MAINE DEPARTMENT OF TRANSPORTATION
HIGHWAY PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Construction of:

BEAR HILL BRIDGE
ROUTE 15
DOVER-FOXCROFT, MAINE

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August 1, 2017

Piscataquis County
WIN 22648.00

Soils Report 2017-21
Bridge No. 6552

August 1, 2017
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GEOTECHNICAL DESIGN SUMMARY

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement of an existing large culvert on Route 15 in Dover-Foxcroft, Maine. Route 15 is a Highway Corridor Priority 2 roadway. The replacement structure will be a 20-foot span by 5-foot rise by 75-foot long precast concrete three-sided box culvert at a skew of approximately 20 degrees to the roadway centerline. The footings of the proposed culvert will bear on and be keyed into bedrock and the structure partially filled with Special Fill to facilitate fish passage. The roadway embankment slopes at the proposed structure’s inlet and outlet shall be no steeper than 2H:1V and shall be riprapped to protect against erosion. The following design recommendations are discussed in detail in Section 6.0.

Precast Concrete Culvert Design and Construction – The precast concrete 3-sided box culvert shall be designed and constructed in accordance with MaineDOT Standard Specification Section 534. The culvert shall be supported on cast-in-place concrete pedestal footings bearing on and keyed into bedrock. The structure will be partially filled with Special Fill to facilitate fish passage.

Bedrock Removal and Bedrock Subgrade Preparation – The structural design intends for the pedestal footings to bear on and be keyed into the prepared bedrock surface or dowelled into Concrete Fill (502.565); a mixed subgrade surface consisting of bedrock/Concrete Fill (502.565) and soil/aggregate fill shall not be accepted. The bedrock shall be prepared in accordance with MaineDOT standard practices. The footing bearing area should be approximately level. Bedrock surface slope shall be less than 4H:1V or it shall be benched in level steps.

Construction activities should not be permitted to create any open fissures. Any irregularities in the existing bedrock surface or irregularities created during the excavation process shall be addressed using Concrete Fill (502.565) prior to footing construction.

The Contractor shall remove any overburden soil and weathered bedrock that can be removed using ordinary excavation equipment to expose competent bedrock at the required elevation. In accordance with MaineDOT standard practices, the bedrock shall be clean and free of debris, soil, and loose rock. The cleanliness and condition of the bedrock surface should be confirmed and accepted by the Resident prior to placing Concrete Fill (502.565) or the cast-in-place concrete footings. If soil is encountered at bedding material subgrade it shall be overexcavated to expose the underlying bedrock surface.

Blasting shall be conducted in accordance with Section 105.2.6 and Section 203.042 of the MaineDOT Standard Specifications. It is also recommended that the Contractor conduct pre- and post-blast surveys, as well as blast vibration monitoring at nearby structures in accordance with the MaineDOT Standard Specifications and industry standards at the time of the blast. The Contractor’s blasting submittals shall address blasting procedures adjacent to an active roadway, including flyrock controls.
It is anticipated that there will be seepage of water from fractures and joints exposed in the bedrock surface. Water should be controlled by pumping from sumps. The Contractor should maintain the excavation so that all work is completed in the dry.

**Settlement** – No settlement issues are anticipated.

**Bearing Resistance** – A factored bearing resistance of 20 kips per square foot (ksf) shall be used when analyzing the service limit state as allowed in AASHTO LRFD Bridge Design Specifications 7th Edition 2014 (LRFD) Article C10.6.2.6.1. The factored bearing pressure at the strength limit state for the precast concrete culvert bearing on slate bedrock shall not exceed the calculated factored bearing resistance of 12 ksf. Calculations are attached to this report.

**Scour and Riprap** – Both the inlet and outlet of the culvert shall be armored with riprap. Riprap slopes shall not be steeper than 2H:1V. The riprap on the slopes shall be underlain by a non-woven Class 1 erosion control geotextile that is underlain by a 1-foot layer of bedding material. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation to form a key.

