Maine Department of Transportation
Highway/Bridge Program
Geotechnical Section
Augusta, Maine

Geotechnical Design Report

for the replacement of

State Route 128 Strut
Woolwich, Maine

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Sagadahoc County

Soils Report No. 2013-15

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Geotechnical Design Summary

MaineDOT proposes to replace a 3-sided 7-foot wide concrete box culvert which carries Brocas Brook under Route 128 in Woolwich, located approximately 0.8 miles north of Brushwood Road. The existing structure is badly deteriorated, and Route 128 does not meet current minimum design standards for a Rural Highway at this location. Horizontal and vertical alignment of Route 128 at this culvert will be corrected as part of this project, and the roadway will be widened to allow a snowplow to pass without crossing the centerline.

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of this structure. The replacement structure will be a 3-sided precast concrete box culvert with a width of 44 feet and a span of 8 feet. Wingwall lengths will be 15 feet on the outlet side with a 10 foot wingwall on the northern inlet and a 45 foot wall on the southern inlet to match the existing stream channel. The proposed structure will be founded directly on bedrock, with a maximum wing height of less than 8 feet. Precast concrete headwalls will retain fill and gravel of the pavement section over the culvert.

Wingwalls will meet the requirements of MaineDOT Special Provision 635, Prefabricated Concrete Modular Gravity Wall. Cast-in-place concrete footings will support the culvert sides and cast-in-place concrete leveling pads will support the wingwalls to provide a level, stable surface for construction of the culvert and walls. Footings and leveling pads will be built of Class LP concrete, cast directly on bedrock.

A one-foot thick layer of crushed stone shall be placed behind the wingwalls to ensure drainage, and one-foot square bond-outs shall be cast into each wingwall as a French Drain outlet. Backfill for the abutments and walls shall consist of material meeting MaineDOT Standard Specification 703.20, Gravel Borrow to ensure that the material drains freely. A geotextile meeting the requirements of Standard Specification 722.03, Erosion Control Geotextile shall be placed between the crushed stone drainage layer and the gravel borrow.

Scour and Riprap – Scour is not anticipated to be a problem in the channel or inlet of this structure as the streambed and surrounding ground is bedrock, although ice action during the winter must be considered. Riprap slopes 4-feet thick with a slope of 1.5H:1v will cover the outlet wingwalls. The toe of these riprap sections should extend to bedrock.

Seismic Design Considerations – Seismic analysis is not required for single span bridge structures and culverts.

Construction Considerations - Although the bedrock surface appears to be fairly smooth and level, bedrock excavation may be required depending on conditions not discovered during the subsurface investigation, to create a level, uniform surface for construction of footings and leveling pads.

If groundwater seepage through bedrock joints is discovered during construction, it may become necessary to control groundwater during construction. Water levels in Brocas Brook are likely to vary depending on the weather. The contractor should maintain the excavation so that all foundations are constructed in the dry.

1.0 Introduction

The purpose of this Geotechnical Design Report is to present geotechnical recommendations for the proposed replacement of an existing box culvert (strut) which carries Brocas Brook under Route 128 in Woolwich, approximately 0.8 miles north of Brushwood Road. Tides in the Kennebec River rise into this culvert, and flow in the brook varies seasonally and depending on rainfall. Route 128 is a Priority 5 Highway Corridor. The project includes 500 feet of approach roadway construction. A subsurface investigation has been completed for this project. This report presents the information obtained at the site and geotechnical design recommendations.

The existing culvert is a 3-sided concrete box with a span of 7 feet, approximately 23 feet long. There is no shoulder and guardrail posts have been undercut by erosion. The horizontal and vertical alignments will be improved and the roadway will be widened by the construction of shoulders to allow snowplows and other large vehicles to pass without crossing the highway centerline. Existing wingwalls are built of dry-laid stone, and on three corners of the structure it is evident the walls are constructed directly on bedrock. Large boulders and riprap obscure much of the bedrock on the remaining corner, but large outcrops are visible near the roadway.

The proposed replacement structure will be a 3-sided concrete box with an 8-foot span, 44 feet long. The proposed highway approaches will have 11-foot lanes and 5-foot shoulders. Cast-in-place concrete headwalls will retain fill and the pavement section above the roadway, and Precast Modular Gravity Walls (PCMG) will be used as wingwalls for the new culvert.

2.0 Geologic Setting

The existing strut carries Brocas Brook under Route 128. Brocas Brook drains a 3.17 square miles in Woolwich, however aerial photography indicates that large areas of storage may be available in ponds upstream, and freshwater wetlands are shown upstream from this culvert on the Surficial Geology Map, Bath Quadrangle, by Maine Geologic Survey (MGS). The culvert outlets into a bay of the Kennebec River, as shown on Sheet 1 – Location Map found at the end of this report.

