MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN RECOMMENDATIONS

SECOND STREET BRIDGE SITE
RETAINING WALL
HALLOWELL, MAINE

Prepared by:

Kathleen Maguire, P.E.
Geotechnical Engineer

Reviewed by:

Laura Krusinski, P.E.
Senior Geotechnical Engineer

Kennebec County
PIN 15614.00

Soils Report No. 2009-107
Bridge No. 0565

Fed No. BH-1561(400)X
January 21, 2009

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0016

JOHN ELIAS BALDACCI
GOVERNOR

DAVID A. COLE
COMMISSIONER

January 21, 2009

Keith Wood, PE
SEA Consultants, Inc.
331 State Street
Augusta, ME 04330

Subject: Hallowell Second Street Bridge
Summary of Findings and Geotechnical Recommendations
Retaining Wall Boring
MaineDOT PIN 15614.00

Dear Keith:

At the request of the MaineDOT Project Manager, Wayne Frankhauser, Jr., PE, one boring was drilled on Second Street in Hallowell in the vicinity of the failed granite block retaining wall adjacent to the Second Street Bridge. See Sheet 1 – Location Map for the site location. This letter provides the findings of the boring and makes geotechnical recommendations for the installation of a sheet pile retaining wall along Second Street. A short cast-in-place retaining wall section will be required adjacent to the existing bridge abutment. The purpose of the boring was to identify soil conditions and to determine the depth to bedrock in order to develop geotechnical engineering recommendations.

EXISTING RETAINING WALL AND CONDITION

The existing retaining wall along the east side of Second Street is approximately 150 feet long and up to approximately 30 feet tall. The wall is two tiered directly adjacent to the Second Street Bridge for less than 50 feet. The wall is constructed of granite blocks and is considered historic. A short section of the wall in the vicinity of Station 103+30 has failed. Field observations indicate that maintenance crews have worked on the failed section of the wall placing granite blocks and stone riprap in the area of the failure. No attempt to reconstruct the wall was evident. Photographs of the failed portion of the retaining wall and Second Street in the vicinity of the retaining wall are attached at the end of this letter.

GEOLOGIC SETTING

According to the Surficial Geologic Map of Maine published by the Maine Geological Survey (1985) the surficial soils in the vicinity of the site consist of esker deposits. Soils in the site area are generally comprised of gravel and sand. The deposit may include minor amounts of till. These soils were chiefly deposited by meltwater streams flowing in tunnels within or beneath the late Wisconsinan ice sheet. Additional geologic units mapped nearby the site are glaciomarine deposits (silt, clay, sand and minor amounts of gravel) and till deposits (sand, silt, clay and stones).

According to the Surficial Bedrock Map of Maine, published by the Maine Geological Survey (1985), the bedrock at the site is identified as Devonian biotite granite. This granite pluton is commonly known as the Hallowell pluton.

SUBSURFACE INVESTIGATION

Subsurface conditions behind the retaining wall were explored by drilling one (1) test boring, BB-HRW-101, on Second Street. The exploration location is shown on Sheet 2 - Boring Location Plan found at the end of this letter. The boring was drilled between December 1 and 3, 2008 by Northern Test Boring of Gorham, Maine. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring log provided at the end of this letter.

The boring was drilled using driven cased wash boring and solid stem auger techniques. Soil samples were obtained where possible at 5-foot intervals using Standard Penetration Test (SPT) methods. During SPT sampling, the sampler is driven 24 inches and the hammer blows for each 6 inch interval of penetration are recorded. The standard penetration resistance, N-value, is the sum of the blows for the second and third intervals. The Northern Test Boring drill rig is equipped with an automatic hammer to drive the split spoon. The hammer was calibrated in February of 2008 and was found to deliver approximately 8 percent less energy during driving than the standard rope and cathead system. All N-values discussed in this letter are corrected values computed by applying an average energy transfer factor of 0.55 to the raw field N-values. This hammer efficiency factor (0.55) and both the raw field N-value and the corrected N-value are shown on the boring log.

The bedrock was cored in the boring using an NQ core barrel. The MaineDOT Geotechnical Team member selected the boring location and drilling methods, designated type and depth of sampling techniques, identified field testing requirements and logged the subsurface conditions encountered. The borings were located in the field by use of a tape after completion if the drilling program.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the boring generally consisted of granular fill, sand, and silty sands all underlain by granite. An interpretive subsurface profile depicting the stratigraphy at the boring location is shown on Sheet 3 - Interpretive Subsurface Profile found at the end of this letter. The boring log is also provided at the end of this letter. The following paragraphs are a brief summary description of the strata encountered during drilling activities:

Fill. Beneath the pavement a layer of fill was encountered. The layer was found to be approximately 22.0 feet thick. The fill generally consisted of brown, light brown and olive brown, damp, fine to coarse sand, fine sand and fine silty sand with trace gravel and organics, mottled. The mottling indicates the intermittent presence of water within the soil layer.