**Seismic Design Considerations** – Seismic analysis is not required.

**Construction Considerations** – Construction of the proposed precast concrete 3-sided box culvert will require soil excavation. Earth support systems will be required if laying back slopes is not feasible. Regardless of the method of excavation, all excavations and earth support systems shall meet all applicable OSHA regulations.

Any loose soils or soft or unsuitable materials encountered in exposed soil subgrade shall be removed and replaced with Granular Borrow Material for Underwater Backfill or Crushed Stone ¾-Inch. Any cobbles or boulders exposed in the soil subgrade that are in excess of 6 inches shall be removed and replaced with compacted Granular Borrow Material for Underwater Backfill or Crushed Stone ¾-Inch. All soil subgrade surfaces shall be protected from any unnecessary construction traffic.

The structural design intends for the pedestal footings to bear on and be keyed into the prepared bedrock surface or doweled into Concrete Fill (502.565) placed over the prepared bedrock surface. The bedrock shall be prepared in accordance with MaineDOT standard practices.

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 to allow construction in the dry.
1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and make geotechnical recommendations for the replacement an existing large culvert on State Route 15 in Dover-Foxcroft, Maine. State Route 15 is a Highway Corridor Priority 2 road. A subsurface investigation has been completed at the site to evaluate subsurface conditions and to develop geotechnical design and construction recommendations for the replacement structure. This report presents the subsurface information obtained during the subsurface investigation and soil laboratory testing programs, and provides design and construction recommendations and geotechnical design parameters for the culvert replacement.

The existing structure consists of an approximately 82-inch span by 64-inch rise by 80-foot long structural plate pipe arch culvert.

The proposed replacement structure will be a 20-foot span by 5-foot rise by 75-foot long precast concrete 3-sided rigid frame culvert on a skew of approximately 20 degrees to the roadway centerline. The 3-sided concrete frame will be supported on pedestal footings that will bear on bedrock. The invert of the proposed culvert is approximately 8 feet below the existing road grade at the roadway centerline. The proposed structure will be partially filled with Special Fill to achieve the design invert and facilitate fish passage. The roadway embankment slopes at the proposed culvert inlet and outlet shall be no steeper than 2H:1V.

2.0 GEOLOGIC SETTING

The existing culvert carries an unnamed stream under Route 115 in Dover-Foxcroft and is located, 0.10 miles north of Bear Hill Road as shown in Sheet 1 Location Map.

According to the map titled Reconnaissance Surficial Geology of the Dover-Foxcroft [15-minute] Quadrangle, Maine, 1981 published by the Maine Geological Survey, the surficial soils at the site consist of till. These soils typically consist of a heterogeneous mixture of sand, silt, clay, and stones.

According to the map titled Reconnaissance Bedrock Geology of the Dover-Foxcroft Quadrangle, Maine, 1971 published by the Maine Geological Survey (Open File No. 71-8), the bedrock underlying the site consists of the Limestone Member of the Sangerville Formation that is characterized as a calcareous meta-siltstone (slate).

3.0 SUBSURFACE INVESTIGATION

Two (2) borings (HB-DF-101 and HB-DF-102) were drilled for this project on November 12, 2015 by New England Boring Contractors (NEBC) using a trailer mounted drill rig. Exploration locations are shown on the attached Boring Location Plan & Interpretive Subsurface Profile sheet. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are shown on the attached boring logs. Both borings were advanced to a depth of 10...
feet using solid stem augers and were completed as standard cased wash borings. Soil samples were obtained in both borings at 5-foot intervals using Standard Penetration Test (SPT) methods.

An experienced geotechnical engineer selected the boring locations, drilling methods, designated type and depth of sampling, reviewed field logs for accuracy and identified field testing requirements. An experienced geotechnical engineer logged the subsurface conditions encountered. The borings were located in the field by taping to surveyed site features after completion of the drilling program.

