9 ft (4:30) 37.9-38.4 ft (1:00) 100% Recovery Core Bit Plugged	
35											
	R2	60/55	38.40 - 43.40	RQD = 92%						R2:Bedrock: Similar to R1. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Excellent. R2:Core Times (min:sec) 38.4-39.4 ft (5:00) 39.4-40.4 ft (5:10) 40.4-41.4 ft (5:15) 41.4-42.4 ft (5:00) 42.4-43.4 ft (5:00) 92% Recovery	
40											
								343.20		——43.40 Bottom of Exploration at 43.40 feet below ground surface.	
45											
50											

Remarks:

Auto hammer #283

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

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

Page 1 of 1

Boring No.: BB-CBB-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19292.00

BRIDGE NO. 0645 WIN 19292.00 BRIDGE PLANS

PROJ. MANAGER		BY	DATE
DESIGN-DETAILED	K.MAGUIRE	T.WHITE	MAY 2012
CHECKED-REVIEWED			
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

BOG BROOK BRIDGE
BOG BROOK
CANTON OXFORD COUNTY

BORING LOGS

SHEET NUMBER
4
OF 4

<u>Appendix A</u>

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)

Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
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., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

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. Consistency is rated according to standard penetration resistance.

Modified Burmister System

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

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 shear strength as indicated.

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

Rock Quality Designation (RQD):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

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

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, 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, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
- -spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
- -tightness (tight, open or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock mass quality (very poor, poor, etc.)
ref: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

Sample Container Labeling Requirements:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Bog Brook Bridge #0645 carries Route 140 over Bog Brook
Location: Canton, Maine

Boring No.: BB-CBB-101
WIN: 19292.00

Driller:	Northern Test Boring	**Elevation (ft.)**	386.8	**Auger ID/OD:**	2.75/6.25" HSA
Operator:	Mike/Adam	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Diedrick D-50 Track	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	1/10/2012; 08:00-15:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2
Boring Location:	12+83.7, 5.7 ft Lt.	**Casing ID/OD:**	HW	**Water Level*:**	6.0 ft bgs
Hammer Efficiency Factor:	0.768	**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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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	S1		0.42 - 4.60				HSA	386.38		5" Pavement — 0.42	
										Brown, moist, fine to coarse Sandy GRAVEL, trace silt, (Fill). Sample off auger flights. Cobble from 1.2-1.7 ft bgs.	G#244701 A-1-a, GW-GM WC=1.9%
								382.20		4.60	
5	1D	24/16	5.00 - 7.00	2/2/2/2	4	5				Brown, wet, loose, fine to medium SAND, little silt, little gravel, trace coarse sand, (Alluvium).	G#244702 A-2-4, SM WC=24.3%
10	2D	24/17	10.00 - 12.00	2/2/3/2	5	6	aHP			Brown, wet, loose, fine SAND, trace silt, trace medium to coarse sand, (Alluvium). aHP = Hydraulic Push	G#244703 A-3, SP-SM WC=27.5%
							aHP				
							18				
							37				
	3D	24/14	14.00 - 16.00	4/4/5/6	9	12	22			Brown, wet, medium dense, fine SAND, trace silt, trace gravel, trace medium to coarse sand, (Alluvium).	G#244704 A-3, SP-SM WC=26.5%
15							36				
							40				
							53	369.30		17.50	
							53				
	4D	24/19	19.00 - 21.00	2/2/2/3	4	5	48			Grey, wet, medium stiff, fine Sandy SILT, trace medium sand, (Glacial Lake Deposits).	
20							52				
							57				
							58				
							57				
	5D	24/18	24.00 - 26.00	1/2/2/2	4	5	62			Grey, wet, medium stiff, fine Sandy SILT, trace medium sand, (Glacial Lake Deposits).	G#244705 A-4, ML
25											

Remarks:

Auto hammer #283

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.

Boring No.: BB-CBB-101

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Bog Brook Bridge #0645 carries Route 140 over Bog Brook **Location:** Canton, Maine	**Boring No.:** BB-CBB-101 **WIN:** 19292.00

Driller:	Northern Test Boring	**Elevation (ft.)**	386.8	**Auger ID/OD:**	2.75/6.25" HSA
Operator:	Mike/Adam	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Diedrick D-50 Track	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	1/10/2012; 08:00-15:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2
Boring Location:	12+83.7, 5.7 ft Lt.	**Casing ID/OD:**	HW	**Water Level*:**	6.0 ft bgs
Hammer Efficiency Factor:	0.768	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:

D = Split Spoon Sample	R = Rock Core Sample	S_u = Insitu Field Vane Shear Strength (psf)	$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
MD = Unsuccessful Split Spoon Sample attempt	SSA = Solid Stem Auger	T_V = Pocket Torvane Shear Strength (psf)	WC = water content, percent
U = Thin Wall Tube Sample	HSA = Hollow Stem Auger	q_p = Unconfined Compressive Strength (ksf)	LL = Liquid Limit
MU = Unsuccessful Thin Wall Tube Sample attempt	RC = Roller Cone	N-uncorrected = Raw field SPT N-value	PL = Plastic Limit
V = Insitu Vane Shear Test, PP = Pocket Penetrometer	WOH = weight of 140lb. hammer	Hammer Efficiency Factor = Annual Calibration Value	PI = Plasticity Index
MV = Unsuccessful Insitu Vane Shear Test attempt	WOR/C = weight of rods or casing	N_{60} = SPT N-uncorrected corrected for hammer efficiency	G = Grain Size Analysis
	WO1P = Weight of one person	N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected	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							66				WC=28.9%
							76				
							83				
							111				
	6D	24/16	29.00 - 31.00	2/2/2/2	4	5	78			Grey, wet, medium stiff, SILT, little fine sand, (Glacial Lake Deposits).	G#244706 A-4, ML WC=29.1%
30							72				
							60				
							67				
							88	353.80		33.00	
	7D	24/2	34.00 - 36.00	11/4/4/3	8	10	42			Grey, wet, loose, fine to coarse SAND, little silt, little gravel.	
35							40				
							47			Roller Coned ahead from 36.0-37.5 ft bgs.	
	R1	60/60	37.50 - 42.50	RQD = 72%			b80 NQ-2	349.30		b80 blows for 0.5 ft. 37.50 Top of Bedrock at Elev. 349.3 ft. R1:Bedrock: Dark grey, fine grained, highly metamorphosed, slightly banded GNEISS to GRANODIORITE, with feldspar, biotite, amphibole, quartz, and garnet, joints dipping at 5 to 40 degrees. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Fair. R1:Core Times (min:sec) 37.5-38.5 ft (5:30) 38.5-39.5 ft (5:00) 39.5-40.5 ft (5:30) 40.5-41.5 ft (7:30) 41.5-42.5 ft (8:00) 100% Recovery	
40											
	R2	60/60	42.50 - 47.50	RQD = 80%						R2:Bedrock: Similar to R1 with muscovite mica, joints dipping at 0 to 20 degrees. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Good. R2:Core Times (min:sec) 42.5-43.5 ft (5:00) 43.5-44.5 ft (5:30) 44.5-45.5 ft (5:00) 45.5-46.5 ft (4:30) 46.5-47.5 ft (4:30) 100% Recovery	
45											
								339.30		47.50 **Bottom of Exploration at 47.50 feet below ground surface.**	
50											