Corrected SPT N-values in the fill ranged from 6 to 17 blows per foot (bpf) indicating that the fill is loose to medium dense in consistency.

Sand. A layer of sand was encountered beneath the fill. This layer was found to be brown, wet, fine to medium sand, little silt and little gravel with iron staining. The iron staining indicates the intermittent presence of water within the soil layer. The thickness of the layer was approximately 13.0 feet. Corrected SPT N-values obtained in the layer ranged from 27 to 42 bpf indicating that the soil is medium dense to dense in consistency.

Silty Sand. A layer of silty sand was encountered beneath the sand. This layer was found to be brown, wet, fine to coarse silty sand, little to some gravel, with broken rock fragments and iron staining. The iron staining indicates the intermittent presence of water within the soil layer. The thickness of the silty sand layer was approximately 16.8 feet. Corrected SPT N-values in the layer ranged from 29 to 67 bpf indicating that the soil is medium dense to very dense in consistency.

Bedrock. Bedrock was encountered and cored at a depth of 51.8 feet below ground surface and Elevation 13.2 feet. The bedrock is identified as grey, fine grained, granite. The rock quality designation (RQD) of the bedrock was determined to range from 0 to 79 percent indicating a rock of very poor to good quality.

RETAINING WALL RECOMMENDATIONS

It is understood that a sheet pile wall faced with granite blocks will be installed in front of the existing granite block retaining wall to retain the roadway (Second Street) at the top of the slope. A short section of cast-in-place retaining wall will be necessary at the northern end of the sheet pile wall adjacent to the existing bridge abutment. The proposed sheet pile retaining wall will be approximately 170 feet long. Based on the subsurface conditions encountered during the subsurface exploration program, the following recommendations are made:

The short section of cast-in-place retaining wall should be designed with an appropriate embedment for frost protection. According to the MaineDOT frost depth maps for the State of Maine (MaineDOT Bridge Design Guide [BDG] Figure 5-1) the site has a design-freezing index of approximately 1600 F-degree days. This correlates to a frost depth of approximately 6.0 feet. Therefore, any foundations placed on granular soils should be founded a minimum of 6.0 feet below finished exterior grade for frost protection.

It is anticipated that the cast-in-place portion of the retaining wall will be founded on the native soils at the site. The wall will need to be designed to provide stability against bearing capacity failure. Applicable permanent and transient loads are specified in LFRD Articles 3.4.1 and 11.5.5. The soil distribution may be assumed to be uniformly distributed over the effective base as shown in LRFD Figure 11.6.3.2-1.

Bearing resistance for any structure founded on the native soils shall be investigated at the strength limit state using factored loads and a factored bearing resistance of 9 ksf for footing less than 4 feet wide and 12 ksf for footings 5 feet or greater. The bearing resistance factor, ϕ_b, for spread footings on soil is 0.45 based on bearing resistance evaluation using semi-empirical methods. A factored bearing resistance of 4 ksf may be used when analyzing the service limit state and for preliminary sizing of footings assuming a resistance factor of 1.0. The bearing resistance for spread footings shall be checked for the extreme limit state with a resistance factor of 1.0.

In no instance shall the factored bearing stress exceed the nominal resistance of the footing concrete, which is taken as 0.3*f'c*. No footing shall be less than 2 feet wide regardless of the applied bearing pressure or bearing material. Any organic material encountered shall be removed to the full depth and replaced with compacted Granular Borrow, MaineDOT 703.19.

The fill material between the existing wall and the proposed retaining wall should be Underdrain Backfill Material, Type C - MaineDOT Specification 703.22 and Stone Ditch Protection - MaineDOT Specification 703.29. The Designer may assume Soil Type 4 (MaineDOT BDG Section 3.6.1) for backfill material soil properties. These backfill properties are: ϕ = 32 degrees, γ = 125 pcf.