**4.0 LABORATORY TESTING**

A laboratory testing program was conducted to assist in soil classification, evaluation of engineering properties of the soils and geologic assessment of the project site. The MaineDOT Geotechnical Team member identified laboratory testing requirements. Laboratory testing consisted of two (2) standard grain size analyses with natural water content and two (2) grain size analyses with hydrometer and natural water content. The results of the laboratory testing program are discussed in the following section and are shown on the attached boring logs, Laboratory Testing Summary Sheet, and Grain Size Distribution Curve sheet.

**5.0 SUBSURFACE CONDITIONS**

Subsurface conditions encountered at the test borings generally consisted of fill (sand and gravel) overlying bedrock. An interpretive subsurface profile depicting the generalized soil stratigraphy at the boring location is shown on the attached Boring Location Plan & Interpretive Subsurface Profile sheet.

Boring HB-DF-101 was drilled to a depth of approximately 15.3 feet below ground surface (bgs) including a 5-foot bedrock core. Boring HB-DF-102 was drilled to a depth of 17.8 feet bgs including an approximately five foot bedrock core.

The following paragraphs discuss the subsurface conditions encountered in the borings in detail.

**Fill.** A layer of fill was encountered beneath the pavement in both of the borings. The fill consisted of:

- Brown, damp to moist, fine to coarse sand, little to appreciable gravel, little to some silt.
- Brown, moist, gravel, some fine to coarse sand, some silt, trace clay.

The thickness of the fill ranged from approximately 10.3 feet in boring HB-DF-101 to approximately 14.3 feet in boring HB-DF-102. SPT N-values obtained in the sand fill ranged from 7 to 22 blows per foot (bpf) indicating that the sand is loose to medium dense in density. Grain size analyses were conducted on three (3) samples from the sand fill and resulted in the soil being classified as an A-2-4 or A-1-b under the AASHTO Soil Classification System and an SM or SC-SM under the Unified Soil Classification System. The measured natural water contents of the fill samples ranged from approximately 5 to 13 percent.
One SPT N-value obtained in the gravel fill was 61 indicating that the gravel is very dense in density. Grain size analysis was conducted on one (1) sample from the gravel and resulted in the soil being classified as an A-2-4 under the AASHTO Soil Classification System and a GC-GM under the Unified Soil Classification System. The measured natural water content of the gravel fill sample tested was approximately 17 percent.

The table below summarizes the refusal elevations at the exploration locations.

<table>
<thead>
<tr>
<th>Boring</th>
<th>Approximate Depth to Bedrock (feet)</th>
<th>Approximate Elevation of Bedrock Surface (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB-DF-101</td>
<td>10.3</td>
<td>306.6</td>
</tr>
<tr>
<td>HB-DF-102</td>
<td>14.3</td>
<td>302.0</td>
</tr>
</tbody>
</table>

The rock was described in the field as hard, fresh to slightly weathered, aphanitic, dark grey slate with few calcareous veins. The Rock Quality Designation (RQD) of all of the bedrock core runs was determined to be 0 percent which correlates to a very poor Rock Mass Quality.

6.0 GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

The proposed replacement structure will consist of a 20-foot span by 5-foot rise by 75-foot long precast concrete 3-sided culvert on a skew of approximately 20 degrees to the roadway centerline. The footings of the proposed culvert will bear on and be keyed into bedrock and the structure partially filled with Special Fill to facilitate fish passage. The roadway embankment slopes at the proposed structure’s inlet and outlet shall be no steeper than 2H:1V and shall be riprapped to protect against erosion.

6.1 Precast Concrete Box Culvert Design and Construction

The proposed replacement structure will be a 20-foot span by 5-foot rise by 75-foot long precast concrete 3-sided box culvert. The proposed culvert shall be designed and constructed in accordance with MaineDOT Standard Specification 534.