The MGS Surficial Geology map shows glaciomarine soils of the Presumpscot Formation in the vicinity of this site. These soils are made up of mostly silt and clay with poor drainage and low permeability. They are typically composed of sediments that washed out of the Late Wisconsian glacier and accumulated on the ocean floor.

The report “Bedrock Geology of the Bath 1:100,000 Map Sheet, Coastal Maine” by MGS describes bedrock at this site to be the Cape Elizabeth Formation.

3.0 Subsurface Investigation

The subsurface investigation for this project was limited to probes and hand soundings to determine the depth to bedrock. Six probes were drilled through the roadway using a solid-stem auger in August, 2012. Five rod soundings were done in March, 2013 to determine the depth to bedrock under the southwest wingwall. Access was not available for soundings in the location of the proposed northwest wingwall because the ground in that quadrant is covered by loose boulders. The locations of these investigations were measured in the field from other topographic features, and are shown on the Geoplan, Sheet 2 of this report. Probe and rod sounding summary sheets are included in the Appendix. No bedrock cores were taken, but the rock was identified at the site by Alex Mann, C.G. on April 10, 2013.

4.0 Subsurface conditions

Probes and soundings indicate that the bedrock surface in the area of the proposed box culvert and wingwalls is fairly uniform. No large differences in bedrock elevation were found. On the eastern side of the existing structure an extensive area of exposed bedrock is visible, and the existing stone walls were built on this exposed rock. The following Table shows bedrock refusal elevations under the roadway and on the western side of the existing roadway.

Table 1 – Bedrock Elevation

Station	*Offset*	*depth to refusal (feet)*	*Bedrock elevation (feet)*
15+04	20 LT	3.3	1.0
15+09	27 LT	1.3	0.2
15+14	23 LT	1.0	0.4
15+14	30 LT	1.6	-1.2
15+14.7	7 RT	11.5	0.8
15+18	5 RT	11.0	1.3
15+19	20 LT	1.1	-0.1
15+20.8	5 LT	10.9	1.4
15+38.8	5.1 LT	11.2	1.1
15+39	4.9 RT	9.4	2.9
15+43.8	7.1 LT	11.0	1.3

The bedrock at this site is a Gray, Slightly Banded generally massive Biotite, Muscovite, Amphibole, Feldspar, Quartz Schist. Though the structure was not studied in detail, several relevant observations were made. The bedrock forms the floor of the culvert

with the general strike of the foliations appearing to be parallel to the structure at that location. In general the outcrops appeared to be massive with a joint spacing of greater than 3 feet in general. The small samples that were taken show very little weathering and were very durable, being difficult to break off in more than small fragments.

The overall description of this rock is very close to the Casco Bay Quadrangle description of the Cape Elizabeth Formation – Medium Gray thin, poorly bedded to moderately well bedded quartz-plagioclase-biotite-muscovite+/-garnet phyllite, with lesser interbedded muscovite-biotite-garnet schist.

5.0 Structure Alternatives

The project team considered several alterative designs: rehabilitate the existing structure with the use of prefabricated slabs cantilevered out from the existing box culvert and walls, excavate bedrock to build a 4-sided precast box culvert, and a 3-sided precast box culvert founded on bedrock. The 3-sided precast concrete box culvert was chosen.

6.0 Geotechnical Recommendations

The following sections discuss geotechnical design recommendations for the proposed 3-sided precast concrete box culvert and Prefabricated Modular Concrete Gravity wingwalls. Leveling pads and footings for the culvert and wingwalls will be founded directly on bedrock. The culvert will have a length of 44 feet, height of 8-feet and a span of 8-feet. Outlet wingwalls will be roughly parallel to the roadway with lengths of 15 feet and heights of less than 8 feet. Inlet wingwalls will be oriented to the bend in the stream as it flows across the existing bedrock channel. The northern inlet wing will be 10 feet long and roughly perpendicular to the roadway. The southern inlet wing will be 45 feet long and at a slight skew to the roadway. These walls are shown on Sheet 2, the Geoplan.

Brocas Brook drains to Burnt Island Channel of the Kennebec River in Woolwich, and high tides will rise into this structure. Backfill soils used in this construction shall meet the requirements of Standard Specification 703.20, Gravel Borrow. A 1-foot thick layer of crushed stone will be built behind the wall to promote drainage of this structure. Separation geotextile.