Remarks:

Auto hammer #283

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: Bog Brook Bridge #0645 carries Route 140 over Bog Brook
Location: Canton, Maine

Boring No.: BB-CBB-102
WIN: 19292.00

Driller:	Northern Test Boring	**Elevation (ft.)**	386.6	**Auger ID/OD:**	2.75/6.25" HSA
Operator:	Mike/Adam	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Diedrick D-50 Track	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	1/9/2012; 09:00-15:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2
Boring Location:	13+15.9, 7.5 ft Rt.	**Casing ID/OD:**	HW	**Water Level*:**	5.0 ft bgs
Hammer Efficiency Factor:	0.768	**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 = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							HSA	386.18		5" Pavement — 0.42	
	1D/A	24/18	1.00 - 3.00	40/17/8/7	25	32				1D (1.0-2.0 ft bgs) Brown, moist, dense, fine to coarse SAND, little gravel, little silt, (Fill).	G#244707 A-2-4, SM WC=6.6%
								384.60		— 2.00 — 1D/A (2.0-3.0 ft bgs) Light brown, moist, dense, fine to coarse SAND, little silt, trace gravel, (Fill).	G#244708 A-2-4, SM WC=13.5%
								382.10		— 4.50	
5	2D	24/20	5.00 - 7.00	1/1/1/2	2	3				Brown, wet, very loose, fine to medium SAND, little silt, trace coarse sand, (Alluvium).	G#244709 A-2-4, SM WC=31.7%
10	3D	24/17	10.00 - 12.00	1/WOH/WOH/1	---		aHP			aHP = Hydraulic Push Grey, wet, very loose, fine SAND, trace silt, trace medium sand, (Alluvium).	G#244710 A-3, SP-SM WC=30.7%
							12				
							22				
							37				
	4D	24/16	14.00 - 16.00	2/2/2/2	4	5	19			Similar to above, loose.	
15							12				
							29				
							65				
							81				
	5D	24/17	19.00 - 21.00	2/2/2/2	4	5	62	367.60		— 19.00 — Grey, wet, loose, Silty fine SAND, trace medium sand, (Alluvium).	G#244711 A-4, SM WC=25.8%
20							52				
							55				
							71				
							93				
	6D	24/18	24.00 - 26.00	1/1/1/2	2	3	70			Similar to above, very loose.	
25											

Remarks:

Auto hammer #283

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:	Bog Brook Bridge #0645 carries Route 140 over Bog Brook	**Boring No.:**	BB-CBB-102		
Location:	Canton, Maine	**WIN:**	19292.00		
Driller:	Northern Test Boring	**Elevation (ft.)**	386.6	**Auger ID/OD:**	2.75/6.25" HSA
Operator:	Mike/Adam	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Diedrick D-50 Track	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	1/9/2012; 09:00-15:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2
Boring Location:	13+15.9, 7.5 ft Rt.	**Casing ID/OD:**	HW	**Water Level*:**	5.0 ft bgs
Hammer Efficiency Factor:	0.768	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu 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 = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane 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							59				
							56				
							65				
							78	357.60		29.00	
	7D	24/20	29.00 - 31.00	1/2/2/2	4	5	68			Grey, wet, medium stiff, SILT, little fine sand, (Glacial Lake Deposits).	G#244712 A-4, ML WC=29.6%
30							77				
							128				
							155				
	R1	54/54	33.90 - 38.40	RQD = 100%			b202 NQ-2	352.70		b202 blows for 0.9 ft. 33.90	
										Top of Bedrock at Elev. 352.7 ft. R1:Bedrock: Dark grey, fine grained, highly metamorphosed, slightly banded GNEISS to GRANODIORITE, with feldspar, biotite, amphibole, quartz, and garnet, joints dipping at 5 to 40 degrees. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Excellent. R1:Core Times (min:sec) 33.9-34.9 ft (6:0) 34.9-35.9 ft (5:00) No water return 35.9-36.9 ft (5:30) 36.9-37.9 ft (4:30) 37.9-38.4 ft (1:00) 100% Recovery Core Bit Plugged	
35											
	R2	60/55	38.40 - 43.40	RQD = 92%						R2:Bedrock: Similar to R1. Anasagunticook Member of the Sangerville Formation. Rock Mass Quality = Excellent. R2:Core Times (min:sec) 38.4-39.4 ft (5:00) 39.4-40.4 ft (5:10) 40.4-41.4 ft (5:15) 41.4-42.4 ft (5:00) 42.4-43.4 ft (5:00) 92% Recovery	
40											
								343.20		43.40	
45										**Bottom of Exploration at 43.40 feet below ground surface.**	
50											

Remarks:

Auto hammer #283

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): Canton Work Number: 19292.00

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
BB-CBB-101, S1	12+83.7	5.7 Lt.	0.42-4.6	244701	1	1.9			GW-GM	A-1-a	0
BB-CBB-101, 1D	12+83.7	5.7 Lt.	5.0-7.0	244702	1	24.3			SM	A-2-4	II
BB-CBB-101, 2D	12+83.7	5.7 Lt.	10.0-12.0	244703	1	27.5			SP-SM	A-3	0
BB-CBB-101, 3D	12+83.7	5.7 Lt.	14.0-16.0	244704	1	26.5			SP-SM	A-3	0
BB-CBB-101, 5D	12+83.7	5.7 Lt.	24.0-26.0	244705	1	28.9			ML	A-4	IV
BB-CBB-101, 6D	12+83.7	5.7 Lt.	29.0-31.0	244706	1	29.1			ML	A-4	IV
BB-CBB-102, 1D	13+15.9	7.5 Rt.	1.0-2.0	244707	2	6.6			SM	A-2-4	II
BB-CBB-102, 1D/A	13+15.9	7.5 Rt.	2.0-3.0	244708	2	13.5			SM	A-2-4	II
BB-CBB-102, 2D	13+15.9	7.5 Rt.	5.0-7.0	244709	2	31.7			SM	A-2-4	II
BB-CBB-102, 3D	13+15.9	7.5 Rt.	10.0-12.0	244710	2	30.7			SP-SM	A-3	0
BB-CBB-102, 5D	13+15.9	7.5 Rt.	19.0-21.0	244711	2	25.8			SM	A-4	III
BB-CBB-102, 7D	13+15.9	7.5 Rt.	29.0-31.0	244712	2	29.6			ML	A-4	IV