The culvert will be constructed on cast-in-place concrete pedestal footings that bear on and are keyed into bedrock or are doweled to a concrete fill poured over the prepared bedrock surface. Prior to construction of the footing, the bedrock surface will be cleaned of all overburden soil, weathered bedrock, and fractured material; the prepared surface shall be free of ponded water. Smooth bedrock should be roughened or serrated prior to placing concrete to enhance sliding stability. The foundation bearing area should be approximately level. The inlet invert of the proposed culvert will be set at approximate elevation 310.15 feet with a 3.43 percent slope.
The soil envelope / backfill of the pedestal footings shall consist of Standard Specification 703.19 - Granular Borrow for Underwater Backfill with a maximum particle size of 4 inches. The backfill material shall be placed in lifts of 6 to 8 inches loose measure and compacted to the manufacturer’s specifications or, in the absence of manufacturer’s specifications, backfill soil shall be compacted to at least 92 percent of the AASHTO T-180 maximum dry density.

6.2 Bedrock Removal and Bedrock Subgrade Preparation

The structural design intends for the pedestal footings to bear on and be keyed into the prepared bedrock surface or dowelled into Concrete Fill (502.565) placed over the prepared bedrock surface. The bedrock shall be prepared in accordance with MaineDOT standard practices. Construction activities should not be permitted to create any open fissures. Any irregularities in the existing bedrock surface or irregularities created during the excavation process shall be addressed using Concrete Fill (502.565) prior to footing construction.

The nature, slope, and degree of fracturing in the bedrock bearing surfaces will not be evident until the excavation for the footings for the culvert is made. The bedrock surface slope shall be less than 4H:1V or it shall be benched in level steps.

The Contractor shall remove any overburden soil and weathered bedrock that can be removed using ordinary excavation equipment to expose competent bedrock at the required elevation. In accordance with MaineDOT standard practices, the bedrock shall be clean and free of debris, soil, and loose rock. The cleanliness and condition of the bedrock surface should be confirmed and accepted by the Resident prior to placing Concrete Fill (502.565) or the cast-in-place concrete footings. If soil is encountered at bedding material subgrade it shall be overexcavated to expose the underlying bedrock surface. The cleanliness and condition of the bedrock bearing surface shall be confirmed and accepted by the Resident prior to placing concrete fill or structural concrete.

Blasting shall be conducted in accordance with Section 105.2.6 and Section 203.042 of the MaineDOT Standard Specifications. It is also recommended that the Contractor conduct pre- and post-blast surveys, as well as blast vibration monitoring at nearby structures in accordance with the MaineDOT Standard Specifications and industry standards at the time of the blast. The Contractor’s blasting submittals shall address blasting procedures adjacent to an active roadway, including flyrock controls. It is anticipated that there will be seepage of water from fractures and joints exposed in the bedrock surface. Water should be controlled by pumping from sumps. The Contractor should maintain the excavation so that all work is completed in the dry.

6.3 Settlement

No settlement issues are anticipated at the site. The pedestal footings for the proposed culvert will bear on bedrock.
6.4 Bearing Resistance

The pedestal footings shall bear on and be keyed into the prepared bedrock surface or dowelled to Concrete Fill (502.565) poured on the prepared concrete surface. A factored bearing resistance of 20 kips per square foot (ksf) shall be used when analyzing the service limit state as allowed in AASHTO LRFD Bridge Design Specifications 7th Edition 2014 (LRFD) Article C10.6.2.6.1. The factored bearing pressure at the strength limit state for the pedestal footings for the precast concrete culvert bearing on slate bedrock shall not exceed the calculated factored bearing resistance of 12 ksf. Calculations are attached to this report.

6.5 Scour and Riprap

Both the inlet and outlet of the precast concrete box culvert shall be protected against scour with riprap conforming to MaineDOT Standard Specification Section 703.26 Plain and Hand Laid Riprap. Slopes shall be no steeper than 2H:1V. No specific scour protection recommendations are needed other than armorng with riprap. The riprap on the slopes shall be underlain by a non-woven, Class 1 Erosion Control Geotextile meeting the requirements of MaineDOT Standard Specification 722.03 that is underlain by a 1-foot thick layer of bedding material consisting of Granular Borrow Material for Underwater Backfill (703.19). The toe of the riprap sections shall be keyed into the existing soils 1 foot below the streambed elevation.