Table 2 presents the resistance factors to be used in design of the culvert and wingwalls and Table 3 shows soils values to be used in design of the walls and culvert.

Table 2 – Resistance Factors

Failure Mechanism	*Symbol*	*Resistance Factor*
Direct Sliding – Soil on Rock	Φ_r	0.9
Bearing Capacity	Φ_{bc}	0.45
Global Stability	Φ_r	0.65

Sliding computations shall assume a maximum allowable frictional coefficient of 0.70 (tan 35°) at the base to bedrock foundation interface.

For the lowest PCMG unit on soil the location of the resultant of the reaction forces at the strength limit state should be within the middle one-half (1/2) of the footing width.

Table 3 – Design Values

Value	*Symbol*	*Value*
Retained soil unit weight	γ_b	125 pcf
Retained soil unit weight below Q 1.1	γ'_b	63 pcf
Retained soil effective friction angle	ϕ'_b	28^o
Live Load Surcharge		250 psf
Allowable Bearing Resistance		70 ksf

6.1 Concrete Box Culvert

Precast concrete box culverts are designed and detailed to allow the contractor a range of options among available structures. The manufacturer is responsible to design the structure according to Special Provision 534, Precast Structural Concrete Arches, Box Culverts. The designer may assume Soil Type 4 as shown in the Bridge Design Guide (BDG), Section 3.6, Table 3.3. Soil properties are as follows: $\phi = 32^o$, $\gamma = 120$ pcf. The gravel borrow and other backfill materials should be placed in 6 to 8-inch thickness lifts and compacted to the structure manufacturer's specifications, or not less than 92% of AASHTO T-180 maximum dry density.

6.2 Prefabricated Concrete Headwalls

Precast concrete headwalls with nominal dimensions of 2-feet wide and variable height will be constructed over the culvert to retain fill soils and gravel of the roadway section. A culvert headwall is essentially a retaining wall, and should be designed for all relevant strength and service loads and load combinations.

6.3 PCMG Walls

Leveling pads for wingwalls will be placed directly on bedrock. A 1-foot thick vertical layer of crushed stone placed behind the wall will allow drainage of surface water and tide water that infiltrates behind the walls, to outlet through bond outs in the wall faces. A 4-foot thick layer of heavy riprap will protect the front of the walls from scour and ice action. Backfill used will be gravel borrow. A geotextile meeting the requirements of Standard Specification 722.03, Erosion Control Geotextile shall be placed between the crushed stone drainage layer and the gravel borrow and also below the surface riprap. The walls will meet the requirements of Special Provision 635, Prefabricated Concrete Modular Gravity Wall.

6.4 Scour and Riprap

For scour and ice protection, the approach slopes and wingwalls should be armored with 4-feet of heavy riprap.

6.5 Frost Protection

The box culvert and wingwalls will be founded directly on bedrock. For foundations on bedrock, heave due to frost is not a design issue and no requirements for minimum depth of embedment are needed.

6.6 Seismic Design Considerations

Seismic analysis is not required for a structure of this size.

7.0 Construction Considerations

Although the bedrock surface appears to be fairly smooth and level, some bedrock excavation may be required depending on conditions not discovered during the subsurface investigation. The nature, slope and degree of fracturing in the bedrock surfaces under the roadway will not be evident until foundation excavations are complete, although bedrock is visible on the sides of the existing roadway. The bedrock surface shall be cleared of all loose fractured bedrock, loose decomposed bedrock and soil. The cleanliness and condition of the bedrock surface shall be confirmed by the Resident prior to placing concrete for the footings and leveling pads.

There may be seepage of water from fractures and joints in the bedrock surface. If groundwater seepage is discovered during construction, it may become necessary to control groundwater during construction. The contractor should maintain the excavation so that all foundations are constructed in the dry.

