MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

SKAGROCK BROOK BRIDGE
ROUTE 1 OVER SKAGROCK BROOK
ORIENT, MAINE

Prepared by:

Michael J. Moreau, P.E.
Geotechnical Engineer

Reviewed by:

Kathleen Maguire, P.E.
Geotechnical Engineer

Aroostook County
WIN 17877.00

Soils Report No. 2011-22
Bridge No. 2772

Fed No. STP-1787(700)X
December 8, 2011

TABLE OF CONTENTS

GEOTECHNICAL DESIGN SUMMARY

This report provides geotechnical recommendations for the replacement of Skagrock Brook Bridge over the Skagrock Brook in Orient, Maine. The proposed replacement bridge will consist of a 7-foot high by 15-foot wide precast concrete box culvert with a 30 degree skew back to the highway, matching the existing bridge skew. Staged construction will be used to construct the new box culvert. The bridge will maintain a 32-foot rail to rail width with 11-foot travel lanes and 5-foot shoulders, as well as accommodation for guardrail. No significant horizontal or vertical alignment changes are planned. The design and construction recommendations below are discussed in greater detail in Section 7.0 Foundation Considerations and Recommendations.

Box Culvert Design and Construction – The concrete box culvert will be supplier-designed and the design shall consider all relevant strength and service limit states and load combinations in accordance with the AASHTO LRFD Bridge Design Specifications, 5th Edition, 2010 (herein referred to as LRFD) and the design requirements in Special Provision 534, Precast Structural Concrete Arches, Box Culverts. The loading specified for the structure shall be Modified HL-93 Strength 1, in which the HS-20 design truck wheel loads are increased by a factor of 1.25.

The culvert will be constructed in general conformance with the MaineDOT Bridge Design Guide (BDG) Section 8, Buried Structures, and Special Provision 534, Precast Structural Concrete Arches, Box Culverts. The box culvert designer may assume Soil Type 4 for backfill soil properties. The backfill properties are as follows: ϕ = 32 degrees, γ = 125 pcf. The soil envelope bedding and backfill shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill with a maximum particle size of 4.0 inches. Bedding and/or backfill should be placed in lifts 6 to 8 inches thick loose measure and compacted to manufacturer's specifications, but in no case shall the bedding and/or backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

Culvert Headwalls – We recommend a minimum 1-foot by 1-foot integral concrete headwall to prevent crushed stone slope protection from dropping or eroding into the waterway. Culvert headwalls larger than the nominal 1-foot by 1-foot dimension shall be designed for all relevant LRFD strength and service limit loads, a live load surcharge of 250 psf, other vehicular loads, creep, and temperature and shrinkage deformations of the concrete box culverts. Footings for any headwall constructed independently of the box culvert shall be placed no less than 2.0 feet below the maximum anticipated depth of scour.

Culvert headwall sections that are fixed to the box culverts to resist movement should be designed for earth pressure 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, equal to 0.31 assuming a level backslope. The active earth pressure coefficient may change if backslope conditions are different.

Box Culvert Bearing Resistance – The factored bearing resistance at the strength limit state for a box culvert on compacted fill or native glacial till should not exceed 7.0 ksf. Based on presumptive bearing resistance values, a factored bearing resistance of 6.0 ksf may be used when analyzing box bottom slabs for the service limit state. In no instance shall the bearing stress exceed the nominal resistance of concrete, which may be taken as $0.3f'c$.

Settlement – Total and post-construction settlements of the prepared culvert subgrade consisting of compacted fill or native soil will be negligible since no grade changes are proposed, the span length will increase reducing soil loads and structure dead loads will be lower than the existing bridge loads. Thus, no settlement issues are anticipated at the site.

Scour Protection – Inlet and outlet seepage cutoff walls below the culvert are required for scour protection. The inlet and outlet cutoff walls should extend below the maximum depth of scour. The bridge approach slopes shall be armored with a 3-foot thick layer of plain riprap adjacent to the culvert openings. The riprap layer shall be constructed in accordance with Standard Detail 620(02) Stone Scour Protection (updated August 2011) and Special Provision 610 Stone Fill, Riprap, Stone Blanket, and Stone Ditch Protection. The riprap slopes should be no steeper than a maximum 1.75:1 (H:V). The toe of riprap sections shall be constructed 1 foot below the streambed elevation.

Frost Protection – If used, foundations placed on granular soils shall be founded a minimum of 6.5 feet below finish exterior grade for frost protection.

Seismic Design Considerations – Since the buried structure does not cross active faults, no seismic analysis is required.

Construction Considerations –

<u>Excavation</u>

- Construction of the new concrete box culvert will require staged construction and soil excavation. Earth support systems may be required.
- Protect the excavated subgrade from exposure to water and unnecessary construction traffic. Remove and replace water-softened, disturbed, or rutted subgrade soil with compacted gravel borrow.

<u>Dewatering</u>

- Control groundwater and surface water infiltration to permit construction in-the-dry.
- Cofferdams, temporary ditches, French drains, pumping from sumps, granular drainage blankets, stone ditch protection, or hand-laid riprap with geotextile underlayment may be needed to divert groundwater if significant seepage is encountered during excavation.

<u>Reuse of Excavated Soil and Bedrock</u>

- <u>Do not</u> use excavated existing subbase aggregate or approach fill soil for pavement structure construction or to re-base shoulders. Excavated subbase sand and gravel or granular fill may be used as fill below subgrade elevation in fill embankment areas provided all other requirements of MaineDOT Standard Specification Sections 203, Excavation and Embankment, and 703, Aggregates, are met.

<u>Embankment Fill Areas</u>

- Bench existing fill slope soils in accordance with MaineDOT Standard Specification 203.09, Preparation of Embankment Area, where new fill slope extensions are constructed over existing slopes.

<u>Erosion Control</u>

- Use MaineDOT Best Management Practices February 2008 to minimize erosion of fine-grained soils found on the project site.

1.0 INTRODUCTION

The Maine Department of Transportation (MaineDOT) plans to replace Skagrock Brook Bridge carrying Route 1 over Skagrock Brook in the Town of Orient, Aroostook County, Maine. We show the project location on Sheet 1, Location Map, at the end of this report. We conducted subsurface investigations at the bridge site to develop geotechnical recommendations for the structure replacement. This report summarizes our findings, discusses our evaluation of the subsurface conditions and presents our geotechnical recommendations for design and construction of the replacement structure.

The existing 14-foot span structure built in 1932 consisted of reinforced concrete cantilever abutments and wing walls with a reinforced concrete slab superstructure constructed at a 30 degree skew back to the highway. The structure is classified as structurally deficient due to the poor condition of the concrete deck slab which has heavy spalling on the downstream face exposing reinforcing steel and due to substandard bridge rail. The downstream wingwall of Abutment No. 1 is in poor condition with significant cracking. Efflorescence of the deck slab has also occurred. The bridge had a sufficiency rating of 46.2 in 2011.

MaineDOT is proposing a 7-foot high by 15-foot wide, precast concrete box culvert to replace the existing bridge. The new box culvert will be on the same horizontal and vertical alignment as the existing bridge, it will match the existing 30 degree back skew and will have a rail-to-rail width of approximately 32 feet. Current plans include 11-foot travel lanes and 5-foot shoulders, as well as accommodation for guardrail, construction of concrete culvert headwalls and toe walls, and armoring the embankments with plain riprap. Staged construction with temporary traffic signals and alternating one lane traffic will be maintained during construction to avoid the use of a 50-mile detour.

2.0 GEOLOGIC SETTING

The Maine Geologic Survey (MGS) "Surficial Geology of Amity Quadrangle, Maine, Open-file No. 80-2" (1980) indicates that surficial soils in the vicinity of Skagrock Brook Bridge consist of glacial stream deposits, swamp and marsh deposits, and glacial till soil unit contacts. The predominant soil unit at the site based on our subsurface explorations are glacial stream deposits which typically consist of sand and gravel.

According to the MGS "Bedrock Geologic Map of Maine" (1985), the bedrock at the Skagrock Brook Bridge site consists of Ordovician-Silurian, interbedded pelites and sandstones. Locally, we have identified the bedrock as shalely limestone which is part of an unnamed formation.

3.0 SUBSURFACE INVESTIGATION

We investigated subsurface conditions at the site by drilling two test borings, BB-OSB-101 and BB-OSB-102, conducted by the MaineDOT drill crew on June 6 and 7, 2011. The MaineDOT geotechnical team member selected the boring locations and drilling methods, designated the type and depth of sampling techniques, and identified field and laboratory testing requirements. A MaineDOT New England Transportation Technician Certification Program (NETTCP) Certified Subsurface Inspector logged the subsurface conditions in the borings. The boring locations are shown on Sheet 2, Boring Location Plan and a profile through the borings is shown on Sheet 3, Interpretive Subsurface Profile provided at the end of this report. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented on Sheet 4, Boring Logs, and in Appendix A, Boring Logs, at the end of this report.