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

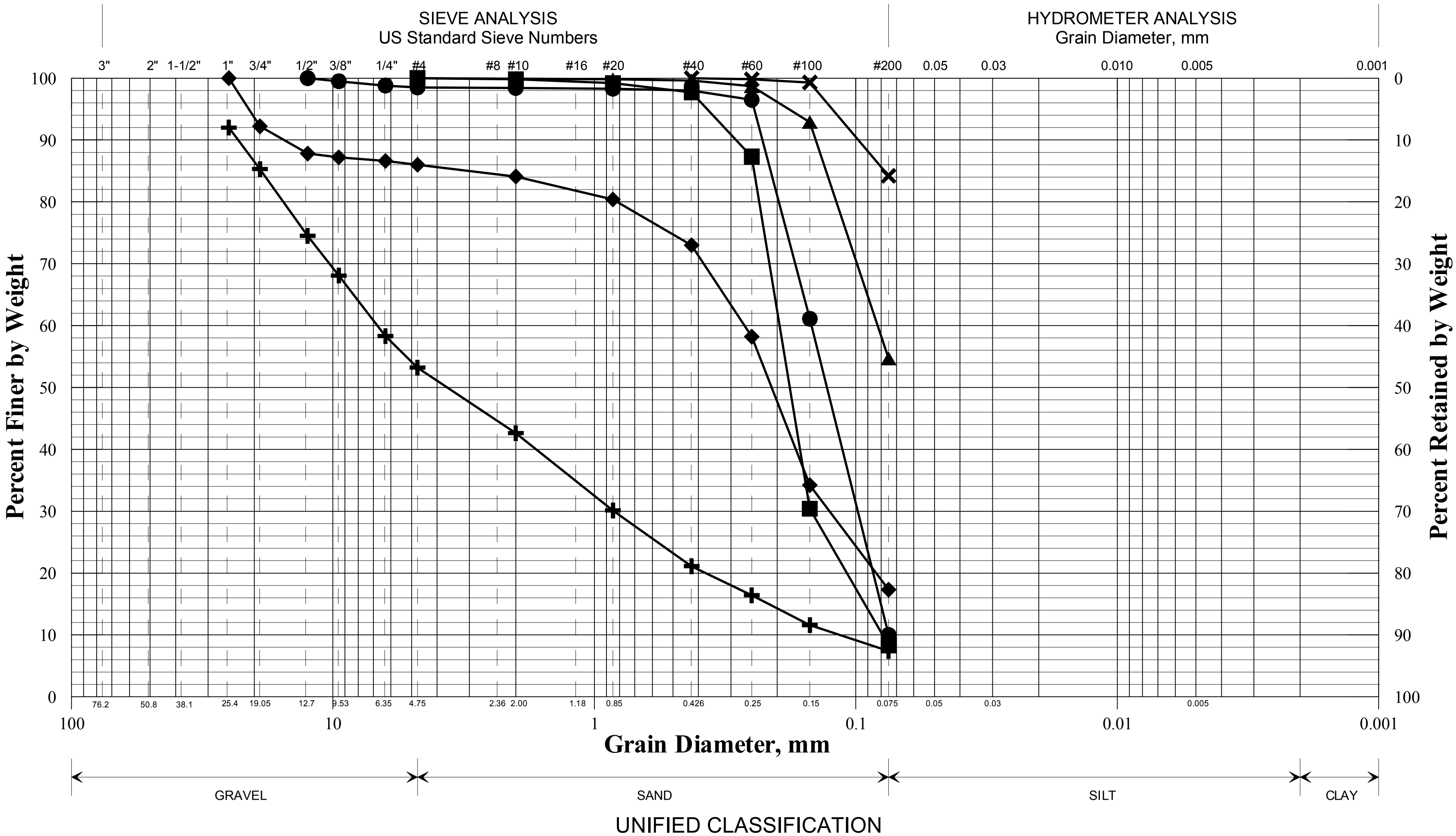
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

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

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

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE



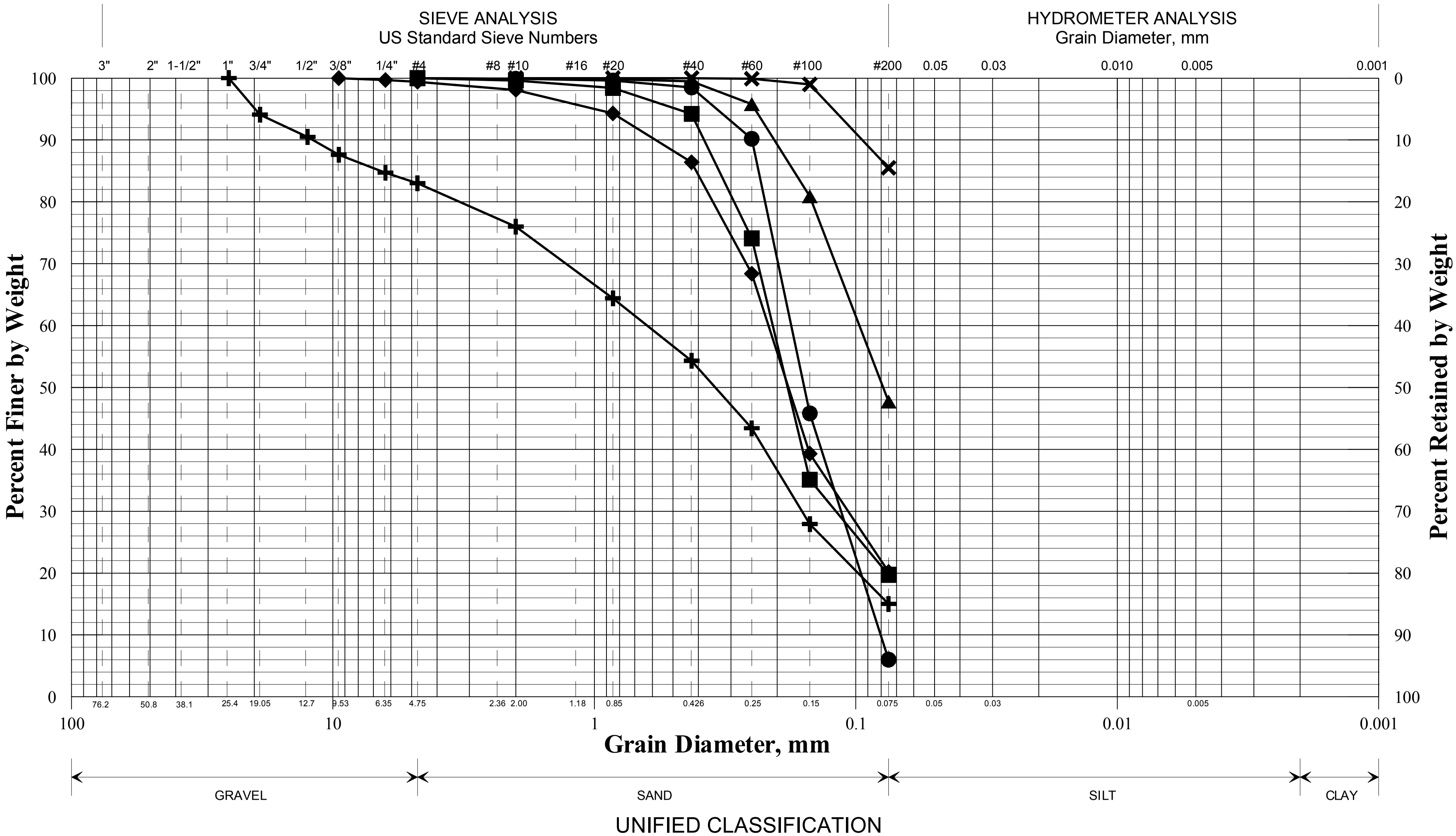
	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-CBB-101/S1	12+83.7	5.7 LT	0.42-4.6	Sandy GRAVEL, trace silt.	1.9			
◆	BB-CBB-101/1D	12+83.7	5.7 LT	5.0-7.0	SAND, little silt, little gravel.	24.3			
■	BB-CBB-101/2D	12+83.7	5.7 LT	10.0-12.0	SAND, trace silt.	27.5			
●	BB-CBB-101/3D	12+83.7	5.7 LT	14.0-16.0	SAND, trace silt, trace gravel.	26.5			
▲	BB-CBB-101/5D	12+83.7	5.7 LT	24.0-26.0	Sandy SILT.	28.9			
✖	BB-CBB-101/6D	12+83.7	5.7 LT	29.0-31.0	SILT, little sand.	29.1			