8.0 Closure

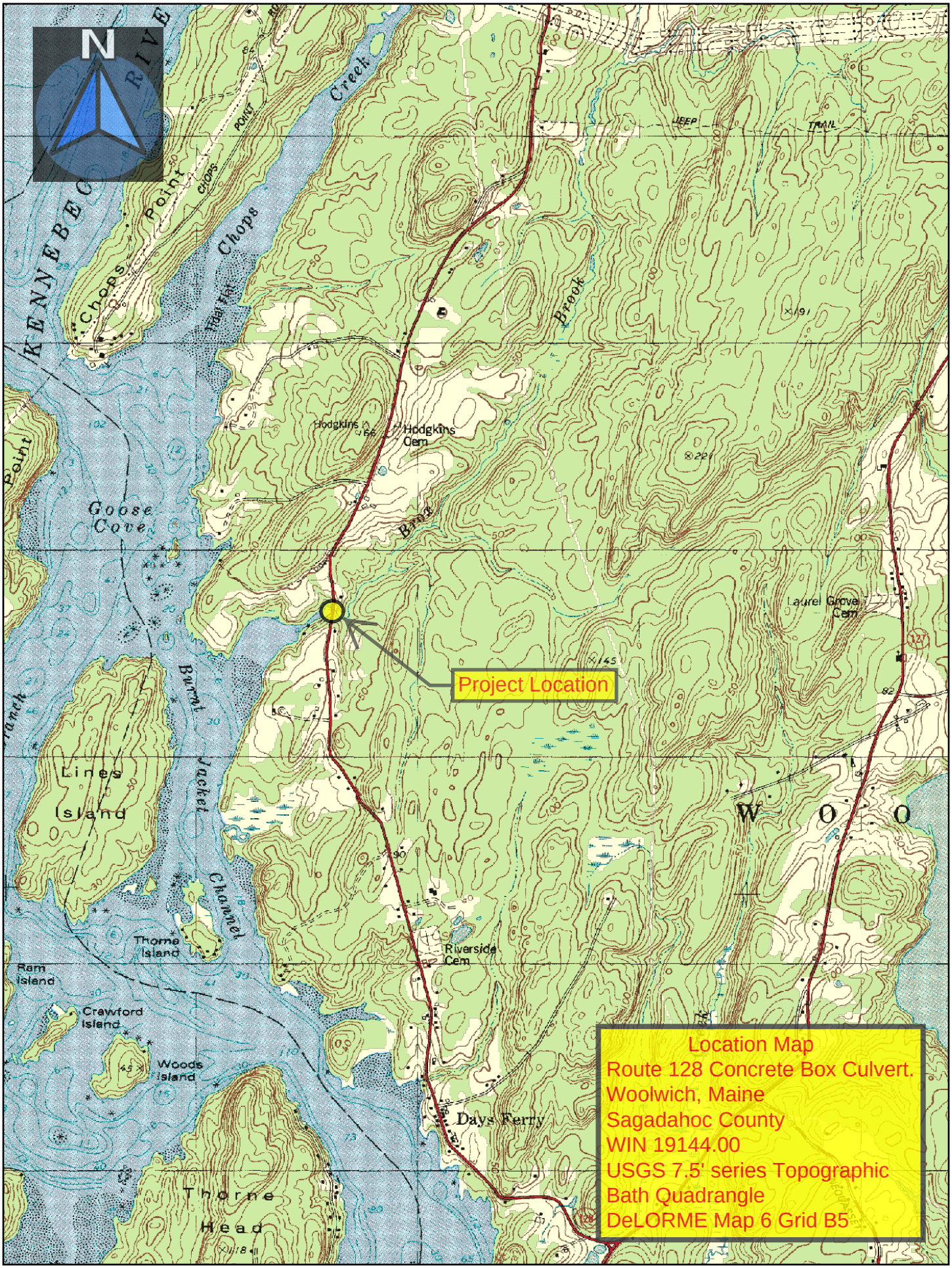
This report has been prepared for the use of the MaineDOT Highway Program for specific application to the proposed replacement of the Box Culvert that carries Brocas Brook under Route 128 in Woolwich, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is 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 subsurface explorations at discrete locations completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