6.6 Seismic Design Considerations

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

6.7 Construction Considerations

Construction activities will include construction of cofferdams and earth support systems to control stream flow during construction. Construction activities will also include common earth excavation. Construction of the proposed precast concrete 3-sided box culvert will require deep soil excavation. Earth support systems shall be implemented if laying back slopes is not feasible. It is possible that the use of complex (four-sided) braced excavations with dewatering will be necessary due to maintenance of traffic and the depth of the excavation. If this is the case, adequate embedment will be necessary to allow for the excavation and maintenance of a stable excavation bottom. All earth support systems shall be designed by a Professional Engineer licensed in the State of Maine. Regardless of the method of excavation, all excavations and earth support systems shall meet all applicable OSHA regulations.

The Contractor shall control groundwater and surface water infiltration using temporary ditches, sumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water as needed to maintain a stable excavation and allow work in the dry.
Using the excavated soils as backfill around the culvert or as roadway base material shall not be permitted. The excavated soils may only be used as common borrow in accordance with MaineDOT Standard Specifications 203 and 703.

The Contractor will have to excavate the existing subbase and subgrade fill soils in the vicinity of the culvert. These materials should not be used to re-base the roadway. Excavated subbase sand and gravel may be used as fill below roadway subgrade level in fill areas provided all other requirements of MaineDOT Standard Specifications 203 and 703 are met.

7.0 CLOSURE

This report has been prepared for the use of the MaineDOT Highway Program and their project design consultant for specific application to the proposed replacement of a large culvert under State Route 15 in Dover-Foxcroft, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

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

It is recommended that a geotechnical engineer be provided the opportunity for a review of the design and specifications in order that the earthwork and foundation recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications.
Sheets
The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch. Road names used on this map may not match official road names.

Location Map
Large Culvert Replacement on Route 15
(East Main Street), Dover-Foxcroft, Maine
Piscataquis County
WIN 22648.00
USGS 7.5' Series Topographic
Dover-Foxcroft Quadrangle
DeLORME Map 32 Grid B2
Appendix A

Boring Logs
**Maine Department of Transportation**

**Soil/Rock Exploration Log**

**US CUSTOMARY UNITS**

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**Project:** Large Culvert Replacement on Route 15 (East Main Street)  
**Location:** Dover-Foxcroft, Maine  
**Boring No.:** HB-DF-101  
**WIN:** 22648.00

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**Driller:** NEBC  
**Operator:** Enos/Share  
**Logged By:** Be Schonewald  
**Datum:** NAVD88  
**Date Start/Finish:** 11/12/2015; 08:20-10:50  
**Drilling Method:** Cased Wash Boring  
**Boring Location:** 9+85.4, 5.40 Li.

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**Auger ID/OD:** 5" Solid Stem  
**Rig Type:** Mobile Drill (Trailer)  
**Rig Type:** Standard Split Spoon  
**Auger ID/OD:** NW

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**Hammer Efficiency Factor:** 0.6  
**Hammer Type:** Automatic

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**Definitions:**
- **R** = Rock Core Sample  
- **S** = Solid Stem Auger  
- **HSA** = Hollow Stem Auger  
- **RC** = Roller Cone  
- **W** = Weight of 1400 lb Hammer  
- **WDH** = Weight of 1400 lb Hammer  
- **WDP** = Weight of Rods or Casing  
- **WD1P** = Weight of One Person  
- **N** = Rock Core Sample  
- **N** = Hammer Efficiency Factor