WIN
019292.00
Town
Canton
Reported by/Date
WHITE, TERRY A 2/17/2012

SHEET 1

State of Maine Department of Transportation

GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-CBB-102/1D	13+15.9	7.5 RT	1.0-2.0	SAND, little gravel, little silt.	6.6			
◆	BB-CBB-102/1DA	13+15.9	7.5 RT	2.0-3.0	SAND, little silt, trace gravel.	13.5			
■	BB-CBB-102/2D	13+15.9	7.5 RT	5.0-7.0	SAND, little silt.	31.7			
●	BB-CBB-102/3D	13+15.9	7.5 RT	10.0-12.0	SAND, trace silt.	30.7			
▲	BB-CBB-102/5D	13+15.9	7.5 RT	19.0-21.0	Silty SAND.	25.8			
✖	BB-CBB-102/7D	13+15.9	7.5 RT	29.0-31.0	SILT, little sand.	29.6			

WIN
019292.00
Town
Canton
Reported by/Date
WHITE, TERRY A 2/17/2012

SHEET 2

Appendix C

Calculations

At-Rest and Active Earth Pressure:

At-Rest Lateral Earth Pressure
from LRFD Article 3.11.5.2 pg 3-71

Effective friction angle of soil $\phi_f := 30 \cdot deg$

$K_o := 1 - \sin(\phi_f)$ $K_o = 0.5$

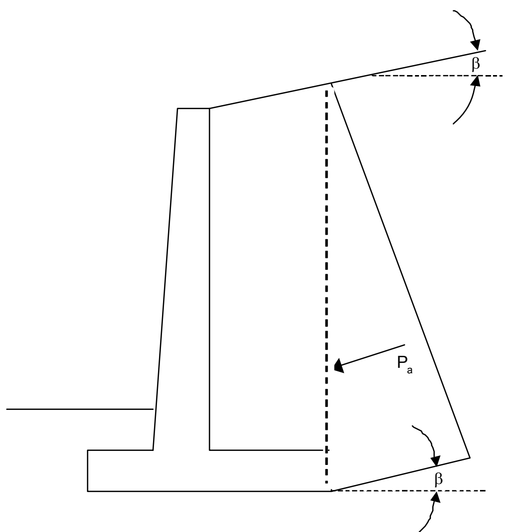
Active Earth Pressure - Rankine Theory
from MaineDOT Bridge Design Guide Section 3.6.5.2 pg 3-7

Soil Type 4 Properties from MaineDOT Bridge Design Guide (BDG)

unit weight: $\gamma_{type4} := 125 \cdot pcf$

Internal Friction Angle: $\phi_{type4} := 32 \cdot deg$

Cohesion: $c_{sand} := 0 \cdot psf$



Generally use Rankine for long heeled cantilever walls where the failure surface is un interrupted by the top of the wall system. The earth pressure is applied to a plane extending vertically up from the heel of the wall base and the weight of the soil on the inside of the vertical plane is considered as part of the wall weight. The failure sliding surface is not restricted by the top of the wall or the backface of the wall.

For cantilever walls with sloped backfill surface:

β = Angel of fill slope to the horizontal

$\beta := 0 \cdot deg$ assume horizontal backfill surface

$$K_{a\_rankine\_slope} := \frac{\cos(\beta) - \sqrt{\cos(\beta)^2 - \cos(\phi_{type4})^2}}{\cos(\beta) + \sqrt{\cos(\beta)^2 - \cos(\phi_{type4})^2}} \qquad K_{a\_rankine\_slope} = 0.31$$

Pa is oriented at an angle of β to the vertical plane.

Bearing Resistance - Native Granular Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - box culvert on granular soils

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 6th Edition 2012
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: Fine to coarse sand (SM)

Based on N-values ranging from WOH to 12 - Soils are very loose to medium dense

Consistency In Place: loose

Bearing Resistance: Ordinary Range (ksf) 2 to 6

Recommended Value of Use: 3 ksf

$tsf := g \cdot \left(\frac{ton}{ft^2}\right)$

Recommended Value: $3 \cdot ksf = 1.5 \cdot tsf$

Therefore: $q_{nom} := 1.5 \cdot tsf$

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

$q_{factored\_bc} := 1.5 \cdot tsf$ or $q_{factored\_bc} = 3 \cdot ksf$

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 native soils

Reference: Foundation Engineering and Design by JE Bowles Fifth Edition

Assumptions:

1. The box culverts will be founded at ~ Elev 376 $D_{box} := 2.0 \cdot ft$
2. Assumed parameters for fill soils: (Ref: Bowles 5th Ed Table 3-4)
   - Saturated unit weight: $\gamma_s := 125 \cdot pcf$
   - Dry unit weight: $\gamma_d := 120 \cdot pcf$
   - Internal friction angle: $\phi_{ns} := 32 \cdot deg$
   - Undrained shear strength: $c_{ns} := 0 \cdot psf$
3. Use Terzaghi strip equations as L>B
4. Effective stress analysis footing on ϕ-c soil (Bowles 5th Ed. Example 4-1 pg 231)

Depth the water table: $D_w := 0 \cdot ft$ Unit Weight of water: $\gamma_w := 62.4 \cdot pcf$

Effective stress at box bearing level:

$$q_{eff} := D_w \cdot \gamma_s + (D_{box} - D_w) \cdot (\gamma_s - \gamma_w) \qquad q_{eff} = 0.125 \cdot ksf$$

Look at 4 widths: $B := \begin{pmatrix} 12 \\ 14 \\ 16 \\ 18 \end{pmatrix} \cdot ft$

Terzaghi Shape factors from Table 4-1 For a strip footing: $s_c := 1.0$ $s_\gamma := 1.0$