The following values can be used in design for the existing soils at the site:

Soil Type	Internal Friction Angle ϕ	Cohesion (c)	Unit Weight of Soil Above Water Table
Existing Fill	32 degrees	0 psf	120 pcf
Existing Sand	34 degrees	0 psf	125 pcf
Existing Silty Sand	34 degrees	0 psf	125 pcf

Design friction factors for sheet piles against the existing site soils are as follows:

- Steel sheet pile against clean sand and gravel: tan δ= 0.30; friction angle δ = 17 degrees
- Steel sheet pile against silty sand or sand: tan δ= 0.25; friction angle δ = 14 degrees

The retaining walls shall be designed to withstand lateral earth pressures. Earth loads shall be calculated using an active earth pressure coefficient, K_a, calculated using Rankine Theory. Where passive earth pressure in front of the wall can be considered, a passive earth pressure coefficient, K_p, calculated using Rankine Theory may be used. The following table presents the recommended earth pressure coefficients:

Internal Friction Angle ϕ	K_a Rankine	K_p Rankine
32 degrees	0.307	3.25
34 degrees	0.283	3.54

A live load surcharge shall be applied where vehicular load is expected to act on the surface of the backfill within a distance equal to one-half the wall height behind the backface of the wall as required by section 3.6.8 of the MaineDOT Bridge Design Guide and AASHTO LRFD Bridge Design Specifications Article 3.11.6.4. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height (H_{eq}) taken from the table below:

Retaining Wall Height	H_{eq} Distance from Wall Backface to Edge of Traffic	
	0 feet	1.0 feet or Further
5 feet	5.0 feet	2.0 feet
10 feet	3.5 feet	2.0 feet
≥20 feet	2.0 feet	2.0 feet

The selected sheet pile section should consider a sacrificial steel loss per the MaineDOT BDG. Due to the apparent amount of water moving through in the retained embankment evidenced by the soil mottling observed, water induced corrosion of the steel is likely.

The use of hot-rolled sheets is recommended. Cold rolled sheet piles are not recommended for permanent applications. Cold rolled piles are typically thinner for the same section modulus. Section loss from corrosion could have a greater effect on cold rolled steel. The use of a ball and socket interlock system is recommended over the hook-type interlock system as the ball and socket system is less likely to unhook and separate underground due to driving pressure or obstructions. The use of ASTM A 572 Grade 50 steel is recommended.

The retaining wall design shall include a drainage system to allow movement of any groundwater behind the wall. Drainage behind the wall shall be in accordance with Section 5.4.1.4 Drainage of the MaineDOT BDG. The roadway should utilize curbing to direct any surface water runoff away from the wall.

SPECIFICATION

Attached to this letter is an example specification to assist SEA Consultants, Inc. in the development of the project specific specification for the proposed sheet pile wall. The MaineDOT geotechnical engineers are available to assist and review the specification at SEA Consultant's request.

CLOSURE

This letter presents preliminary recommendations which are provided to SEA Consultants, Inc. solely for the purpose of development of a sheet pile retaining wall and associated costs at the Second Street Bridge project site. These recommendations are based upon data obtained from one test boring conducted at the site. The subsurface conditions presented from that boring are only relevant at the boring location. Soil conditions along the wall vary and are probably erratic. The nature and extent of variations to the subsurface conditions may not be apparent until construction. If variations appear during construction, it may be necessary to re-evaluate these recommendations.

Sincerely,

Kathleen Maguire, PE
Geotechnical Engineer
MaineDOT Bridge Program

Attachments:
Sheet 1 – Location Map
Sheet 2 – Boring Location Plan
Sheet 3 – Interpretive Subsurface Profile
Photographs
Boring log
Specification

Sheets

Data use subject to license.

www.delorme.com

TN
MN (16.4°W)