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**Sample Information**

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Sample No.</th>
<th>Pen./Rec. (in.)</th>
<th>Sample Depth (ft.)</th>
<th>Blows (/6 in.)</th>
<th>Shear Strength (psf)</th>
<th>RQD (%)</th>
<th>N-uncorrected</th>
<th>Casing Blows (ft.)</th>
<th>Elevation (ft.)</th>
<th>Graphic Log</th>
<th>Visual Description and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SSA</td>
<td>11&quot; HMA.</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Brown, damp, medium dense, fine to coarse SAND, some silt, little gravel. (Fill).</td>
</tr>
</tbody>
</table>
| 10         | MD         | 000           | 10.00 - 10.00     | 50(0")        | QRD = 0%             | 0      |              | R1                 | 306.60         | 306.60 | Failed sample attempt, no penetration.  
|            | R1         | 34.8/34.8     | 12.40 - 15.30     | QRD = 0%       |                      |        |              | R2                 | 301.60         | 301.60 | Top of Bedrock at Elev. 306.6 ft.  
|            | R2         | 34.8/34.8     | 12.40 - 15.30     | QRD = 0%       |                      |        |              |                    |                |           | R1/Bedrock: Hard, fresh to slightly weathered, aphanitic, dark grey SLATE with occasional calcareous veins. Very close, vertical breaks along bedding, undulating, rough, fresh to decomposed, typically open with mud infilling.  
|            |            |                |                   |                |                      |        |              | R2/Bedrock: Same as R1. |
|            |            |                |                   |                |                      |        |              | Rock Mass Quality = Very Poor  
|            |            |                |                   |                |                      |        |              | R1/Coreres Time (min:sec): 10.3-11.0 ft (3.40)  
|            |            |                |                   |                |                      |        |              | 11.0-12.4 ft (4.15)  
|            |            |                |                   |                |                      |        |              | 12.0-12.4 ft (4.15)  
|            |            |                |                   |                |                      |        |              | 13.0-14.0 ft (4.45)  
|            |            |                |                   |                |                      |        |              | 14.0-15.3 ft (5.55)  
|            |            |                |                   |                |                      |        |              | Bottom of Exploration at 15.30 feet below ground surface.  
|            |            |                |                   |                |                      |        |              | REFUSAL |

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**Remarks:**

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.  
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.
**Maine Department of Transportation**  
**Soil/Rock Exploration Log**  
**US CUSTOMARY UNITS**

**Project:** Large Culvert Replacement on Route 15  
**Location:** Dover-Foxcroft, Maine  
**Boring No.:** HB-DF-102  
**WIN:** 22648.00

**Driller:** NEBC  
**Elevation (ft.):** 316.3  
**Auger ID/OD:** 5” Solid Stem

**Operator:** Enos/Share  
**Datum:** NAVD88  
**Sampler:** Standard Split Spoon

**Logged By:** Be Schonewald  
**Rig Type:** Mobile Drill (Trailer)  
**Hammer WL/Fall:** 140/30

**Date Start/Finish:** 11/12/2015; 10:55-14:25  
**Drilling Method:** Cased Wash Boring  
**Core Barrel:** NQ-2

**Boring Location:** 10+21.2, 17.6 ft Rt.  
**Casing ID/OD:** NW  
**Water Level:** None Observed

**Hammer Efficiency Factor:** 0.6

**Definitions:**
- R = Rock Core Sample
- SSA = Solid Stem Auger
- HSA = Hollow Stem Auger
- RC = Roller Cone
- NW = Unconfined Compressive Strength (kcf)
- RC = Roller Cone
- SW = Weight of 140lb. Hammer
- WDH = Weight of 140lb. Hammer

**Visual Description and Remarks**

- **Top of Bedrock at Elev. 302.0 ft.**
  - Water return and roller cone Refusal.
  - Top of Bedrock: Rock Quality = Very Poor
  - R1: Core Times (min:sec) 14.4-15.4 ft (9:05)  
  - R2: Core Times (min:sec) 14.4-15.4 ft (9:05)

- **Bottom of Exploration at 17.80 feet below ground surface.**
  - REFUSAL

**Remarks:**

- 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.