We used solid stem auger and cased wash boring techniques to conduct the borings. Soil samples were obtained, where possible, at 5-foot intervals using Standard Penetration Test (SPT) methods. The standard penetration resistances, or N-values, discussed in this report are corrected for average hammer energy transfer. We compute the corrected or, N_{60}-values, by applying an average hammer energy transfer factor of 0.84 to the raw field N-values obtained with the MaineDOT drill rig. Boring BB-OSB-101 was terminated with a bedrock core and BB-OSB-102 was terminated with roller cone refusal on apparent bedrock. Bedrock was cored in boring 101 using an NQ-2 core barrel producing a 2.0-inch diameter rock core. The MaineDOT survey crew determined the boring location coordinates in the field after the borings were completed. The survey coordinates are based on the NAVD 88 datum.

4.0 LABORATORY TESTING

We conducted a laboratory soil testing program on selected samples recovered from the test borings to evaluate soil classification, material reuse, and subgrade soil properties. Laboratory testing consisted of eleven (11) standard grain size analyses with natural water contents tests. We present results of laboratory testing in Appendix B, Laboratory Test Data. The AASHTO and Unified Soil Classification System (USCS) soil classifications and water content data are also presented on the boring logs in Appendix A.

5.0 SUBSURFACE CONDITIONS

The bridge approach from the south is constructed over a glacial stream deposit and the north approach is built over swamp and marsh deposits. We encountered approximately 7.0 to 7.5 feet of granular fill in the approach embankments behind the existing bridge abutments overlying approximately 46.1 to 51.3 feet of glacial stream sand and gravel. The glacial stream sand and gravel overlies apparent bedrock at the boring locations. We present a profile depicting the generalized soil stratigraphy at the bridge site on Sheet 3, Interpretive Subsurface Profile, provided at the end of this report. For a detailed description of the subsurface conditions, please refer to Appendix A, Boring Logs, at the end of this report. A summary description of the subsurface conditions follows.

5.1 Granular Fill

We encountered granular fill in both borings to a depth ranging between approximately 7.0 and 7.5 feet below ground surface (bgs). The granular fill consists of fine to coarse sand, with some gravel and little silt. Drill attitude also indicated the presence of cobbles in the fill. The SPT N_{60}-values in the granular fill ranged from 10 to 31 blows per foot (bpf) indicating that the unit is loose to dense in consistency.

The granular fill samples had water contents on the order of 6 percent. Grain size analyses conducted on selected samples of the fill soils indicate that the soils are classified as A-1-b by the AASHTO Classification System and SM under the Unified Soil Classification System.

5.2 Glacial Stream Deposits

The glacial stream deposits found in the borings are comprised of:

- fine to coarse sand, little gravel, little silt;
- fine to coarse sand, some gravel, trace to some silt;
- gravelly fine to coarse sand, trace silt and;
- fine to coarse sandy gravel, trace silt.

The thickness of this soil unit ranged between approximately 46.1 to 51.3 feet. SPT N_{60}-values ranged from 10 to 43 bpf, indicating the glacial stream deposit is loose to dense in consistency.

The glacial stream unit samples had water contents ranging between approximately 10 and 17 percent. Grain size analyses conducted on selected samples of the glacial stream soils indicate that the soils are classified as A-1-a and A-1-b by the AASHTO Classification System and SM, SP, SW-SM, GP, and GW-GM under the Unified Soil Classification System.

5.3 Bedrock

In the borings, we encountered apparent bedrock at approximate depths ranging between 53.1 and 58.8 feet bgs. We visually identified the bedrock cores as grey, fine-grained, metasedimentary shaley limestone that is moderately hard with 60% to 80% white calcite veins, fresh to slightly weathered, with joints from horizontal to vertical that are close to moderately close and tight with minor silt in-filling. We determined that the rock quality designation (RQD) ranged between 0 and 88 percent which correlates to a rock mass quality of very poor to good.

We only collected bedrock cores from BB-OSB-101 during the explorations for this project since the proposed replacement structure is a concrete box culvert and additional rock core was not necessary. The table below summarizes the approximate top of bedrock elevations at the boring locations based bedrock cores and roller cone refusal:

Substructure	Boring	Station	Approx. Depth to Apparent Bedrock (feet bgs)	Approx. Elevation of Bedrock Surface (feet)
Abutment No. 1	BB-OSB-101	7+35.7, 10.1 RT	58.8	388.4
Abutment No. 2	BB-OSB-102	7+62.3, 10.3 LT	53.1	394.1

Approximate Bedrock Depth and Elevation at the Boring Locations

5.4 Groundwater

We observed the groundwater level at approximate depths of 5.8 to 6.0 feet bgs in boring BB-OSB-101 and BB-OSB-102, respectively. However, the groundwater level will fluctuate with seasonal changes, runoff, and adjacent construction activities.

6.0 FOUNDATION ALTERNATIVES

The project team initially considered rehabilitation of the bridge but they determined that structural deterioration is significant and that rehabilitation would only provide 20 to 30 additional years of life to the structure. The project team decided that this is not acceptable for the Route 1 corridor especially considering that a 50-mile detour would be required if the bridge failed. The team then considered three replacement alternatives:

- 14-foot span, cast-in-place deck with cantilever abutments on shallow spread footings;
- precast concrete box culvert with a 15-foot span and a 7-foot rise and 2 feet of special fill inside the culvert to emulate natural bottom;
- precast concrete box culvert with a 13-foot span and a 6-foot rise and 2 feet of special fill inside the culvert to emulate natural bottom.

For a small additional cost, and in an effort to meet environmental guidelines of 1.2 bankfull and natural stream bottom for areas requiring formal Section 7 consultation for Atlantic Salmon such as at Skagrock Brook, the project team selected a precast concrete box culvert with a 15-foot span and a 7-foot rise and 2 feet of special fill inside the culvert for the replacement structure. Materials removed from the streambed during construction will be placed in the bottom of the box to emulate a natural stream bottom. The following section presents geotechnical design recommendations for the precast concrete box culvert alternative.

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

The proposed replacement structure at the Orient site will consist of a 15-foot wide by 7-foot high precast concrete box culvert. The proposed new culvert will be on the same horizontal and vertical alignment as the existing bridge and the new structure will have a rail-to-rail width of approximately 32 feet. The base of the bottom slab will be buried approximately three feet (2 feet of special fill in the culvert and 1-foot concrete culvert base slab thickness).

The design methodology used in the following evaluation is referenced from the AASHTO LRFD Bridge Design Specifications, 5th Edition, 2010 (LRFD). See Appendix C, Calculations, at the end of this report for supporting documentation for the design parameters discussed below.

7.1 Box Culvert Design and Construction

Precast concrete boxes are typically detailed on the contract plans with only the basic layout and required hydraulic opening so that the contractor may choose an appropriate structure. The manufacturer is responsible for the design of the structure in accordance with Special Provision 534, Precast Structural Concrete Arches, Box Culverts, which includes determination of the wall thickness, haunch thickness and reinforcement. The loading specified for the structure should be Modified HL-93 Strength 1, 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 Section 3.6, Earth Loads, of the BDG to design earth loads from the soil envelope. The Soil Type properties are as follows: ϕ = 32 degrees, γ = 125 pcf.

The precast concrete box culvert will be supplier-designed for all relevant strength and service limit states and load combinations specified in LRFD Article 3.4.1, and LRFD Section 12. The culverts will be designed and constructed in general conformance with BDG Section 8, Buried Structures, and Special Provision 534, Precast Structural Concrete Arches, Box Culverts. The culvert bedding and soil envelope backfill shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill, except that the maximum particle size shall be limited to 4 inches. We recommend a bedding layer 12 inches thick. Bedding and/or backfill should be placed in lifts 6 to 8 inches thick loose measure and compacted to manufacturer's specifications, but in no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

7.2 Culvert Headwalls

We recommend integral concrete headwalls with minimum 1-foot by 1-foot dimensions to prevent crushed stone slope protection from dropping or eroding into the waterway. Culvert headwalls larger than the nominal 1-foot by 1-foot dimension are essentially retaining walls sharing a continuous base slab and should be designed for all relevant strength and service limit states and load combinations specified in LRFD Articles 3.4.1, and 11.5.5 and 11.6. 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 also 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 the table below. For this culvert replacement, the live load surcharge is 250 psf which is equivalent to 2.0 feet of soil.

Retaining 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: $\geq$ 1 feet
5	5.0	2.0
10	3.5	2.0
$\geq$ 20	2.0	2.0

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, equal to 0.31 assuming a level backslope. The active earth pressure coefficient may change if backslope conditions are different.

Footings for any headwall or wingwall constructed independently of the box culvert should be placed no less than 2 feet below the maximum anticipated depth of scour.