Meyerhof Bearing Capacity Factors - Bowles 5th Ed. table 4-4 pg 223

For ϕ=30 deg $N_c := 30.13$ $N_q := 18.4$ $N_\gamma := 15.7$

Nominal Bearing Resistance per Terzaghi equation (Bowles 5th Ed. Table 4-1 pg 220)

$$q_{nominal} := c_{ns} \cdot N_c \cdot s_c + q_{eff} \cdot N_q + 0.5(\gamma_s) B \cdot N_\gamma \cdot s_\gamma$$

$$q_{nominal} = \begin{pmatrix} 7 \\ 8 \\ 9 \\ 10 \end{pmatrix} \cdot tsf$$

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

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

$$q_{factored} = \begin{pmatrix} 3.2 \\ 3.6 \\ 4.1 \\ 4.5 \end{pmatrix} \cdot tsf \qquad B = \begin{pmatrix} 12 \\ 14 \\ 16 \\ 18 \end{pmatrix} \cdot ft$$

$$q_{factored} = \begin{pmatrix} 6.3 \\ 7.2 \\ 8.1 \\ 9 \end{pmatrix} \cdot ksf \qquad B = \begin{pmatrix} 12 \\ 14 \\ 16 \\ 18 \end{pmatrix} \cdot ft$$

At Strength Limit State:

Recommend a limiting factored bearing resistance of 8 ksf for box culvert with a 14 foot opening and 1 foot thick walls (B=16 feet)

Frost Protection:

Method 1 - MaineDOT Design Freezing Index (DFI) Map and Depth of Frost Penetration Table are in BDG Section 5.2.1.

From the Design Freezing Index Map:
Canton, Maine
DFI = 1600 degree-days

From the lab testing: soils are coarse grained with a water content = ~20%

From Table 5-1 MaineDOT BDG for Design Freezing Index of 1600 and wc =20%
Frost Penetration = 70.2 inches

$\text{Frost\_depth} := 70.2\text{in}$ $\quad$ $\text{Frost\_depth} = 5.9 \cdot \text{ft}$

Method 2 - Check Frost Depth using Modberg Software

Closest Station is Rumford

--- ModBerg Results ---

Project Location: Rumford 1 SSE, Maine
Air Design Freezing Index = 1631 F-days
N-Factor = 0.80
Surface Design Freezing Index = 1305 F-days
Mean Annual Temperature = 43.5 deg F
Design Length of Freezing Season = 136 days

Layer #:Type	t	w%	d	Cf	Cu	Kf	Ku	L
1-Coarse	82.3	20.0	125.0	34	46	3.8	1.9	3,600

t = Layer thickness, in inches.
w% = Moisture content, in percentage of dry density.
d = Dry density, in lbs/cubic ft.
Cf = Heat Capacity of frozen phase, in BTU/(cubic ft degree F).
Cu = Heat Capacity of thawed phase, in BTU/(cubic ft degree F).
Kf = Thermal conductivity in frozen phase, in BTU/(ft hr degree).
Ku = Thermal conductivity in thawed phase, in BTU/(ft hr degree).
L = Latent heat of fusion, in BTU / cubic ft.

Total Depth of Frost Penetration = 6.86 ft = 82.3 in.

$\text{Frost\_depth}_{\text{modberg}} := 82.3 \cdot \text{in}$

$\text{Frost\_depth}_{\text{modberg}} = 6.858 \cdot \text{ft}$

Use Frost Depth = 6.0 feet for design

Appendix D

Special Provisions

SPECIAL PROVISION
SECTION 203
CRUSHED STONE

Description This work shall consist of constructing a leveling pad of crushed stone in accordance with these specifications and in reasonably close conformity with the width, grade and thickness shown on the plans or established by the Resident.

MATERIALS

Aggregate Crushed stone material shall meet the requirements of ASTM Standard Specification C33, Standard Specification for Concrete Aggregates.

The aggregate shall meet the following gradation requirements:

Particle size	Percent by Weight Passing
1 inch	100
¾ inch	90 – 100
½ inch	20 – 55
⅜ inch	0 – 15
No. 4	0 - 5

Construction Requirements The crushed stone shall be placed and graded as shown on the plans or as directed by the Resident. The crushed stone shall be compacted as required to ensure that all voids in the stone are filled, as approved by the Resident.

Method of Measurement Aggregate for crushed stone will be measured by the cubic yard complete in place.

Basis of Payment The accepted quantity of crushed stone will be paid for at the contract unit price per cubic yard of aggregate complete in place.

Payment will be under

Pay Item	Unit
203.35 Crushed Stone	Cubic Yard

SPECIAL PROVISION 534
PRECAST STRUCTURAL CONCRETE
(Precast Structural Concrete Arches, Box Culverts, Frames)

The following replaces Section 534 in the Standard Specifications in its entirety:

534.01 Description The Contractor shall design, manufacture, furnish, and install elements, precast structural concrete structures, arches, box culverts or three sided frames and associated wingwalls, headwalls, toe walls/cut off walls and appurtenances, in accordance with the Contract Documents.

534.02 Materials Structural precast elements for the arch, box culvert, or frame and associated precast elements shall meet the requirements of the following Subsection except as noted otherwise in this specification:

Structural Precast Concrete Units	712.061

New concrete mix designs and mix designs not previously approved by the Fabrication Engineer, including Self-Consolidating Concrete (SCC) mixes, shall be qualified by trial batches prepared in accordance with AASHTO T 126 (ASTM C 192). The test results shall demonstrate that the concrete meets the requirements of the Plans and this Specification. If accelerated curing is to be used in production, the test specimens shall be similarly cured.

Grout, concrete patching material, and geotextiles shall be one of the products listed on the Department's list of prequalified materials, unless otherwise approved by the Department.

Bedding and backfill material shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill, with the additional requirement that the maximum particle size be limited to 4 inches, or as shown on the Plans.

534.03 Drawings Prepare shop detail, erection and other necessary Working Drawings in accordance with Section 100 of the Standard Specifications. The Department will review and approve the drawings in accordance with the applicable requirements of Section 100 of the Standard Specifications. Changes and revisions to the approved Working Drawings shall require further approval by the Fabrication Engineer.

Concrete mix designs shall be part of the Working Drawing submittal. Include aggregate specific gravity, absorption, percent fracture, fineness modulus and gradation as part of the mix design. Provide the mix design calculations demonstrating how the batch weights, water-cement ratio and admixture dosage rate were determined.

534.04 Design Requirements The Contractor shall design the precast structural concrete structure in accordance with the AASHTO LRFD Bridge Design Specifications, latest edition. The HL-93 live load specified in the AASHTO LRFD Bridge Design Specifications shall be used for all limit states except for Strength I. The live load used for the Strength I limit state shall be the Maine Modified live load which consists of the standard HL-93 Live Load with a 25% increase in the Design Truck. (Wheel loads based on the Design Truck shall be increased 25%). In addition, if the governing load rating factor based on the HL-93 live load is equal to or less than 1.10 a load rating based on the Maine legal truck (Configuration #6) shall also be checked to insure the rating factor is equal to or greater than 1.0.

The live load deflection check per AASHTO LRFD Bridge Design Specifications Section 2.5.2.6.2 for the top slab of box culverts and frames with clear spans 15 feet or greater and cover depths of 4 feet or less is mandatory. The live load deflection check shall be documented in the design computations submittal.