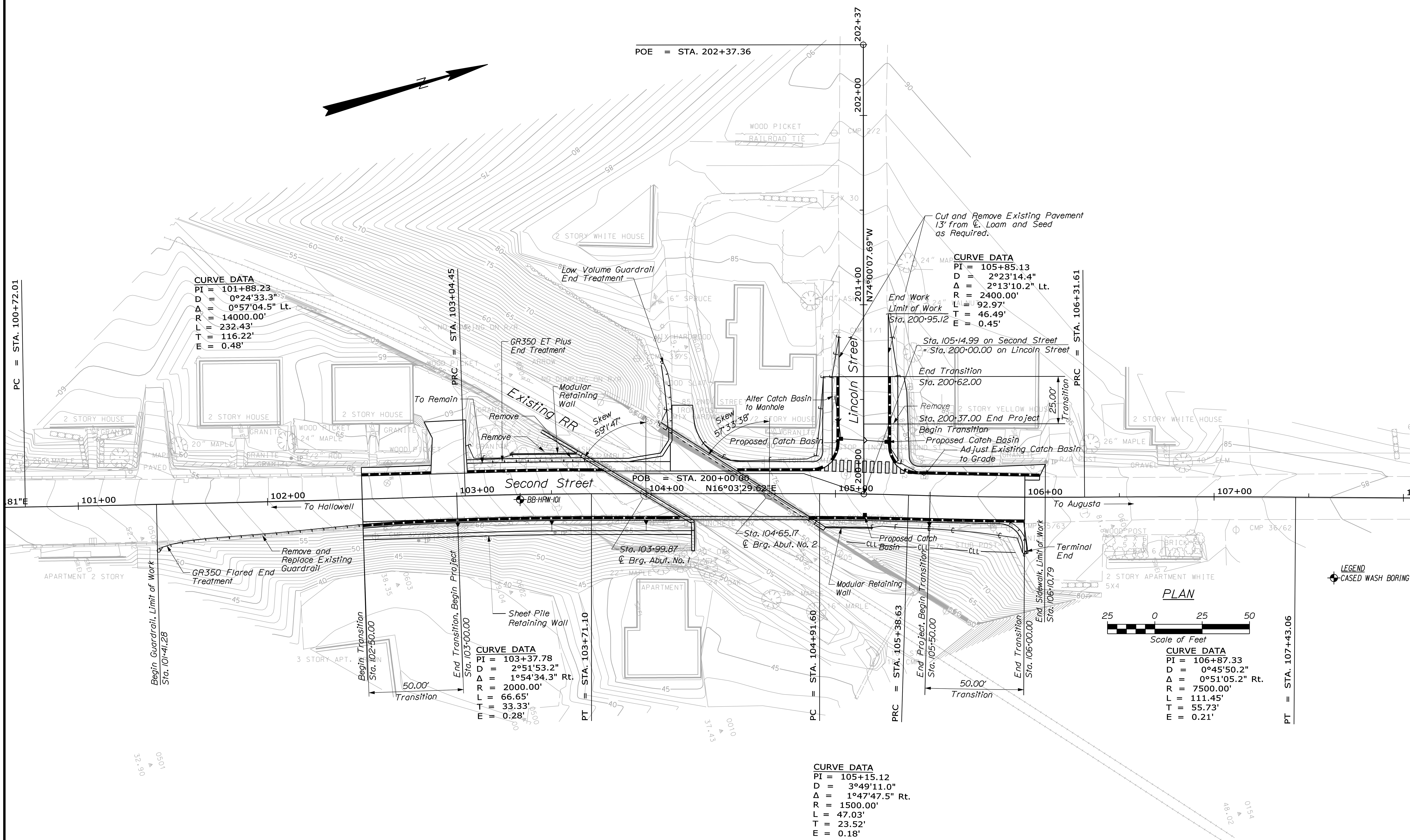
Scale 1 : 12,800

1" = 1,066.7 ft

Data Zoom 14-0

Sheet 1 - Location Map

Filename: ...\00\GEOTECH\MSTA\006_BLP1.dgn   Division: GEOTECH   Username: Kate.maguire   Date:1/21/2009



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BH-1561(400)X

PIN 15614.00

BRIDGE PLANS

BRIDGE NO. 0565

	BY	DATE
PROJ. MANAGER	K. MAGUIRE	
DESIGN-DETAILED	T. WHITE	DEC 2008
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