7.3 Box Culvert Bearing Resistance

In our analysis, we determined the factored bearing resistance at the strength limit state for the box culvert on compacted fill should not exceed 7.0 ksf. Based on presumptive bearing resistance values, a factored bearing resistance of 6.0 ksf may be used when analyzing box bottom slabs for 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 structure concrete, which may be taken as 0.3 $f'c$.

7.4 Settlement

We have evaluated the potential settlement at the Orient site based on the following. MaineDOT currently does not plan horizontal or vertical alignment changes. The proposed concrete box culvert increases the span length which reduces soil weight and the box culvert structure loads will be less than the existing bridge structure loads. Consequently, we estimate that total and post-construction settlements of the prepared culvert subgrade consisting of compacted fill and native glacial stream soils will be negligible. No settlement issues are anticipated at the site.

7.5 Scour Protection

The box culvert will be fitted with integral concrete headwalls to prevent crushed stone slope protection from dropping or eroding into the waterway, and inlet and outlet section seepage cutoff walls below the culvert, all to provide scour protection per BDG 8.3.1. The bridge approach slopes shall be armored with a 3-foot thick layer of riprap adjacent to the culvert openings. The riprap layer shall be constructed in accordance with Standard Detail 620(02) Stone Scour Protection (updated August 2011) and Special Provision 610 Stone Fill, Riprap, Stone Blanket, and Stone Ditch Protection. The riprap slopes should be no steeper than a maximum 1.75:1 (H:V). The toe of riprap sections shall be constructed 1 foot below the streambed elevation.

7.6 Frost Protection

Any foundation placed on granular subgrade soils should be designed with an appropriate embedment for frost protection. Based on State of Maine frost depth maps, BDG Figure 5-1, the site has a design-freezing index of approximately 2070 F-degree days. Considering site soils and natural water contents, this correlates to a frost depth of approximately 6.8 feet at this site. We also considered frost depth projections computed by Modberg software developed by the US Army Cold Regions Research and Engineering Laboratory. The results of the Modberg frost depth model indicate a potential frost depth of approximately 6.8 feet. Consequently, if spread footings are used, we require that any spread footing or leveling pads constructed at the site be founded a minimum of 6.5 feet below finished exterior grade for frost protection.

7.7 Seismic Design Considerations

In accordance with LRFD Articles 3.10.1 and 12.6.1, Loading, earthquake loading should only be considered where buried structures cross active faults. Since there are no known active faults in Maine, no seismic analysis is required.

7.8 Construction Considerations

7.8.1 Excavation

Construction of the new concrete box culvert will require soil excavation. Earth support systems may be required. We recommend that the contractor protect any subgrade from exposure to water and any unnecessary construction traffic. If disturbance and rutting occur, the contractor shall remove the disturbed materials and replace them with compacted gravel borrow. If the subgrade soil contains cobbles or boulders, we recommend that the contractor remove any cobbles and boulders larger than 6 inches in diameter. After excavating to the subgrade level, the contractor should proof-roll the surface to identify weak soil areas.

If encountered, unsuitable soils should also be excavated from the subgrade to a depth of one foot and replaced with compacted granular borrow. Granular borrow should conform to MaineDOT Standard Specification 703.19, Granular Borrow. The granular borrow should be compacted to 92 percent of the Modified Proctor maximum dry density (AASHTO T-180).

7.8.2 Dewatering

In some locations, the native soil units may be saturated and significant water seepage may be encountered during excavation. The groundwater may be trapped in layers and lenses of coarse-grained soil within or overlying glacial stream sediments. We anticipate that this seepage will be temporary but there may be localized sloughing and near-surface instability of some soil slopes.

The contractor should control groundwater and surface water infiltration to permit construction in-the-dry. We recommend that the contractor use cofferdams, temporary ditches, sumps, granular drainage blankets, stone ditch protection, or hand-laid riprap with geotextile underlayment to divert groundwater if significant seepage is encountered during construction. We also recommend using French drains daylighted to nearby ditches if significant seepage is encountered in the subgrade along the construction areas. If the amount of seepage is significant, we anticipate that pumping from sumps will likely be needed to control the water.

7.8.3 Reuse of Excavated Soil

The project plans call for excavation of the existing approach areas to achieve proposed grades. In the process, the contractor will excavate both the existing subbase gravel, and subgrade fill soils. We do not recommend using the excavated subbase aggregate to re-base the bridge approaches. Excavated subbase and subgrade sand and gravel may be used as fill below the roadway subgrade elevation in fill embankment areas provided all other requirements of MaineDOT Standard Specification Sections 203, Excavation and Embankment, and 703, Aggregates, are met. Contractors should expect that, prior to placement and compaction, it may be necessary to spread out and dry portions of the glacial stream soils that are excessively moist. This soil may also be used for dressing slopes, but only below the bottom elevation of the shoulder subbase gravel.

7.8.4 Embankment Fill Areas

The current project plans require construction of fill extensions along the bridge approaches. The plans indicate that the side slopes will be constructed to 1.75:1 (H:V) grades or flatter and will be armored with riprap. We recommend benching the existing fill slope soils in accordance with MaineDOT Standard Specification 203.09, Preparation of Embankment Area, where new fill slope extensions are constructed over existing slopes in preparation for construction of the riprap layer.

7.8.5 Erosion Control Recommendations

We recommend using appropriate erosion control measures during construction as described in the MaineDOT Best Management Practices February 2008 guidelines to minimize erosion of the fine-grained soils at the site.

8.0 CLOSURE

This report has been prepared for use by the MaineDOT Bridge Program for specific application to the replacement of the Skagrock Brook Bridge over Skagrock Brook in Orient, Maine. We have prepared the report in accordance with generally accepted soil 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 completed at discrete locations on the project 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.

We recommend that we be provided the opportunity for a general review of the final design drawings and specifications in order that we may verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design.

REFERENCES

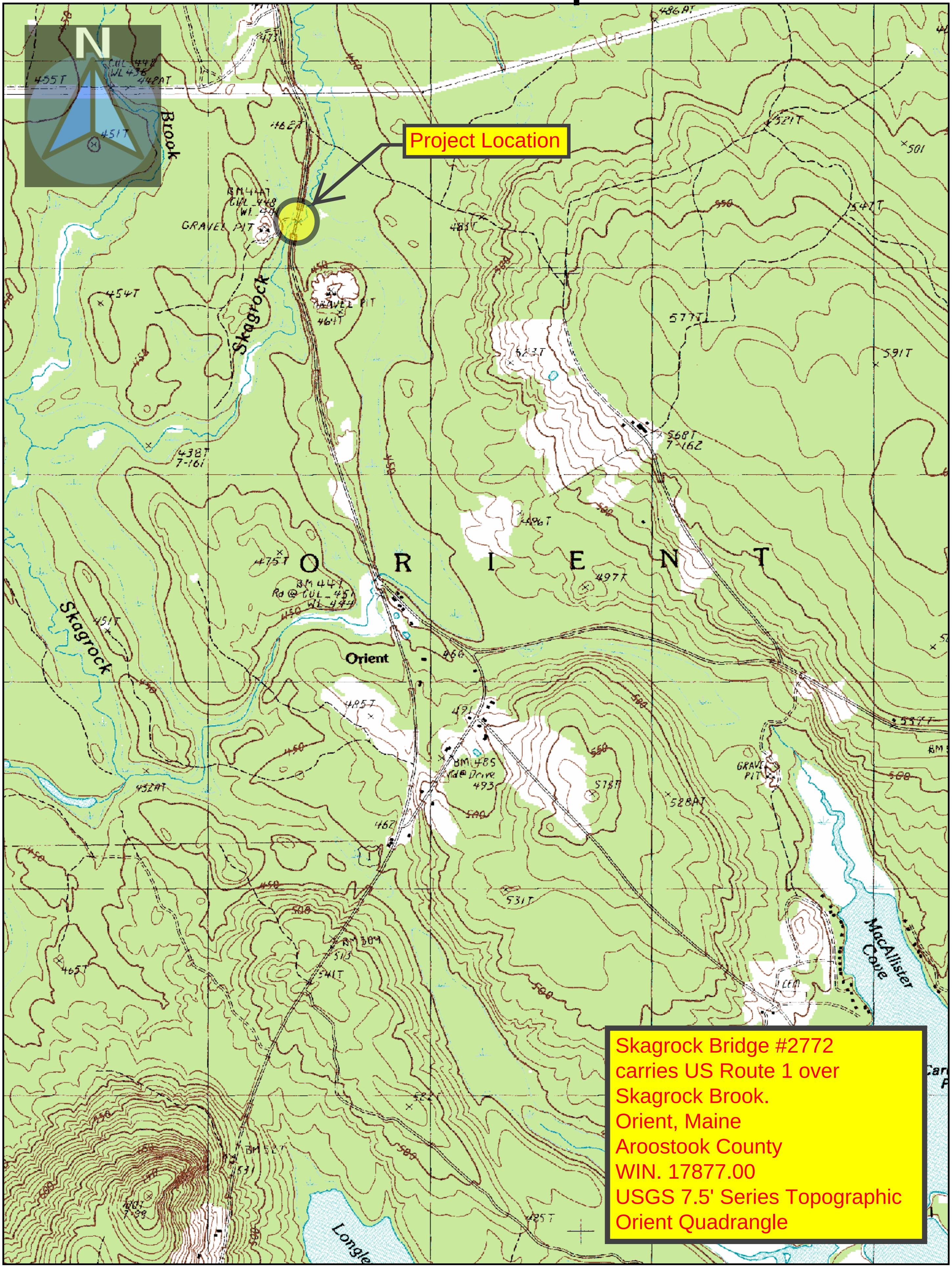
AASHTO, (2010), LRFD Bridge Design Specifications, Fifth, AASHTO, Washington, D.C.