Design calculations that consist of computer program generated output shall be supplemented with at least one hand calculation and graphic demonstrating the design methodology used. The hand calculation shall document at a minimum the Strength I load case flexural design check of the top slab positive moment reinforcing steel. Design calculations shall provide thorough documentation of the sources of equations used and material properties.

The design shall be load rated in accordance with the AASHTO Manual for Bridge Evaluation, latest edition by the LRFR method and in accordance with the MaineDOT Load Rating Guide.

The Contractor shall submit design calculations, load rating if applicable and working/shop drawings for the precast structure to the Department for approval. A Licensed Professional Engineer, licensed in accordance with State of Maine laws, shall sign and seal all design calculations and drawings. Drawings shall conform with Section 105.7 - Working Drawings.

The Contractor shall submit the following items for review by the Resident at least forty five (45) working days prior to production:

A) The name and location of the manufacturer.
B) Method of manufacture and material certificates.
C) Description of method of handling, storing, transporting, and erecting the members.
D) Design computations (bound and indexed)
E) Load rating computations and completed load rating form (bound and indexed)
F) Shop Drawings with the following minimum details:

1) Fully dimensioned views showing the geometry of the members, including all projections, recesses, notches, openings, block outs, and keyways.
2) Details and bending schedules of reinforcing steel including the size, spacing, and location. Reinforcing provided under lifting devices shall be shown in detail.
3) Details and locations of all items to be embedded.
4) Total weight of each member.

534.05 Facilities for Inspection Provide a private office at the fabrication plant for the Department's inspection personnel, or Quality Assurance Inspectors (QAI's). The office shall be in close proximity to the Work. The office shall be climate controlled to maintain the temperature between 68° F and 75° F and have the exit(s) closed by a door(s) equipped with a lock and 2 keys which shall be furnished to the QAI's.

The QAI's office shall meet the following minimum requirements:

Description	Quantity
QAI's office (minimum ft^2)	100
Drafting Table Surface (ft^2)	35
Drafting stools-each	1
Office Desk	1
Ergonomic Swivel Chairs	1
Folding Chairs	2
Cordless telephone	1
Answering machine	1
High-speed internet connection (ports)	1
Fluorescent Lighting of 100 ft-candles minimum for all work areas	2
110 Volt 60 Cycle Electric Wall Outlets	3
Wall Closet	1
Plan Rack	1
Waste Basket with trash bags	1
Two-drawer file cabinet (locking)	1
Broom	1
Dustpan	1
Cleaning Materials	1
Water Cooler	1

The Contractor will be responsible for disposing of trash and supplying commercially bottled water for the water cooler.

The QAI will have the option to reject any furniture or supplies provided to the QAI's office, based on general poor condition.

Provide parking space for the QAI(s) in close proximity to the entrance to the QAI's office. Maintain the pathway between the parking area and the QAI's office so that it is free of obstacles, debris, snow and ice.

The facilities and all furnishings shall remain the property of the Contractor upon completion of the Work. Payment for the facilities, heating, lighting, telephone installation, internet connection, basic monthly telephone and internet charges and all furnishings shall be incidental to the Contract.

Failure to comply with the above requirements will be considered denial of access to the Work for the purpose of inspection. The Department will reject all Work done when access for inspection is denied.

534.06 Notice of Beginning Work Give the Department a minimum of two weeks notice for in-state work and three weeks notice for out-of-state work prior to beginning production. If the production schedule changes, notify the Fabrication Engineer no less than three (3) working days prior to the initial start-up date. Any Work done without the QAI present will be rejected. Advise the Fabrication Engineer of the production schedule and any changes to it. If Work is suspended on a project, the Fabrication Engineer will require 72 hours notice prior to the resumption of Work.

534.07 Quality Control Quality Control (QC) is the responsibility of the Contractor.

Provide a copy of the Quality System Manual (QSM) to the Fabrication Engineer if requested.

Inspect all aspects of the Work in accordance with the Contractor's QSM. Reject materials and workmanship that do not meet Contract requirements.

Record measurements and test results on the appropriate forms from APPENDIX E of Precast/Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Structural Precast Concrete Products MNL 116 or an equivalent form prepared by the user. Provide copies of measurements and test results to the QAI as follows:

Type of Report	When Provided to QAI*
Aggregate gradations-fine aggregate and coarse aggregate	Prior to beginning work and at least once a week thereafter
Material certifications / stressing calculations / calibration certifications	Prior to beginning work (anticipate adequate time for review by QAI)
Pre-pour inspection report	Prior to the concrete placement
Concrete Batch Slips	The morning of the next work day
Results of concrete testing	The morning of the next work day
Concrete temperature records	Provide with compressive testing (for release)
Non-conformance reports/repair procedures	Within 24 hours of discovery
Results of compressive testing (for design strength)	Prior to stopping curing / Prior to final acceptance
Post-pour inspection report	Prior to final acceptance

* The Contractor and QAI may, by mutual agreement, modify any part of the schedule; however, failure to provide the documentation when required by the Fabrication Engineer will result in the product being deemed unacceptable. The Contractor may perform testing in addition to the minimum required. The results of all testing shall be made available to the Department.

534.08 Quality Assurance Quality Assurance (QA) is the prerogative of the Department.

The QAI will witness or review documentation, workmanship, testing and assure the Work is being performed in accordance with the QSM.

The QAI has the authority to reject materials and products that do not meet the Contract requirements including Work rejected due to denial of access or the lack of adequate notice of the beginning of production. The acceptance of material or workmanship by the QAI will not prevent subsequent rejection, if the Work is unacceptable.

534.09 Rejections Correct or replace rejected material and/or workmanship. Generate a non-conformance report (NCR); provide a copy to the QAI and forward a copy to the Fabrication Engineer for determination of corrective action.

In the event that an item fabricated under this Specification does not meet the Contract requirements but is deemed suitable for use by the Department, said item may be accepted in accordance with Section 100 of the Standard Specifications (see 106.8).

534.10 Forms and Casting Beds Construct forms to conform to the Working Drawings. The forms shall be well constructed, carefully aligned and sufficiently tight to prevent leakage of mortar. Reject forms that do not maintain the Plan dimensions. Inspect the bulkheads after each cast and repair or replace worn or damaged pieces.

Seal wooden forms to prevent absorption of water. Apply and cure the sealer in accordance with the manufacturer's product data sheet.

Remove all paint, adherent material, foreign matter and debris prior to placing concrete.

Apply a non-staining bond-breaking compound to the forms in accordance with the manufacturer's product data sheet. Solvent clean reinforcing steel and welded steel wire fabric contaminated with the bond-breaking compound.

534.11 Reinforcing Steel Fabricate, package, handle, store, place, splice and repair reinforcing steel in accordance with Section 503 of the Standard Specifications.

Accurately locate and securely anchor the reinforcing steel to prevent displacement during concrete placement. Install and secure all reinforcing steel prior to beginning the concrete placement.

The concrete cover shown on the approved Working Drawings shall be the minimum allowable cover. Use sufficient bar supports and spacers to maintain the minimum concrete cover. The bar supports and spacers shall be made of a dielectric material or other material approved by the Fabrication Engineer.