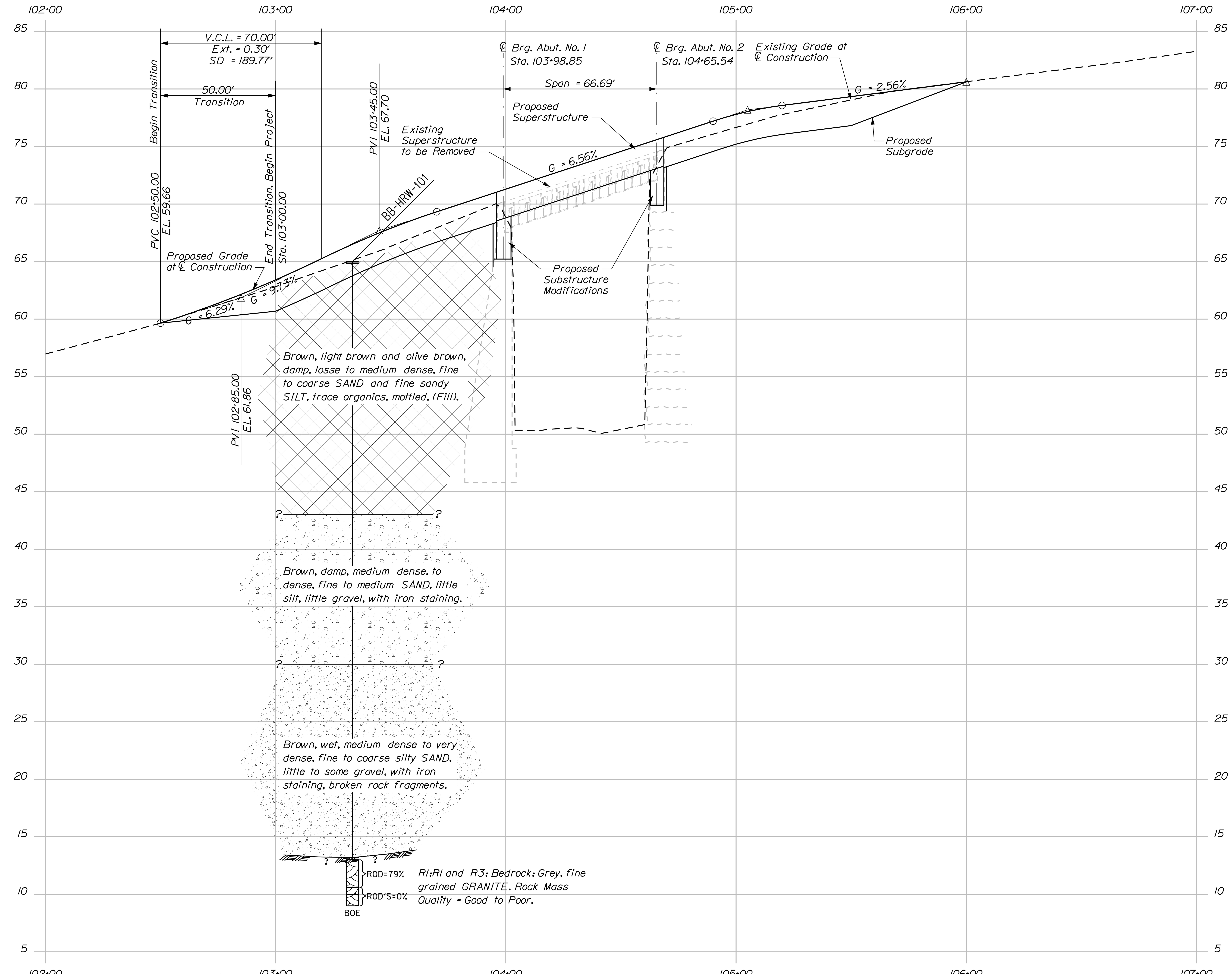
SECOND STREET BRIDGE
MAINE CENTRAL RAILROAD
HALLOWELL KENNEBEC COUNTY

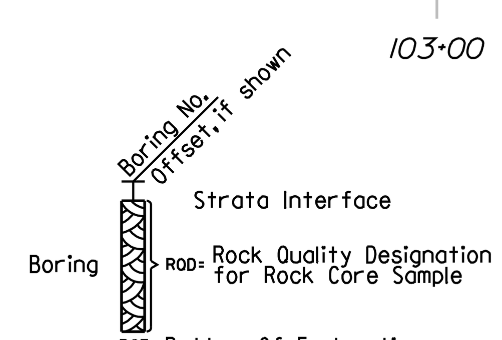
BORING LOCATION PLAN

SHEET NUMBER

2

OF _





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.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BH-1561(400)X

PIN 15614.00

BRIDGE PLANS

BRIDGE NO. 0565

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	K. MAGUIRE	T. WHITE	DEC 2008
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

SECOND STREET BRIDGE
MAINE CENTRAL RAILROAD
HALLOWELL KENNEBEC COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

3

OF _

Photographs

Photo No. 1 - Failure Area

Photo No. 2 – Failure Area from Second Street

Boring Log

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project:	Second Street Bridge #0565 carries Second Street over Maine Central Railroad	**Boring No.:**	BB-HRW-101		
Location:	Hallowell, Maine	**PIN:**	15614.00		
Driller:	Northern Test Boring	**Elevation (ft.)**	65.0	**Auger ID/OD:**	4" Solid Stem
Operator:	Nick/Mike	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	Dietrick D50 #149	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/1/08-12/3/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	103+33.4, 2.7 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.55	**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	64.8		Pavement 0.2	
	1D	24/18	1.0 - 3.0	10/10/8/6	18	17				Brown, damp, medium dense, fine to coarse SAND, little silt, trace gravel, (Fill).	
5	2D	24/20	5.0 - 7.0	3/3/4/5	7	6				Light brown, damp, loose, fine sandy SILT, trace organics, mottled, (Fill).	
10	3D	24/18	10.0 - 12.0	2/2/4/6	6	6	32			Light brown, damp, loose, fine SAND, little silt, trace organics, mottled, (Fill).	
							61				
							83				
							70				
							63				
15	4D	24/20	15.0 - 17.0	4/5/8/12	13	12	26			Olive brown, damp, medium dense, SILT, little fine sand, mottled, trace organics, (Fill).	
							42				
							88				
							93				
							112				
20	5D	24/10	20.0 - 22.0	7/9/6/13	15	14	74			Brown, damp, medium dense, fine silty SAND, (Fill).	
							68				
							89	43.0		22.0	
							82				
							156				
25											

Remarks:

Tried putting core barrel back down hole, hole collapsed at 54.5' bgs.