Bowles, Joseph E. (1996), Foundation Analysis and Design, Fifth Edition, McGraw-Hill, New York, NY.

MaineDOT, (2003), Bridge Design Guide, MaineDOT Bridge Program, Augusta, ME with various Interims.

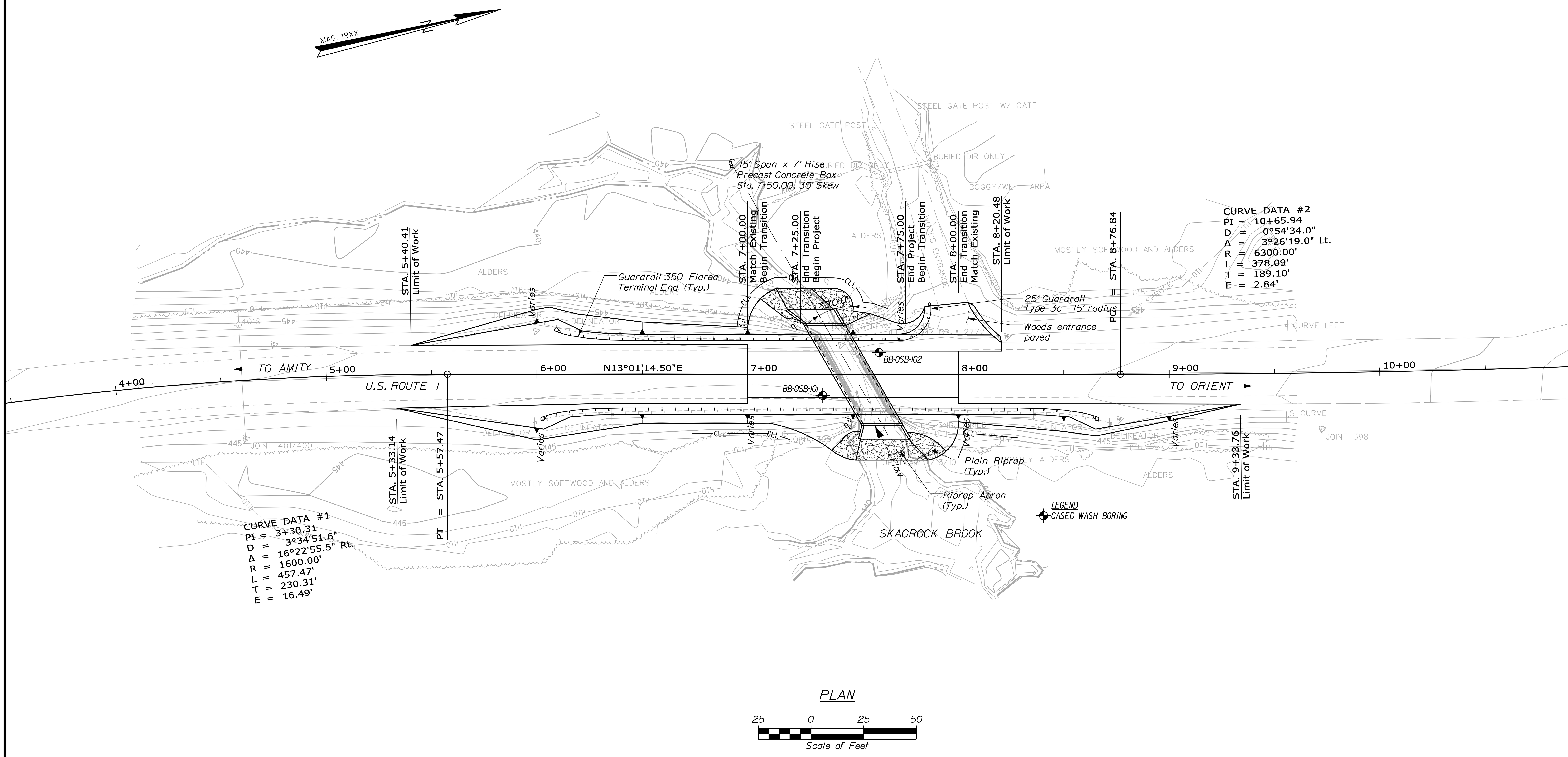
Sheets

Location Map



Map Scale 1:24000

Filename: ...\00\geotech\msta\006_BLP1.dgn Division: GEOTECH Username: terry.white Date:11/14/2011



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1787(700)X

BRIDGE NO. 2772

WIN 17877.00

BRIDGE PLANS

		BY	DATE
PROJ. MANAGER	S. Bodge		
DESIGN-DETAILED	M.MOREAU	T.WHITE	JUN 2011
CHECKED-REVIEWED			
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

DATE

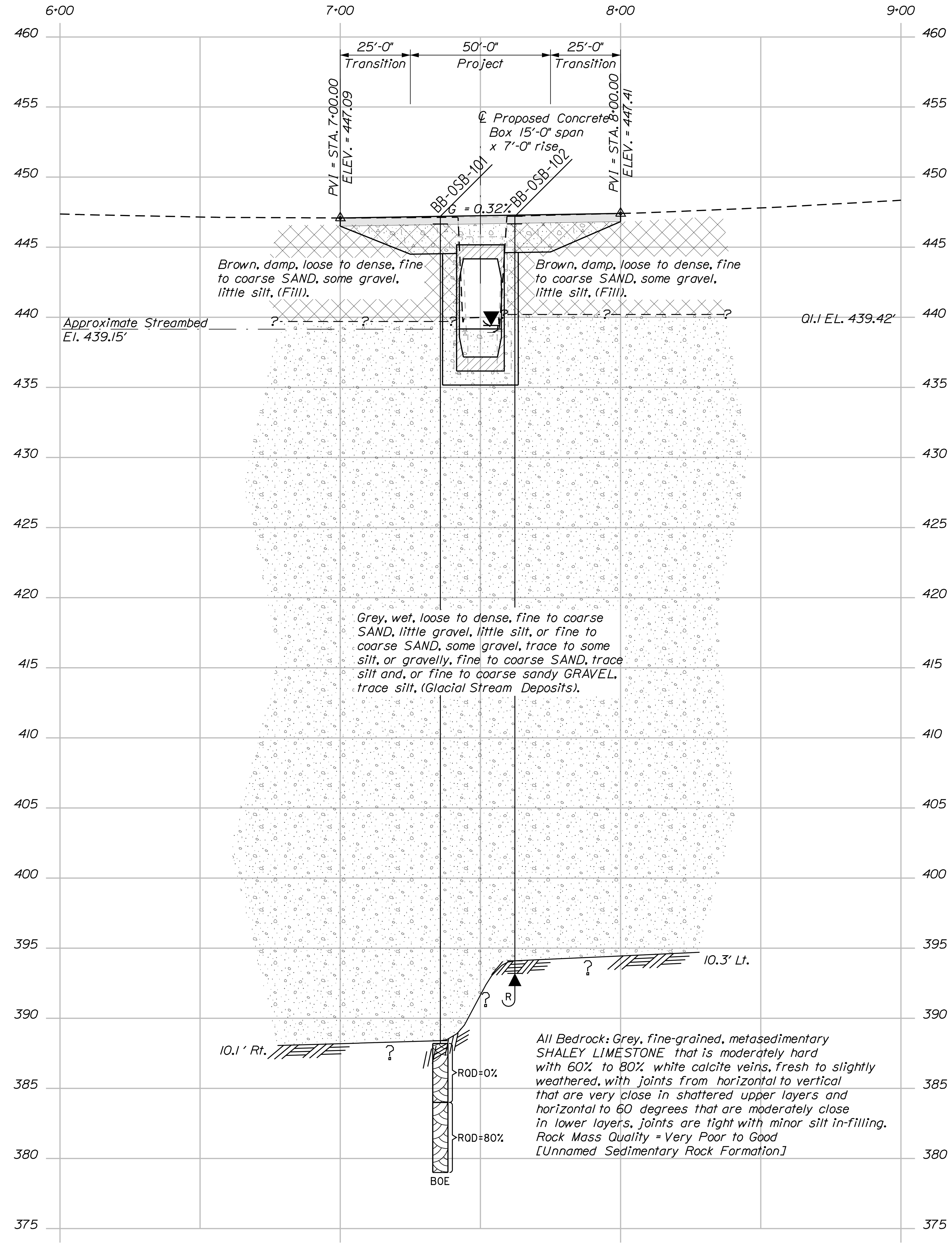
SKAGROCK BRIDGE
SKAGROCK BROOK
ORIENT AROOSTOOK COUNTY

BORING LOCATION PLAN

SHEET NUMBER

2

OF 4



LEGEND

Boring No.
Offset, if shown
Pavement Thickness if applicable
Strata Interface
Boring
RQD= Rock Quality Designation for Rock Core Sample
BOE= Bottom Of Exploration

PROFILE

HORIZ 25 0 25 50
VERT 5 0 5 10
SCALE

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.