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

Sheets

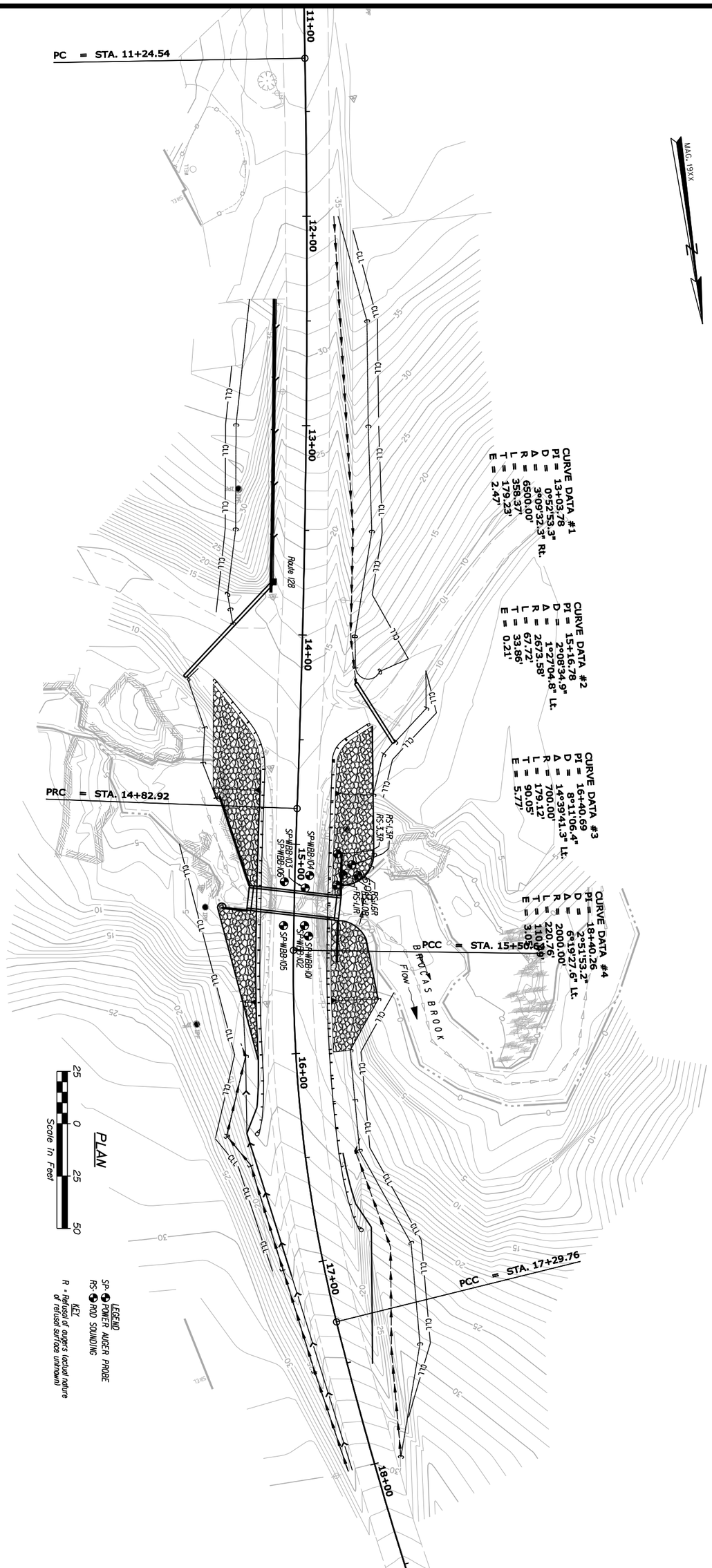
Sheet 1 - Location Plan

Sheet 2 - Geoplan



Map Scale 1:24000

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.



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

SIGNATURE

P.E. NUMBER

DATE

WOOLWICH
ROUTE 128 STRUT

GEOPLANS

SHEET NUMBER 2 OF -

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

019144.00

WIN
WIN 19144.00 HIGHWAY PLANS

Appendix

Boring Summary Sheet
Probe Summary Sheet
Site Photographs

State of Maine - Department of Transportation

Power Auger Probe Summary Sheet

Town(s): Woolwich Work Number: 19144.00

Station (Feet)	Offset (Feet)	Weathered Rock (Feet)	Refusal (Feet)	No Refusal (Feet)	Water Depth (Ft.)	Comments / Date 8/30/2012
15+43.8	7.1 Lt.		11.0			SP-WBB-101
15+38.8	5.1 Lt.		11.2			SP-WBB-102
15+20.8	5.0 Lt.		10.9			SP-WBB-103
15+14.7	7.0 Lt.		11.5			SP-WBB-104
15+39	4.9 Rt.		9.4			SP-WBB-105
15+18	5.0 Rt.		11.0			SP-WBB-106
Probes are not in Station order.						

MaineDOT Drill Crew
Logged By: B. Wilder
Drill Rig: CME 45C

5" Solid Stem Auger

State of Maine - Department of Transportation

Rod Sounding Summary Sheet

Town(s): Woolwich Work Number: 19144.00

Boring	Station (Feet)	Offset (Feet)	Refusal (Feet)	No Refusal (Feet)	Water (X) = Yes	Comments 3/20/2013
15+04	20.0 Lt.		3.3			Refusal Elev. 1.0 ft.
15+09	27.0 Lt.		1.3			Refusal Elev. 0.2 ft.
15+14	30.0 Lt.		1.6			Refusal Elev. -1.2 ft.
15+14	23.0 Lt.		1.0			Refusal Elev. 0.4 ft.
15+19	20.0 Lt.		1.1			Refusal Elev. -0.1 ft.