If reinforcing steel is not noted on the plans or drawings, the minimum amount of steel required shall be the area of steel equal to a grid of No. 4 bars at 18 inches in both directions, horizontally and vertically. Only one mat of steel is required for concrete thickness of 7 inches or less; two mats, one each face is required for thickness greater than 7 inches.

534.12 Voids and Inserts Voids shall be non-absorbent. The out-to-out dimensions of the voids shall be within 2% of Plan dimensions. Repair damaged voids in a manner acceptable to the Fabrication Engineer. Store, handle and place voids in a manner that prevents damage.

Accurately locate and securely anchor, securely cap and vent the voids in the form. Any portion of a void that is displaced beyond the allowable dimensional tolerances shall be cause for rejection of the slab or beam.

Open the void drains immediately upon removing the product from the form.

Recess inserts, ties or other steel items a minimum of 1 inch from the surface unless noted otherwise on the Plans. Any recess shall be filled with a product from the Department's Qualified Products List. The QAI is not responsible for verifying the location of inserts or other hardware installed for the convenience of the Contractor.

534.13 Concrete Placement Do not batch or place concrete until all the form(s) for any continuous placement have been inspected and accepted by the QCI and the QAI concurs.

Test concrete in accordance with the following Standards:

AASHTO T23 (ASTM C 31) Practice for Making and Curing Concrete Test Specimens in Field
AASHTO T 22 (ASTM C 39) Test Method for Compressive Strength of Cylindrical Concrete Specimens
AASHTO T119 (ASTM C 143) Test Method for Slump of Hydraulic Cement Concrete
AASHTO T141 (ASTM C 172) Practice for Sampling Freshly Mixed Concrete
AASHTO T152 (ASTM C 231) Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 1064-Test Method for Temperature of Freshly mixed Portland Cement Concrete
ASTM C 1611/C 1611M-05-Standard Test Method for Slump Flow of Self-Consolidating Concrete

Test the first two loads of concrete for temperature, air entrainment and slump, or spread for SCC. If the first load is unacceptable, test the second load as the first. Continue this process until two consecutive loads are acceptable. After two consecutive cylinders are acceptable, the frequency of testing shall be at the discretion of the QAI.

Test the concrete for temperature, air entrainment and slump, or spread for SCC, if there is a change in the dosage rate of any admixture, a change of three inches or more in slump or a change of more than 5° F in mix temperature.
Test every load of 1 cubic yard, or less, from a stationary mixer or 2 cubic yards, or less, from a transit mixer for temperature, air entrainment and slump, or spread for SCC, prior to placing the concrete in the forms.

Perform all testing in the presence of the QAI. The QAI will designate the loads to be tested. Make cylinders used to determine stripping strength during the last 1/3 of the placement.

Place the concrete as nearly as possible to its final location. Control the depth of each lift in order to minimize entrapped air voids. The maximum depth of an unconsolidated lift shall be 18 inches. Vibrate the concrete with internal or internal and external vibrators. Do not use external vibrators alone. Insert internal vibrators vertically and penetrate the lower layer of concrete by at least 4 inches. Insert the vibrators in the concrete to assure that the radii of action of the vibrators overlap. Hold the vibrators in position from 5 to 15 seconds. Do not use vibrators to move concrete horizontally. Each lift of concrete shall have sufficient plasticity to be consolidated with subsequent lifts.

Do not re-temper the concrete with water after discharging has begun. The Contractor may add HRWR to the concrete after batching if that practice conforms to the manufacturer's product data sheet. Discard concrete that becomes unworkable.

Do not use water or water-based products to aid in finishing fresh concrete.

After the concrete has been placed and finished and before the forms are covered, remove all concrete from projecting reinforcing steel

<u>534.14 Process Control Test Cylinders</u> Make concrete test cylinders for each day’s casting. Cylinders tested to determine stripping strength and early design strength shall be field cured in accordance with AASHTO T23 (ASTM C 31). 28 day cylinders shall be standard cured. Record unit identification, entrained air content, water-cement ratio, slump and temperature of the sampled concrete at the time of cylinder casting. Once a week, make four cylinders for use by the Department. They shall be standard cured in accordance with AASHTO T23 (ASTM C 31).

If the Contractor fails to make enough cylinders to demonstrate that the product meets the Contract requirements, the product will be considered unacceptable.

The compressive strength of the concrete will be determined by averaging the compressive strength of two test cylinders made from the same sample. For the purpose of determining design strength, the average of two cylinders shall meet or exceed the design strength, and, neither cylinder shall have a compressive strength less than 90% of design strength.

Perform compressive testing to determine transfer and design strength in the presence of the QAI. Cylinder tests not witnessed by the QAI will not be acceptable.

534.15 Manufacture of Precast Units The cover of concrete over the outside circumferential reinforcement shall be 2 inches minimum. The concrete cover over the inside reinforcement shall be 1 ½ inches minimum. The clear distance of the end of circumferential wires shall not be less than 1 inch or more than 2 inches from the end of the sections. Reinforcement shall be single or multiple layers of welded wire fabric or a single layer of deformed billet steel bars.

Welded steel wire fabric shall meet the space requirements and contain sufficient longitudinal wires extending through the section to maintain the shape and position of the reinforcement. Longitudinal distribution reinforcement may be welded steel wire fabric or deformed steel bars which meet the spacing requirements. The ends of the longitudinal distribution reinforcement shall be not more than 3 inches from the ends of the sections.

Do not use more than three layers of reinforcing to form a single mat. If reinforcing steel is cut to install lifting devices install additional reinforcing adjacent to the cut steel.

Tension splices in the reinforcement will not be permitted. For splices other than tension splices, the overlap shall be a minimum of 12 inches for welded steel wire fabric or deformed steel bars. The spacing center to center of the circumferential wires in a wire fabric sheet shall be not less than 2 inches or more than 4 inches. For the wire fabric, the spacing center to center of the longitudinal wires shall not be more than 8 inches. The spacing center to center of the longitudinal distribution steel for either line of reinforcing in the top slab shall not be more than 15 inches.

The members shall be free of fractures. The ends of the members shall be normal to the walls and centerline of the section, within the limits of variation provided, except where beveled ends are specified. The surfaces of the members shall be a smooth steel form or troweled surface finish, unless a form liner is specified. The ends and interior of the assembled structure shall make a continuous line of members with a smooth interior surface.

Defects which may cause rejection of precast units include the following:

1) Any discontinuity (crack or rock pocket etc.) of the concrete which could allow moisture to reach the reinforcing steel.
2) Rock pockets or honeycomb over 6 square inches in area or over 1 inch deep.
3) Edge or corner breakage exceeding 12 inches in length or 1 inch in depth.
4) Extensive fine hair cracks or checks.
5) Any other defect that clearly and substantially impacts the quality, durability, or maintainability of the structure as measured by accepted industry standards.

The manufacturer of the members shall sequentially number and shop fit each adjacent member to ensure that they fit together in the field. This fit up shall be witnessed by the QA inspector. Any non-fitting members shall be corrected or replaced at no cost to the Department.