Filename: ...\00\geotech\msta\007_ISP1.dgn Division: GEOTECH Username: terry.white Date:11/14/2011

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1787(700)X

BRIDGE NO. 2772 | WIN 17877.00 | BRIDGE PLANS

PROJ. MANAGER	S. Bodge	BY	DATE
DESIGN-DETAILED	M.MOREAU	T.WHITE	JUN 2011
CHECKED-REVIEWED	-----	-----	-----
DESIGN2-DETAILED2	-----	-----	-----
DESIGN3-DETAILED3	-----	-----	-----
REVISIONS 1	-----		-----
REVISIONS 2	-----		-----
REVISIONS 3	-----		-----
REVISIONS 4	-----		-----
FIELD CHANGES	-----		-----

SIGNATURE

P.E. NUMBER

DATE

SKAGROCK BRIDGE
SKAGROCK BROOK
AROOSTOOK COUNTY
ORIENT

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3
OF 4

Filename: ...\msta\008_BORING LOGS1.dgn   Division: GEOTECH   Username: terry.white   Date:11/14/2011

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-101
WIN: 17877.00

Driller:	MaineDOT	Elevation (ft.)	447.2	Auger ID/OD:	5" Solid Stem
Operator:	Giguere/Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/6/11-6/7/11	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	7+35.7, 10.1 ft Rt.	Casing ID/OD:	NW	Water Level*:	5.8 ft bgs.
Hammer Efficiency Factor: 0.84		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	446.66	6.5" PAVEMENT. — 0.54	
	1D	24/18	1.00 - 3.00	16/15/7/9	22	31			Brown, damp, dense, fine to coarse SAND, some gravel, little silt, (Fill).	G#261727 A-1-b, SM WC=5.6%
5	2D	24/8	5.00 - 7.00	5/4/4/4	8	11			Similar to above, except medium dense.	
								439.70	— 7.50	
10	3D	24/17	10.00 - 12.00	2/3/6/11	9	13	19		Grey, wet, medium dense, fine to coarse SAND, little gravel, little silt, (Glacial Stream Deposit).	G#261728 A-1-b, SM WC=16.7%
							24			
							29			
							32			
							68	433.20	— 14.00	
15	4D	24/14	15.00 - 17.00	4/4/6/5	10	14	14		Grey, wet, medium dense to dense, fine to coarse SAND, some gravel, trace silt, (Glacial Stream Deposit).	G#261729 A-1-a, SW-SM WC=15.1%
							31			
							35			
							47			
							38			
20	5D	24/13	20.00 - 22.00	12/13/10/15	23	32	51			
							48			
							58			
							39			
							47			
25	6D	24/9	25.00 - 27.00	9/10/12/19	22	31	31		Grey, wet, medium dense to dense, fine to coarse SAND, some gravel, some silt, (Glacial Stream Deposit).	
							50			
							56			
							50			
							48			
30	7D	24/7	30.00 - 32.00	10/9/12/11	21	29	31			
							53			
							62			
							63			
							45			
35	8D	24/8	35.00 - 37.00	7/6/5/7	11	15	39			
							45			
							42			
							51	408.70	— 38.50	
							47			
40	9D	24/14	40.00 - 42.00	7/9/7/10	16	22	46		Grey, wet, medium dense, gravelly, fine to coarse SAND, trace silt, (Glacial Stream Deposit).	G#261730 A-1-a, SW-SM WC=12.4%
							42			
							38			
							47			
							50			
45	10D	24/12	45.00 - 47.00	6/6/9/9	15	21	36			
							44			
							48			
							72			
							63			
50	11D	24/11	50.00 - 52.00	14/8/9/18	17	24	35		Grey, wet, medium dense, gravelly, fine to coarse SAND, trace silt, (Glacial Stream Deposit).	
							47			
							65			
							48	393.70	— 53.50	
							52			
55	12D	24/8	55.00 - 57.00	3/4/8/10	12	17	36		Grey, wet, medium dense, fine to coarse SAND, some gravel, trace silt, (Glacial Stream Deposit).	G#261731 A-1-a, SW-SM WC=12.3%
							46			
							136			
							a133	388.40	a133 blows for 0.8 ft. Roller Coned ahead to 59.0 ft bgs. — 58.80	
	R1	50.4/50.4	59.00 - 63.20	RQD = 0%			NQ-2		Top of Bedrock at Elev. 388.4 ft. R1 and R2 Bedrock: Grey, fine-grained metasedimentary SHALEY LIMESTONE, with 60% to 80% white calcite veins, moderately hard. R1 is shattered and slightly weathered. R2 is fresh with joints from near horizontal to 60 degrees above horizontal, close to moderately close, tight with minor silt in-filling. Rock Mass Quality is Very Poor to Good. [Unnamed Sedimentary Rock Formation]	
60									R1:Core Times (min:sec) 59.0-60.0 ft (3:00) 60.0-61.0 ft (2:50) 61.0-62.0 ft (2:30) 62.0-63.0 ft (3:50) 63.0-63.2 ft (2:25) 100% Recovery	
	R2	60/57	63.20 - 68.20	RQD = 80%					R2:Core Times (min:sec) 63.2-64.2 ft (2:50) 64.2-65.2 ft (3:30) 65.2-66.2 ft (3:20) 66.2-67.2 ft (4:00) 67.2-68.2 ft (5:30) 95% Recovery	
65								379.00	— 68.20 Bottom of Exploration at 68.20 feet below ground surface.	
70										
75										

Remarks:

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

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

Page 1 of 1

Boring No.: BB-OSB-101

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-102
WIN: 17877.00

Driller:	MaineDOT	Elevation (ft.)	447.2	Auger ID/OD:	5" Solid Stem
Operator:	Giguere/Giles/Daggett	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	6/7/11; 09:00-15:30	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	7+62.3, 10.3 ft Lt.	Casing ID/OD:	NW	Water Level*:	6.0 ft bgs.
Hammer Efficiency Factor: 0.84		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	446.66	6.5" PAVEMENT. — 0.54	
	MD	2.4/0	1.00 - 1.20	25(2.4")	---				Cobble from 1.2-1.5 ft bgs.	
5	1D	24/17	5.00 - 7.00	4/4/3/3	7	10			Brown, damp, loose, fine to coarse SAND, some gravel, little silt, (Fill).	G#261732 A-1-b, SM WC=6.5%
								440.20	— 7.00	
10	2D	24/17	10.00 - 12.00	5/8/8/9	16	22	37		Grey, wet, medium dense, fine to coarse SAND, some gravel, little silt, (Glacial Stream Deposit).	G#261733 A-1-b, SM WC=13.8%
							28			
							52			
							52			
							50			
15	3D	24/14	15.00 - 17.00	9/16/15/16	31	43	22	431.70	— 15.50 Grey, wet, medium dense to dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	G#261734 A-1-a, GW-GM WC=11.9%
							44			
							36			
							39			
							33			
20	4D	24/5	20.00 - 22.00	7/7/8/10	15	21	16			
							30			
							62			
							83			
							35			
25	5D	24/12	25.00 - 27.00	5/6/11/12	17	24	28		Grey, wet, medium dense to dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	G#261735 A-1-a, GW-GM WC=11.6%
							41			
							50			
							31			
							47			
30	6D	24/14	30.00 - 32.00	9/11/14/23	25	35	34			
							78			
							63			
							42			
							44			
35	7D	24/7	35.00 - 37.00	5/7/11/14	18	25	22			
							51			
							52			
							55			
							68	408.20	— 39.00	
40	8D	24/10	40.00 - 42.00	9/12/17/15	29	41	40		Grey, wet, dense, fine to coarse SAND, some gravel, trace silt, (Glacial Stream Deposit).	G#261736 A-1-a, SP WC=17.1%
							43			
							51			
							33			
							38	403.20	— 44.00	
45	9D	24/6	45.00 - 47.00	13/9/9/8	18	25	49		Grey, wet, medium dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	
							59			
							69			
							99			
							101			
50	10D	24/6	50.00 - 52.00	19/12/12/11	24	34	64		Grey, wet, dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	G#261737 A-1-a, GP WC=9.5%
							79			
							96	394.10	a75 blows for 0.1 ft. — 53.10	
							a75	393.20	Top of Apparent Bedrock at Elev. 394.1 ft. Roller Coned ahead to 54.0 ft bgs. Grey and white chips in wash. — 54.00 Bottom of Exploration at 54.00 feet below ground surface. Very hard Roller Cone REFUSAL. No rock core taken.	
55										
60										
65										
70										
75										

Remarks:
NW Casing broke at 30.0 ft bgs. left 25.0 ft of casing in hole. pulled per Geotechnical Engineer.