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

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

Boring No.: BB-HRW-101

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

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Location:	Hallowell, Maine	**PIN:**	15614.00		
Driller:	Northern Test Boring	**Elevation (ft.)**	65.0	**Auger ID/OD:**	4" Solid Stem
Operator:	Nick/Mike	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	Dietrick D50 #149	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/1/08-12/3/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	103+33.4, 2.7 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.55	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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	24/18	25.0 - 27.0	9/11/18/21	29	27	95			Brown, damp, medium dense, fine to medium SAND, little silt, little gravel.	
							100				
							250				
							324				
							271				
30	7D	24/15	30.0 - 32.0	18/24/22/30	46	42	a52			Similar to above, dense, with iron staining. aWashed ahead of Casing to 45.0' bgs.	
							110				
							158				
							78				
							46				
35	8D	24/6	35.0 - 37.0	29/18/14/17	32	29	57	30.0		35.0 Brown, wet, medium dense, fine to coarse silty SAND, some gravel, with iron staining.	
							66				
							85				
							88				
							92				
40	9D	24/6	40.0 - 42.0	13/18/18/50	36	33	75			Brown, wet, medium dense, fine to coarse silty SAND, some gravel, with iron staining.	
							55				
							128				
							130				
							131				
45	10D	24/4	45.0 - 47.0	26/59/14/16	73	67	109			Brown, wet, very dense, fine to coarse silty SAND, little gravel, with broken rock fragments.	
							325				
							341				
							347				
50							281				

Remarks:

Tried putting core barrel back down hole, hole collapsed at 54.5' bgs.

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.

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US CUSTOMARY UNITS

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Driller:	Northern Test Boring	**Elevation (ft.)**	65.0	**Auger ID/OD:**	4" Solid Stem
Operator:	Nick/Mike	**Datum:**	NAVD 88	**Sampler:**	24" Standard Split Spoon
Logged By:	K. Maguire	**Rig Type:**	Dietrick D50 #149	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	12/1/08-12/3/08	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	103+33.4, 2.7 Rt.	**Casing ID/OD:**	HW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.55	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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	11D	20.4/13	50.0 - 51.7	34/27/36/50(2.4)	63	58	b106				
							c250	13.2			
	R1	28.8/27.6	52.0 - 54.4	RQD = 79%			NQ				
	R2	7.2/0	54.4 - 55.0	RQD = 0%							
55	R3	12/3	55.0 - 56.0	RQD = 0%				9.0			
60											
65											
70											
75											

Visual Description and Remarks:

Brown, wet, very dense, fine to coarse silty SAND, some gravel with broken rock fragments.
bWashed ahead of Casing to 51.8' bgs.
c250 blows for 0.8'.
51.8
Top of Bedrock at Elev. 13.2'.
Rolled Coned ahead to 51.9' bgs, then drove casing to 51.8' bgs, then washed ahead to 52.0' bgs.
R1:Bedrock: Grey, fine grained GRANITE.
Rock Mass Quality = Good
R1:Core Times (min:sec)
52.0-53.0' (10:49)
53.0-54.0' (7:36)
54.0-54.4' (3:45) 96% Recovery
Core Blocked
No water return.
R2:Core Times (min:sec)
54.4-55.0' (9:50) 0% Recovery
New bit used for R2.
No water Return.
R3:Bedrock: Fractured, broken, grey, GRANITE pieces. Possibly seam in bedrock. Rock Mass Quality = Poor.
R3:Core Times (min:sec)
55.0-56.0' (8:52) 25% Recovery
No water return.
56.0

Bottom of Exploration at 56.00 feet below ground surface.

Remarks:

Tried putting core barrel back down hole, hole collapsed at 54.5' bgs.

Specification

SPECIAL PROVISION
SECTION 504
EARTH RETENTION SYSTEM

504.01 Description. The work under this section consists of designing, furnishing and installing an earth retention system comprised of a sheet pile wall as shown on the plans and specified herein. Work under this item shall also include confirming utility and drainage system locations, backfilling the earth retention system, providing weep holes.

504.02 Submittals.

A. Shop Drawings: Submit drawings for approval prior to start of the work or ordering materials. Include details of top protection, splices, fabricated additions to plain piles. Include method of installation, type and size of pile hammer, cut-off method, and corrosion protection. Drawings for piling including fabricated sections shall show complete dimensions including details of piling and the driving schedule, sequence and location of piling. Include details and dimensions of templates and other temporary guide structures for installing the piling. Provide details of the method of handling sheet piling to prevent permanent deflection, distortion or damage to interlocks.