Documentation The producer of the structural precast units shall keep accurate records of aggregate gradations, concrete batching, testing, curing, and inspection activities to verify that forms, reinforcing and unit dimensions conform to these requirements. Copies of reports shall be furnished to the Resident when requested.

534.16 Tolerances Dimensional tolerances shall be in conformance with the applicable reference specification or the established industry standards for the product being produced. The internal dimensions shall not vary by more than 1 percent from the design dimensions or 1 ½ inches, whichever is less with the exception of the cross diagonal dimension which shall not vary by more than ½ inch from the design dimension. The haunch dimensions shall not vary by more than ¾ inch from the design dimension. The dimension of the legs shall not vary by more than ¼ inch from the dimension shown on the approved shop drawings.

The slab and wall thickness shall not be less than the design thickness by more than ¼ inch. A thickness greater than the design thickness shall not be cause for rejection.

Variations in laying lengths of two opposite surfaces shall not be more than ⅝ inch in any section, except where beveled ends for laying of curves are specified.

The under-run in length of any section shall not be more than ½ in.

534.17 Finishing Concrete Products shall meet ordinary finish requirements per subsection 502.14. Fascia members shall receive a rubbed finish per subsection 502.14. The Contractor may use alternative methods of achieving an acceptable finish on fascia members if approved by the Fabrication Engineer.

Marking The date of manufacture, the production lot number, and the type of unit shall be clearly and indelibly scribed on a rear, unexposed portion of each unit.

543.18 Repairing Defects Exposed surfaces shall be of uniform appearance; only minor repairs to remove and blend fins, patch minor spalls and to repair small, entrapped air pockets shall be permitted. Units that are cracked or require surface repairs larger than 2 in^2 or an accumulated repair area greater than 10% of the surface being repaired may be rejected.

Repair honeycombing, ragged or irregular edges and other cosmetic defects using a patching material from the MaineDOT Qualified Products List. The repair, including preparation of the repair area, mixing and application and curing of the patching material, shall be in accordance with the manufacturer's product data sheet. Corners not exposed in the final product may be ground smooth with no further repair necessary if the depth of the defect does not exceed ½ inch. Remove form ties and other hardware to a depth of not less than 1 inch from the face of the concrete and patch the holes using a patching material from the MaineDOT Qualified Products List.

Repair structural defects only with the approval of the Fabrication Engineer. Submit a non-conformance report (NCR) to the Fabrication Engineer with a proposed repair procedure. Do not perform structural repairs without an approved NCR. Structural defects include, but are not be limited to, exposed reinforcing steel or strand, cracks in bearing areas, through cracks and cracks 0.013 inch in width that extend more than 12 inches in length in any direction. Give the QAI adequate notice prior to beginning structural repairs.

<u>534.19 Handling, Storage and Transportation</u> Handle store and transport members in a manner as to eliminate the danger of chipping, cracks, fracture, and excessive bending stresses. Any units found damaged upon delivery, or damaged after delivery, shall be subject to rejection.

Do not place precast members in an upright position until a compressive strength of at least 4350 psi is attained. Precast products a may be handled and moved, but do not transport products until the 28 day design strength has been attained.

Support stored precast/prestressed products above the ground on dunnage in a manner to prevent twisting or distortion. Protect the products from discoloration and damage.

<u>534.20 Installation of Precast Units</u> Do not ship precast members until sufficient strength has been attained to withstand shipping, handling and erection stresses without cracking, deformation, or spalling. A minimum strength of 4350 psi shall be attained prior to shipping in all cases.

Set precast members on ½ inch neoprene pads during shipment to prevent damage to the section legs. The Contractor shall repair any damage to precast members resulting from shipping or handling by saw cutting a minimum of ½ inch deep around the perimeter of the damaged area and placing a polymer-modified cementitious patching material.

When footings are required, install the precast members on concrete footings that have reached a compressive strength of at least 2900 psi. Construct the completed footing surface to the lines and grades shown on the Plans. When checked with a 10 foot straightedge, the surface shall not vary more than ¼ inch in 10 feet. The footing keyway shall be filled with a non-shrink flowable cementitious grout with a design compressive strength of at least 5000 psi.

Box culvert joints shall be sealed with an approved flexible joint sealant in accordance AASHTO M 198 (ASTM C 990). Joints shall be closed tight to within 0.625 inches ±0.125 inch. Culvert sections shall be equipped with joint closure mechanisms to draw sections together and close joints to the required opening.

Fill holes that were cast in the units for handling, with either Portland cement mortar, or with precast plugs secured with Portland cement mortar or other approved adhesive. Completely fill the exterior face of joints between precast members with an approved material and cover with a minimum 12 inch wide joint wrap. The surface shall be free of dirt and deleterious materials before applying the filler material and joint wrap. Install the external wrap in one continuous piece over each member joint, taking care to keep the joint wrap in place during backfilling. Seal the joints between the end unit and attached elements with a non-woven geotextile. Install and tighten the bolts fastening the connection plate(s) between the elements that are designed to be fastened together as designated by the manufacturer.

Place and compact the bedding material as shown on the plans prior to lifting and setting the culvert sections. Backfill the structure in accordance with the manufacturer's instructions and the Contract Documents. Uniformly distribute backfill material in layers of not more than 8 inches in depth, loose measure, and thoroughly compact each layer using approved compactors before successive layers are placed. Compact the Granular Borrow bedding and backfill in accordance with Section 203.12 - Construction of Earth Embankment with Moisture and Density Control, except that the minimum required compaction shall be 92 percent of maximum density as determined by AASHTO T-180, Method C or D. Place and compact the backfill without disturbance or displacement of the structure, keeping the fill at approximately the same elevation on both sides of the structure. Whenever a compaction test fails, the Contractor shall not place additional backfill over the area until the lift is re-compacted and a passing test achieved.

Use hand-operated compactors within 5 feet of the precast structure as well as over the top until it is covered with at least 12 inches of backfill. The Contractor shall take adequate precautions to protect the top of the culvert from damage during backfilling and/or paving operations. Any damage to the top of the culvert shall be repaired or members replaced at no cost to the Department.

<u>534.21 Method of Measurement</u> The Department will measure Precast Structural Concrete Arch, Box Culvert or three sided Frames for payment per Lump Sum each, complete in place and accepted.

<u>534.22 Basis of Payment</u> The Department will pay for the accepted quantity of Precast Structural Concrete Arch (Including Frames) or Precast Concrete Box Culvert at the Contract Lump Sum price, such payment being full compensation for all labor, equipment, materials, professional services, and incidentals for furnishing and installing the precast concrete elements and accessories. Falsework, reinforcing steel, welded steel wire fabric, jointing tape, geotextile, grout, cast-in-place concrete fill or grout fill for anchorage of precast wings and/or other appurtenances is incidental to the Lump Sum pay item. Cast-in-place concrete, reinforcing steel in cast-in-place elements, and membrane waterproofing will be measured and paid for separately under the provided Contract pay items. Pay adjustments for quality level will not be made for precast concrete.

Payment will be made under:

Pay Item		Pay Unit
534.70	Precast Structural Concrete Arch	Lump Sum
534.71	Precast Concrete Box Culvert	Lump Sum