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-OSB-102

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BR-1787(700)X

BRIDGE PLANS

WIN 17877.00

BRIDGE NO. 2772

PROJ. MANAGER	S. Bodge	BY	DATE
DESIGN-DETAILED	M.MOREAU	T.WHITE	JUN 2011
CHECKED-REVIEWED			
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE
P.E. NUMBER
DATE

SKAGROCK BRIDGE
SKAGROCK BROOK
AROOSTOOK COUNTY
ORIENT

BORING LOGS

SHEET NUMBER
4
OF 4

Appendix A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

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

Desired Soil Observations: (in this order)
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

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

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

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-101
WIN: 17877.00

Driller:	MaineDOT	**Elevation (ft.)**	447.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giguere/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/6/11-6/7/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+35.7, 10.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	5.8 ft bgs.
Hammer Efficiency Factor:	0.84	**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							SSA	446.66		6½" PAVEMENT. 0.54	
	1D	24/18	1.00 - 3.00	16/15/7/9	22	31				Brown, damp, dense, fine to coarse SAND, some gravel, little silt, (Fill).	G#261727 A-1-b, SM WC=5.6%
5	2D	24/8	5.00 - 7.00	5/4/4/4	8	11				Similar to above, except medium dense.	
								439.70		7.50	
10	3D	24/17	10.00 - 12.00	2/3/6/11	9	13	19			Grey, wet, medium dense, fine to coarse SAND, little gravel, little silt, (Glacial Stream Deposit).	G#261728 A-1-b, SM WC=16.7%
							24				
							29				
							32				
							68	433.20		14.00	
15	4D	24/14	15.00 - 17.00	4/4/6/5	10	14	14			Grey, wet, medium dense to dense, fine to coarse SAND, some gravel, trace silt, (Glacial Stream Deposit).	G#261729 A-1-a, SW-SM WC=15.1%
							31				
							35				
							47				
							38				
20	5D	24/13	20.00 - 22.00	12/13/10/15	23	32	51				
							48				
							58				
							39				
25							47				

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-101
WIN: 17877.00

Driller:	MaineDOT	**Elevation (ft.)**	447.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giguere/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/6/11-6/7/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+35.7, 10.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	5.8 ft bgs.

Hammer Efficiency Factor: 0.84 **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.
25	6D	24/9	25.00 - 27.00	9/10/12/19	22	31	31			Grey, wet, medium dense to dense, fine to coarse SAND, some gravel, some silt, (Glacial Stream Deposit).	
							50				
							56				
							50				
							48				
30	7D	24/7	30.00 - 32.00	10/9/12/11	21	29	31				
							53				
							62				
							63				
							45				
35	8D	24/8	35.00 - 37.00	7/6/5/7	11	15	39				
							45				
							42				
							51	408.70		38.50	
							47				
40	9D	24/14	40.00 - 42.00	7/9/7/10	16	22	46			Grey, wet, medium dense, gravelly, fine to coarse SAND, trace silt, (Glacial Stream Deposit).	G#261730 A-1-a, SW-SM WC=12.4%
							42				
							38				
							47				
							50				
45	10D	24/12	45.00 - 47.00	6/6/9/9	15	21	36				
							44				
							48				
							72				
							63				
50											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-101
WIN: 17877.00

Driller:	MaineDOT	**Elevation (ft.)**	447.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giguere/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/6/11-6/7/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+35.7, 10.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	5.8 ft bgs.
Hammer Efficiency Factor:	0.84	**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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50	11D	24/11	50.00 - 52.00	14/8/9/18	17	24	35		Grey, wet, medium dense, gravelly, fine to coarse SAND, trace silt, (Glacial Stream Deposit).	
							47			
							65			
							48	393.70	53.50	
							52			
55	12D	24/8	55.00 - 57.00	3/4/8/10	12	17	36		Grey, wet, medium dense, fine to coarse SAND, some gravel, trace silt, (Glacial Stream Deposit).	G#261731 A-1-a, SW-SM WC=12.3%
							46			
							136			
							a133	388.40	a133 blows for 0.8 ft. Roller Coned ahead to 59.0 ft bgs. 58.80	
	R1	50.4/50.4	59.00 - 63.20	RQD = 0%			NQ-2		Top of Bedrock at Elev. 388.4 ft.	
60									R1 and R2 Bedrock: Grey, fine-grained metasedimentary SHALEY LIMESTONE, with 60% to 80% white calcite veins, moderately hard. R1 is shattered and slightly weathered. R2 is fresh with joints from near horizontal to 60 degrees above horizontal, close to moderately close, tight with minor silt in-filling. Rock Mass Quality is Very Poor to Good. [Unnamed Sedimentary Rock Formation]	
	R2	60/57	63.20 - 68.20	RQD = 80%					R1:Core Times (min:sec) 59.0-60.0 ft (3:00) 60.0-61.0 ft (2:50) 61.0-62.0 ft (2:30) 62.0-63.0 ft (3:50) 63.0-63.2 ft (2:25) 100% Recovery	
65									R2:Core Times (min:sec) 63.2-64.2 ft (2:50) 64.2-65.2 ft (3:30) 65.2-66.2 ft (3:20) 66.2-67.2 ft (4:00) 67.2-68.2 ft (5:30) 95% Recovery	
								379.00	68.20	
70									**Bottom of Exploration at 68.20 feet below ground surface.**	
75										

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook	**Boring No.:**	BB-OSB-102
Location:	Orient, Maine	**WIN:**	17877.00

Driller:	MaineDOT	**Elevation (ft.)**	447.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giguere/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7/11; 09:00-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 10.3 ft Lt.	**Casing ID/OD:**	NW	**Water Level*:**	6.0 ft bgs.
Hammer Efficiency Factor:	0.84	**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							SSA	446.66		6½" PAVEMENT. 0.54	
	MD	2.4/0	1.00 - 1.20	25(2.4")	---					Cobble from 1.2-1.5 ft bgs.	
5	1D	24/17	5.00 - 7.00	4/4/3/3	7	10				Brown, damp, loose, fine to coarse SAND, some gravel, little silt, (Fill).	G#261732 A-1-b, SM WC=6.5%
								440.20		7.00	
10	2D	24/17	10.00 - 12.00	5/8/8/9	16	22	37			Grey, wet, medium dense, fine to coarse SAND, some gravel, little silt, (Glacial Stream Deposit).	G#261733 A-1-b, SM WC=13.8%
							28				
							52				
							52				
							50				
15	3D	24/14	15.00 - 17.00	9/16/15/16	31	43	22	431.70		15.50 Grey, wet, medium dense to dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	G#261734 A-1-a, GW-GM WC=11.9%
							44				
							36				
							39				
							33				
20	4D	24/5	20.00 - 22.00	7/7/8/10	15	21	16				
							30				
							62				
							83				
							35				
25											

Remarks:

NW Casing broke at 30.0 ft bgs, left 25.0 ft of casing in hole, pulled per Geotechnical Engineer.

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: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-102
WIN: 17877.00

Driller:	MaineDOT	**Elevation (ft.)**	447.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giguere/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7/11; 09:00-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 10.3 ft Lt.	**Casing ID/OD:**	NW	**Water Level*:**	6.0 ft bgs.
Hammer Efficiency Factor:	0.84	**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	5D	24/12	25.00 - 27.00	5/6/11/12	17	24	28			Grey, wet, medium dense to dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	G#261735 A-1-a, GW-GM WC=11.6%
							41				
							50				
							31				
							47				
30	6D	24/14	30.00 - 32.00	9/11/14/23	25	35	34				
							78				
							63				
							42				
							44				
35	7D	24/7	35.00 - 37.00	5/7/11/14	18	25	22				
							51				
							52				
							55				
							68	408.20		39.00	
40	8D	24/10	40.00 - 42.00	9/12/17/15	29	41	40			Grey, wet, dense, fine to coarse SAND, some gravel, trace silt, (Glacial Stream Deposit).	G#261736 A-1-b, SP WC=17.1%
							43				
							51				
							33				
							38	403.20		44.00	
45	9D	24/6	45.00 - 47.00	13/9/9/8	18	25	49			Grey, wet, medium dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	
							59				
							69				
							99				
							101				
50											

Remarks:

NW Casing broke at 30.0 ft bgs, left 25.0 ft of casing in hole, pulled per Geotechnical Engineer.