B. Design Calculations: The earth retention system shall be designed and sealed by a Professional Engineer licensed in accordance with the laws of the State of Maine. The contractor shall submit a copy of the designer's calculation as part of the shop drawing submittal. Design calculations that consist of computer generated output shall be supplemented with at least one hand calculation and graphic demonstrating the design methodology used. Design calculations shall provide thorough documentation of the sources of equations used and material properties.

C. Records: Pile driving records

D. Certificates: Material certificates including chemical and physical test results.

504.03 Materials.

A. Sheet piles shall be hot-rolled steel meeting the chemical and mechanical requirements of ASTM A 572 Grade 50. The interlock of sheet piling shall be free-sliding, and maintain continuous interlocking when installed. Sheet piling including special fabricated sections shall be full-length sections of the dimensions shown. Fabricated sections shall conform to the requirements herein and the piling manufacturer's recommendations for fabricated sections. Provide sheet piling with standard pulling holes. Any metalwork fabrication for sheet pile sections shall conform to the requirements of Section 504, Structural Steel. Provide cast steel sheet pile protectors, in one-piece Z configuration, at the bottom of each pile.

B. Sheet Pile Connectors – Where sheet pile changes direction, connectors shall be equivalent to those manufactured by PilePro LLC or Skyline Steel LLC or LB Foster Company. Connectors shall be of the same material as the sheet pile.

C. Drainage Geotextile shall be non-woven and conform to the requirements of Subsection 722.02, Drainage Geotextile.

D. Wall backfill shall meet the requirements of Subsection 703.22 Underdrain Backfill Material, Type C, and 703.29, Stone Ditch Protection.

E. Certification: Contractor shall certify that all component materials, manufacturing operations, and/or furnished products conform to all MaineDOT requirements pertinent to the project plans, special provisions and specifications for the contract items indicated.

<u>504.04 Design Requirements</u> The earth retention system shall be designed in accordance with the following:

A. The earth retention system shall be designed in accordance with the current edition of AASHTO LRFD Bridge Design Specifications. The design shall also consider traffic surcharge loading and traffic impact loads on traffic barriers or guardrail posts, as applicable.

B. The contractor shall submit design calculations as described in section 504.02, Submittals.

C. The Contract Plans.

D. The requirements specified herein.

E. The manufacturer’s requirements.

<u>504.05 Construction Methods</u>.

A. Earthwork

1. Any excavation and backfill shall be performed in accordance with Section 203 Excavation and Embankment.

2. Obstructions encountered in pile locations shall be dealt with as follows:

    a. All rocks, timbers, or other obstructions within 5 feet of the existing ground surface which interfere with pile advance shall be removed. Excavation and removal of obstructions shall be paid for under pay item 203.20 Common Excavation.

b. In the case of an apparent obstruction below the level in (a), but above anticipated full depth, which prevents appreciable penetration of a pile (s), the abnormal condition will receive further consideration by the Resident. Depending on depth and resistance of the obstruction, the Resident will decide whether to consider the pile (s) acceptable or order the obstruction removed. The decision may be deferred until the driving of adjacent piles indicates the obstruction to be isolated or extending over the area of several piles.

B. Installation

1. Pile Hammer

For steel sheet piles, both a vibratory and an impact hammer shall be available to the Contractor to install the sheet piles. Use a pile hammer having a delivered force or energy suitable for the total weight of the pile and the character of subsurface material to be encountered. Operate hammer at the rate (s) recommended by the manufacturer throughout the entire driving period. Repair damage to piling caused by use of a pile hammer with excess delivered force or energy.

2. Pile Protection

Use a protective cap during driving to prevent damage to the top of the piles.

3. Templates for Sheet Piles

Prior to driving, provide template or driving frame suitable for aligning, supporting, and maintaining sheet piling in the correct position during setting and driving. Use a system of structural framing sufficiently rigid to resist lateral and driving forces and to adequately support the sheet piling until design tip elevation is achieved. Provide at least two levels of support, at third points. Templates shall not move when supporting sheet piling. Fit templates with wood blocking to bear against the web of each alternate sheet pile and hold the sheet pile at the design location alignment. Provide outer template straps or other restraints as necessary to prevent the sheets from warping or wandering from the alignment. Mark template for the location of the leading edge of each alternate sheet pile. If in view, also mark the second level to assure to that the piles are vertical and in position. If two guide marks cannot be seen, other means must be used to keep the sheet pile vertical along its leading edge.

4. Pile Driving

Drive sheet piles to the indicated tip elevations. Maintain piling vertical during driving. Drive piles in such a manner as to prevent damage to the piles and to provide a continuous closure.

Where possible for sheet piles, drive Z-pile with the ball end leading. If an open socket is leading, a bolt or similar object placed in the bottom of the interlock will minimize packing material into it and ease driving for the next sheet. Incrementally sequence the driving of individual piles such that the tip of any sheet pile shall not be more than 4 feet below that of any adjacent sheet pile.