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**Soil/Rock Exploration Log**

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Sample No.</th>
<th>Pen./Rec. (in.)</th>
<th>Sample Depth</th>
<th>Blows (/6 in.)</th>
<th>Shear Strength (psf)</th>
<th>N-uncorrected</th>
<th>N60</th>
<th>Casing Blows</th>
<th>Elevation (ft.)</th>
<th>Graphic Log</th>
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<td>1D</td>
<td>24/5</td>
<td>1.00 - 3.00</td>
<td>6/7/7/10</td>
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</tr>
<tr>
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<td>2D</td>
<td>24/5</td>
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<tr>
<td>15</td>
<td>R1</td>
<td>16.8/16.8</td>
<td>14.40 - 15.80</td>
<td>RQD = 0%</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>R2</td>
<td>24/24</td>
<td>15.80 - 17.80</td>
<td>RQD = 0%</td>
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</tr>
<tr>
<td>25</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Laboratory Testing Results/ AASHTO and Unified Class.**

- G6301160 A-1-b, SM WC=5.0%  
- G6301161 A-2-4, GC-GM WC=16.7%

---

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

---
Appendix B

Laboratory Test Results
### Laboratory Testing Summary Sheet

**Town(s):** Dover-Foxcroft  
**Work Number:** 22648.00

<table>
<thead>
<tr>
<th>Boring &amp; Sample Identification Number</th>
<th>Station (Feet)</th>
<th>Offset (Feet)</th>
<th>Depth (Feet)</th>
<th>Reference Number</th>
<th>G.S.D.C. Sheet</th>
<th>W.C. %</th>
<th>L.L.</th>
<th>P.I.</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB-DF-101, 1D</td>
<td>9+85.4</td>
<td>5.4 Lt.</td>
<td>2.0-4.0</td>
<td>301158</td>
<td>1</td>
<td>10.3</td>
<td></td>
<td></td>
<td>SM A-2-4 II</td>
</tr>
<tr>
<td>HB-DF-101, 2D</td>
<td>9+85.4</td>
<td>5.4 Lt.</td>
<td>5.0-7.0</td>
<td>301159</td>
<td>1</td>
<td>12.9</td>
<td></td>
<td></td>
<td>SC-SM A-2-4 III</td>
</tr>
<tr>
<td>HB-DF-102, 1D</td>
<td>10+21.2</td>
<td>17.6 Rt.</td>
<td>1.0-3.0</td>
<td>301160</td>
<td>1</td>
<td>5.0</td>
<td></td>
<td></td>
<td>SM A-1-b II</td>
</tr>
<tr>
<td>HB-DF-102, 2D</td>
<td>10+21.2</td>
<td>17.6 Rt.</td>
<td>10.0-12.0</td>
<td>301161</td>
<td>1</td>
<td>16.7</td>
<td></td>
<td></td>
<td>GC-GM A-2-4 II</td>
</tr>
</tbody>
</table>

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
Appendix C

Calculations
Bearing Resistance - 3-Sided Box Culvert on Bedrock:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance

Presumptive Bearing Resistance for Service Limit State ONLY

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: weathered or broken bedrock (slate)

Based on RQD of 0 percent

Consistency In Place: medium hard rock

Bearing Resistance: Ordinary Range (ksf) 16 to 24

AASHTO Recommended Value of Use: 

\[ q_{nom} = 20 \text{ ksf} \]

Resistance factor at the service limit state \[ \Phi = 1.0 \text{ (LRFD Article 10.5.5.1) } \]

\[ q_{factored} = q_{nom} \Phi \]

\[ q_{factored} = 20 \text{ ksf} \]

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

Part 2 - Strength Limit State

Determine Bearing Resistance using RMR Method

Section 10.4.6.4 Rock Mass Strength

Parent rock at the site is metasedimentary found to be "very poor" in quality. RQD of 0%.