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: Skagrock Bridge #2772 carries US Route 1 over Skagrock Brook
Location: Orient, Maine

Boring No.: BB-OSB-102
WIN: 17877.00

Driller:	MaineDOT	**Elevation (ft.)**	447.2	**Auger ID/OD:**	5" Solid Stem
Operator:	Giguere/Giles/Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	6/7/11; 09:00-15:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 10.3 ft Lt.	**Casing ID/OD:**	NW	**Water Level*:**	6.0 ft bgs.
Hammer Efficiency Factor:	0.84	**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.
50	10D	24/6	50.00 - 52.00	19/12/12/11	24	34	64			Grey, wet, dense, fine to coarse sandy GRAVEL, trace silt, (Glacial Stream Deposit).	G#261737 A-1-a, GP WC=9.5%
							79				
							96				
							a75	394.10		a75 blows for 0.1 ft. 53.10	
								393.20		Top of Apparent Bedrock at Elev. 394.1 ft. Roller Coned ahead to 54.0 ft bgs. Grey and white chips in wash. 54.00	
55										**Bottom of Exploration at 54.00 feet below ground surface.** Very hard Roller Cone REFUSAL. No rock core taken.	
60											
65											
70											
75											

Remarks:

NW Casing broke at 30.0 ft bgs, left 25.0 ft of casing in hole, pulled per Geotechnical Engineer.

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 Data

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Orient   Project Number: 17877.00

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-OSB-101, 1D	7+35.7	10.1 Rt.	1.0-3.0	261727	1	5.6			SM	A-1-b	II
BB-OSB-101, 3D	7+35.7	10.1 Rt.	10.0-12.0	261728	1	16.7			SM	A-1-b	II
BB-OSB-101, 4D	7+35.7	10.1 Rt.	15.0-17.0	261729	1	15.1			SW-SM	A-1-a	0
BB-OSB-101, 9D	7+35.7	10.1 Rt.	40.0-42.0	261730	1	12.4			SW-SM	A-1-a	0
BB-OSB-101, 12D	7+35.7	10.1 Rt.	55.0-57.0	261731	1	12.3			SW-SM	A-1-a	0
BB-OSB-102, 1D	7+62.3	10.3 Lt.	5.0-7.0	261732	2	6.5			SM	A-1-b	II
BB-OSB-102, 2D	7+62.3	10.3 Lt.	10.0-12.0	261733	2	13.8			SM	A-1-b	II
BB-OSB-102, 3D	7+62.3	10.3 Lt.	15.5-17.0	261734	2	11.9			GW-GM	A-1-a	0
BB-OSB-102, 5D	7+62.3	10.3 Lt.	25.0-27.0	261735	2	11.6			GW-GM	A-1-a	0
BB-OSB-102, 8D	7+62.3	10.3 Lt.	40.0-42.0	261736	2	17.1			SP	A-1-b	0
BB-OSB-102, 10D	7+62.3	10.3 Lt.	50.0-52.0	261737	2	9.5			GP	A-1-a	0

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.

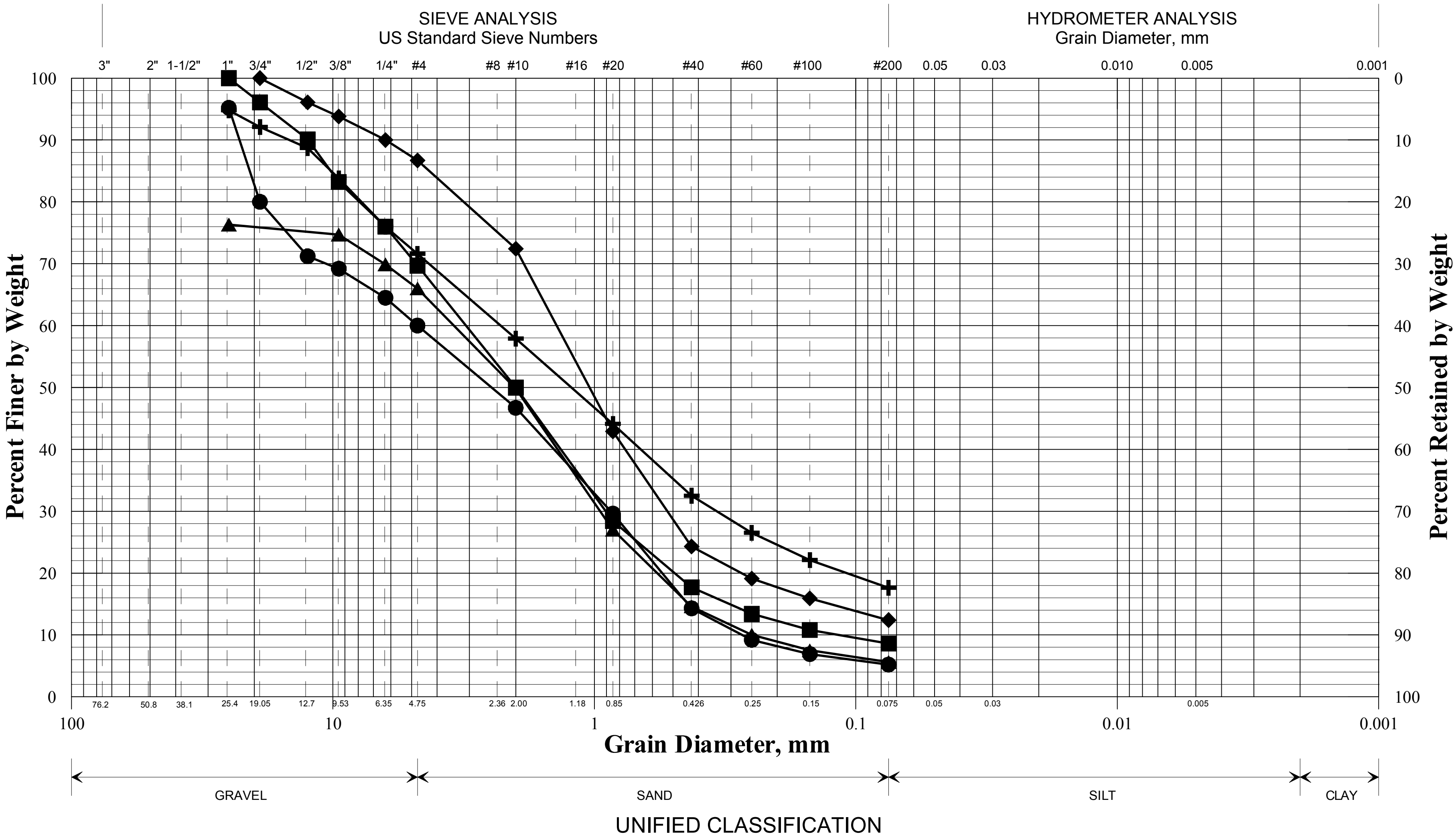
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