5. Cutting and Splicing

Piles driven to refusal or the point where additional penetration cannot be attained and are extending above the required top elevation in excess of the specified tolerance shall be cut off to the required elevation. Piles driven below the required top elevation and piles damaged by driving and cut off to permit further driving shall be extended as required to reach the top elevation by splicing when directed by the Resident. One splice per pile will be permitted. Piles adjoining spliced piles shall be full length unless otherwise approved. Welding of splices shall conform to the requirements of Section 504, Structural Steel. Ends of piles to be spliced shall be squared before splicing to eliminate dips or camber. Splice piles with concentric alignment of the interlocks so that there are no discontinuities, dips or camber at the abutting interlocks. Spliced piles shall be free sliding and able to obtain the maximum swing with contiguous piles. Trim the tops of piles excessively battered during driving, when directed at no cost. Pile cut-offs shall become the property of the Contractor and shall be removed from the site. Use a straight edge in cutting by burning to avoid abrupt nicks. Bolt holes shall be drilled or may be burned and reamed by approved methods which will not damage the surrounding metal. Holes other than bolt holes shall be smooth and the proper size for rods or other items to be inserted. Do not use explosives for cutting.

6. Welding

Shop and field welding, qualifications of welding procedures, welders, and welding operators shall be in accordance with AWS D1.1.

7. Tolerances in Driving

<u>Sheet Piles</u>
Drive all piles with a variation from vertical of not more than ¼ inch per foot. Place the pile so the face will not be more than 6 inches from vertical alignment at any point over the entire length of the earth retention system. Top of pile at elevation of cut-off shall be within 2 in. horizontally and 2 in. vertically of the location indicated. Manipulation of piles to force them into position will not be

permitted. Check all piles for heave. Redrive all heaved piles to the required tip elevation.

8. Backfilling

   The contractor shall backfill the space between the existing wall and the new earth retention system with crushed stone meeting the requirements of 703.22, Underdrain Backfill, Type C, up to within 6 inches of the top of the new earth retention system. The contractor shall assist the consolidation of the crushed stone backfill by attaching and vibrating the piles with short bursts of a vibratory hammer as the backfill operation progresses. When backfilling is complete, the contractor shall cover the crushed stone with 722.02 non-woven Drainage Geotextile and then place 703.29 Stone Ditch Protection rock over the geotextile.

9. Weep Holes

   The contractor shall provide weep holes through the face of the new earth retention system one foot above the adjacent highway grade and approximately every 5 feet along the width of the new earth retention system. The contractor shall fasten or weld heavy wire grating across the weep hole to prevent loss of backfill aggregate.

C. Inspection

Perform continuous inspection during pile driving by frequent optical surveying of the pile alignment relative to an established reference base line. Inspect all piles for compliance with tolerance requirements regarding horizontal and vertical alignment. Bring any unusual problems which may occur to the attention of the Resident.

1. Inspection of Driven Piling

   The Contractor shall inspect the interlocks of the portion of driven sheet piles that extend above ground. Remove and replace piles found to be out of interlock.

2. Pulling and Redriving

   The Contractor may be required to pull selected piles after driving to bring into location tolerance, or to determine the condition of the underground portions of piles. The pile pulling method must be approved by the Resident. Remove and replace at the Contractor’s expense any pile pulled and found to be damaged to the extent that its usefulness in the structure is impaired. Redrive piles pulled and found to be in satisfactory condition.

3. Installation Records

   Maintain a pile driving record for each pile. Indicate on the installation record installation dates and times, type and size of hammer, rate of operation, total driving time, dimensions of driving helmet and cap used, blows or time required per foot for each foot of penetration, driving resistance in blows for final 6 in. of penetration, pile locations, tip elevations, ground elevations, and cut-off elevations. Record any unusual pile driving problems. Submit complete records to the Resident.

542.06 Method of Measurement. The four earth retention systems, two at each bridge abutment, will be measured together as one lump sum complete and accepted as shown on the plans or as directed by the resident.

542.07 Basis of Payment. The accepted quantity of earth retention system will be paid for at the contract lump sum price, complete in place. The price shall be full compensation for furnishing, transporting, handling, placing or erecting the material specified including confirming utility and drainage system locations, installing sheet piles and connecting walls or soldier piles and lagging, all hardware, excavating debris from the front of the existing cribwork walls, backfilling the earth retention system, providing weep holes, removal and disposal of any obstructions, and any pile testing as specified by the plans and described in these specifications.

Payment will be made under:

Pay Item	Pay Unit
504.95 Earth Retention System	Lump Sum