Determine RMR from Table 10.4.6.4-1 Geomechanics Classification of Rock Mass

From AASHTO - RMR is determined as the sum of the five relative ratings listed in Table 10.4.6.4-1

1. Strength of intact rock

Table 4.4.8.1.2B uniaxial compressive strength for slate = 3,000 to 4,400 ksf = 21,000 to 30,000 psi
Use: \[ q_u = 3000 \text{ ksf} \]
\[ q_u = 20833 \text{ psi} \]

From Table 10.4.6.4.-1:
For Uniaxial Compressive Strength = 2160 - 4320 ksf: Relative Rating = 12

2. Drill Core Quality

Bedrock RQD = Average 0% (very poor)

From Table 10.4.6.4.-1: RQD <25% Relative Rating = 3

3. Spacing of joints

Spacing of less than 2 inches Closely spaced vertical joints

From Table 10.4.6.4.-1: Relative Rating = 5
4. Condition of joints
Assume slightly rough surfaces <0.05 in, soft joint wall rock
From Table 10.4.6.4.-1: Relative Rating = 12

5. Groundwater conditions
General Conditions = Water under moderate pressure
From Table 10.4.6.4.-1: Relative Rating = 4

Raw RMR = 36
Adjustment to RMR for joint Orientations from Table 10.4.6.4-2
Assume Strike and Dip Orientations of Joints = Poor
High angle joints, unfavorable for with respect to foundations
For Foundations: Rating = -15

Adjusted RMR = 21

Determine Rock Mass Class from Adjusted RMR Rating
For Adjusted RMR = 21 From LRFD Table 10.4.6.4.-3: Class No. = IV - Poor Rock

Determine Rock Type from LRFD Table 10.4.6.4.-4
Rock Type B - lithified argillaceous rock

Determine Rock Property constants \( m \) and \( s \):
\[
m/m_i = \exp\left(\frac{(RMR-100)}{14}\right) \quad \text{Eq 18 - for disturbed rock masses}
\]
where \( m_i = m \) for intact rock \( m_i = 10 \) From LRFD Table 10.4.6.4-4
\[
m_{B_{poor}} = m_i \exp\left(\frac{RMR - 100}{14}\right) \quad m_{B_{poor}} = 0.035
\]
\[
s = \exp\left(\frac{(RMR-100)}{6}\right) \quad \text{Eq 19 - for disturbed rock masses}
\]
\[
s_{B_{poor}} = \exp\left(\frac{RMR - 100}{6}\right) \quad s_{B_{poor}} = 1.91 \times 10^{-6}
\]

Determine nominal and factored bearing resistance of Bedrock:
Foundation Shape correction factor:
\[ C_f^\ell := 1.0 \quad \text{From Foundations on Rock, Wyllie, Table 5.4 pg 138} \]
Uniaxial Compressive Strength for slate = 3,000 to 4,400 ksf = 21,000 to 30,000 psi
\[
q_{uc} := \begin{bmatrix} 21000 \\ 24000 \\ 27000 \\ 30000 \end{bmatrix} \text{ psi} \quad \text{Upper and lower bounds from from Standard Specifications for Highway Bridges 17th Edition - 2002 Table 4.4.8.1.2B} \]
Determine Nominal Bearing Resistance:
From Foundations on Rock, Wyllie, Table 5.4 pg 138

\[ q_{\text{nom}} = C_{f1} \cdot \sqrt{s_{B\text{poor}}} \cdot q_{uc} \left[ 1 + \sqrt{m_{B\text{poor}} \left( \frac{s_{B\text{poor}}}{s_{B\text{poor}}} - \frac{1}{2} \right) + 1} \right] \]

\[ q_{\text{nom}} = \begin{cases} 26 \\ 29 \\ 33 \\ 37 \end{cases} \text{ ksf} \]

Determine Factored Bearing Resistance at the Strength Limit State:
From Table 10.5.5.2.2-1 Resistance factor for footing on rock \( \phi_b = 0.45 \)

The factored resistance \( q_R = \phi_b \times q_n \) equation 10.6.3.1.1-1 AASHTO LRFD

\[ q_R = \begin{cases} 12 \\ 13 \\ 15 \\ 17 \end{cases} \text{ ksf} \]

Recommend 12 ksf for Strength Limit State