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

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

State of Maine Department of Transportation
GRAIN SIZE DISTRIBUTION CURVE

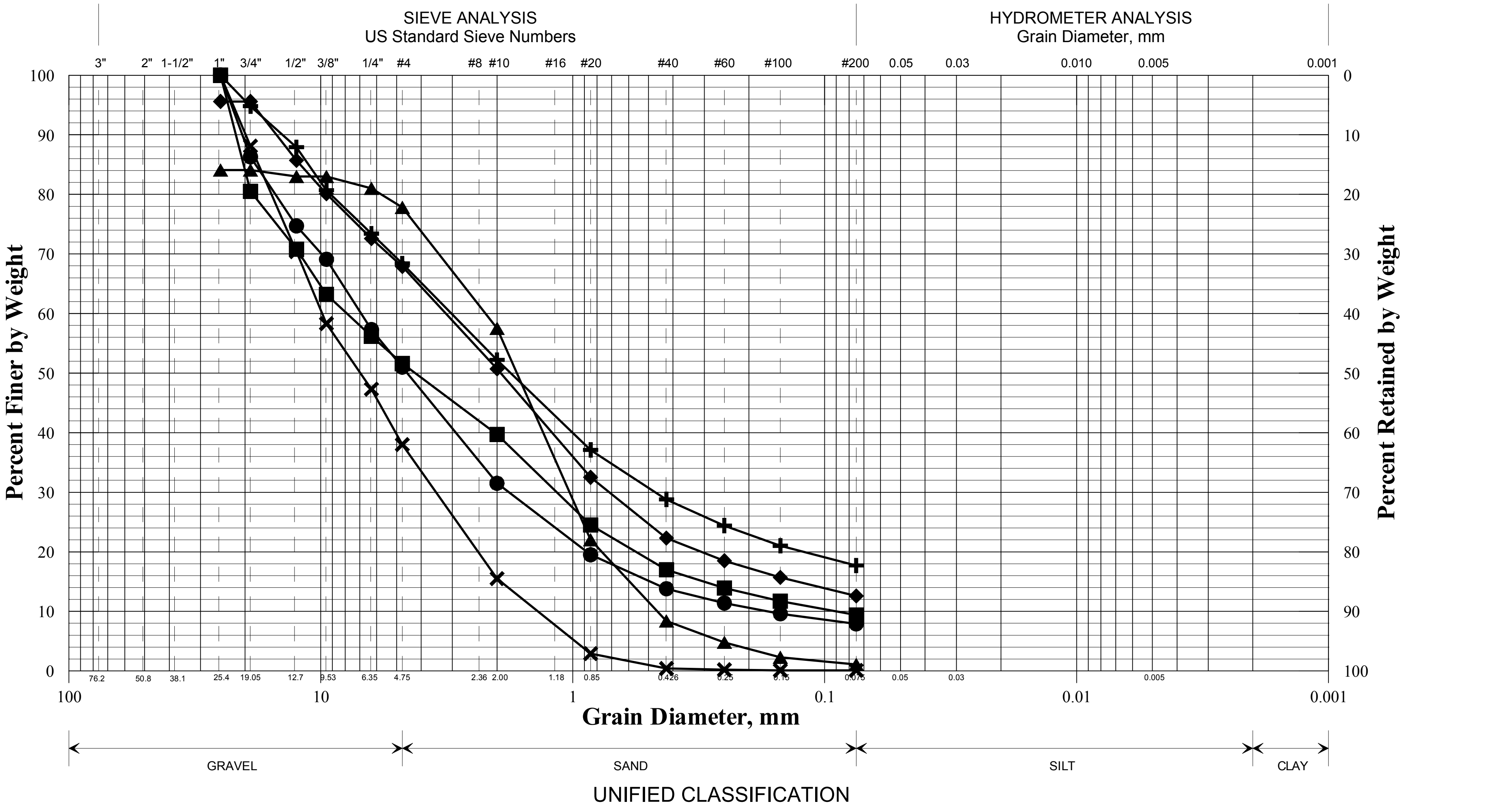


	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-OSB-101/1D	7+35.7	10.1 RT	1.0-3.0	SAND, some gravel, little silt.	5.6			
◆	BB-OSB-101/3D	7+35.7	10.1 RT	10.0-12.0	SAND, little gravel, little silt.	16.7			
■	BB-OSB-101/4D	7+35.7	10.1 RT	15.0-17.0	SAND, some gravel, trace silt.	15.1			
●	BB-OSB-101/9D	7+35.7	10.1 RT	40.0-42.0	Gravelly SAND, trace silt.	12.4			
▲	BB-OSB-101/12D	7+35.7	10.1 RT	55.0-57.0	SAND, some gravel, trace silt.	12.3			
✖									

PIN
017877.00
Town
Orient
Reported by/Date
WHITE, TERRY A 6/24/2011

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-OSB-102/1D	7+62.3	10.3 LT	5.0-7.0	SAND, some gravel, little silt.	6.5			
◆	BB-OSB-102/2D	7+62.3	10.3 LT	10.0-12.0	SAND, some garvel, little silt.	13.8			
■	BB-OSB-102/3D	7+62.3	10.3 LT	15.5-17.0	Sandy GRAVEL, trace silt.	11.9			
●	BB-OSB-102/5D	7+62.3	10.3 LT	25.0-27.0	Sandy GRAVEL, trace silt.	11.6			
▲	BB-OSB-102/8D	7+62.3	10.3 LT	40.0-42.0	SAND, some gravel, trace silt.	17.1			
✖	BBOSB-102/10D	7+62.3	10.3 LT	50.0-52.0	Sandy GRAVEL, trace silt.	9.5			

PIN
017877.00
Town
Orient
Reported by/Date
WHITE, TERRY A 6/24/2011

Appendix C

Calculations

HEADWALL ACTIVE EARTH PRESSURE:

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

Either Rankine or Coulomb may be used for long-heeled cantilever walls where the failure surface is uninterrupted by the top of the wall stem. In general, use Rankine though.

Soil angle of internal friction: $\phi := 32deg$

Slope angle of backfill soil from horizontal: $\beta := 0deg$

$$K_a := \tan\left[45deg - \left(\frac{\phi}{2}\right)\right]^2$$

$K_a = 0.31$

FROST PROTECTION

Method 1:

From the Maine Design Freezing Index Map:
DFI = 2070 degree-days
Site has Coarse Grained Native Soils With Wn = 14% to 17%, Assume 20%

From the 2003 Bridge Design Guide Table 5-1:

$Frost\_depth := [0.7 \cdot (80.7in - 78.7in) + 80.7in]$

$Frost\_depth = 82.1 \cdot in$

$Frost\_depth = 6.84 \cdot ft$

Method 2:

```
------------------------
--- ModBerg Results ---
-----------------------

Project Location: Houlton Airport, Maine

Air Design Freezing Index        =  2354 F-days
N-Factor                         =  0.70
Surface Design Freezing Index    =  1648 F-days
Mean Annual Temperature          =  39.7 deg F
Design Length of Freezing Season =  152 days

---------------------------------------------------------
Layer
#:Type             t    w%     d    Cf   Cu    Kf   Ku      L
---------------------------------------------------------
1-Asphalt        7.0    .1 140.0   28   28    .9   .9      0
2-Coarse        72.0   6.0 120.0   24   28   1.1  1.2  1,037
3-Coarse         2.0  16.0 120.0   30   40   2.6  1.6  2,765
---------------------------------------------------------

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 = 6.75 ft = 81.0 in.
*********************************************************
```

Use 6.5 feet

BEARING RESISTANCE ON COMPACTED FILL SOILS:

Consider this for use with Box Culverts and Headwalls.

SERVICE LIMIT STATE:

LRFD Table C10.6.2.6.1-1, (Based on NAVFAC DM 7.2) - "Presumptive Bearing Resistances for Spread Footing Foundations at the Service Limit State"

Bearing Material	Consistency in Place	Bearing Resistance (kips per sq. foot)	Recommend Value
Coarse to Medium sand, little gravel	Very dense	8 to 12	8 ksf
	Medium dense to dense	4 to 8	6 ksf
	Loose	2 to 4	3 ksf

Recommend **6.0 ksf** to control settlements for **Service Limit State** analyses and for preliminary footing sizing.

STRENGTH LIMIT STATE:

Nominal and Factored Bearing Resistance for box culvert on fill soils at the Strength Limit State:

Assumptions:

1. Box Culvert will be embedded 3.0 feet.

   $D_f := 3.0ft$

2. Assumed parameters for soils:
   Assume granular fill

   Moist unit weight: $\gamma_m := 125pcf$

   Saturated unit weight: $\gamma_{sat} := 130pcf$

   Soil angle of internal friction: $\phi_{ns} := 32$

   Undrained shear strength (cohesion): $c_{ns} := 0psf$

3. Use Terzaghi strip equations as L > B

Depth to Groundwater table based on boring data: $D_w := 0 \cdot ft$

Unit weight of water: $\gamma_w := 62.4pcf$

Effective Stress at the footing bearing level: $q_{eff\_str} := D_w \cdot \gamma_m + (D_f - D_w) \cdot (\gamma_{sat} - \gamma_w)$

$q_{eff\_str} = 0.2 \cdot ksf$

Box Culvert Width: $B := 15ft$

Terzaghi Shape Factors from Table 4-1, p. 220
For strip footing: $s_c := 1.0$

$s_\gamma := 1.0$

Meyerhof Bearing Capacity Factors For ϕ = 32 deg Bowles 5th Ed. Table 4-4 pg. 223

$N_c := 35.47$ $N_q := 23.2$ $N_\gamma := 22.0$

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

$q_{nom} := c_{ns} \cdot N_c \cdot s_c + q_{eff\_str} \cdot N_q + 0.5(\gamma_{sat} - \gamma_w) \cdot B \cdot N_\gamma \cdot s_\gamma$

$q_{nom} = 15.9 \cdot ksf$

Resistance Factor from LRFD Table 10.5.5.2.2-1 pg. 10-32: $\phi_b := 0.45$

$q_{fac} := q_{nom} \cdot \phi_b$

$q_{fac} = 7.1 \cdot ksf$

Recommend **Strength Limit State** Factored Bearing Resistance of **7.0 ksf** for the box culvert.