PRELIMINARY GEOTECHNICAL DESIGN REPORT

19-1434

June 15, 2020

Explorations and Geotechnical Engineering Services

Hall Bridge #2341 Replacement
Route 2 over Hooper/Butterfield Brook
Wilton, Maine
WIN 023144.00

PREPARED FOR:
Erdman Anthony
Attention: Christopher Sichak, P.E.
145 Culver Road, Suite 200
Rochester, NY 14620

PREPARED BY:
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S.W.COLE ENGINEERING, INC.

- *Geotechnical Engineering*
- *Construction Materials Testing and Special Inspections*
- *GeoEnvironmental Services*
- *Test Boring Explorations*

www.swcole.com

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19-1434

June 15, 2020

Erdman Anthony
Attention: Christopher Sichak, P.E.
145 Culver Road, Suite 200
Rochester, NY 14620

Subject: Preliminary Geotechnical Design Report
Explorations and Geotechnical Engineering Services
Hall Bridge #2341 Replacement
Route 2 over Hooper/Butterfield Brook
Wilton, Maine
WIN 023144.00

Dear Chris:

In accordance with our Proposal dated October 8, 2019, we have made subsurface explorations for the subject project. The purpose of our services was to obtain subsurface information in order to provide geotechnical parameters and recommendations for foundations and earthwork associated with the proposed construction. The contents of this report are subject to the limitations in Appendix A.

1.0 INTRODUCTION

1.1 Site Conditions

The site is Hall Bridge #2341 carrying Route 2 over Hooper/Butterfield Brook in Wilton, Maine. The site location is shown on the "Site Location Map" attached in Appendix B.

Based on the provided information, we understand the existing crossing was originally constructed in 1932 and widened with a deck rehabilitation in 1971. Historic Bridge Plans indicate the original wingwalls were left in place during the 1971 bridge widening. The existing structure is a single-span bridge with concrete deck slab on soil supported concrete abutments. We understand the existing structure is about 23 feet long (end-to-end) and 47 feet wide (out-to-out) with zero skew.

1.2 Proposed Construction

Based on discussions with Erdman Anthony (EA) and the Maine Department of Transportation (MaineDOT), we understand the existing structure will be replaced. Replacement alternatives under consideration include:

- Precast concrete box culvert; and
- Precast concrete three-sided frame supported on strip footings.

We understand current planning is considering a clear span of at least 19 feet (e.g. 1.2 times bank full width of 15.5 feet) with a 0 degree skew. We understand the horizontal and vertical alignment will remain the same.

2.0 EXPLORATIONS AND TESTING

2.1 Explorations

Two test borings (BB-WHBB-101 and BB-WHBB-102) were made at the site on November 14 and 15, 2019 by S. W. Cole Explorations, LLC, a subsidiary of S. W. Cole Engineering, Inc. (S.W.COLE). The exploration locations were selected by S.W.COLE in consultation with EA and established in the field by S.W.COLE using taped measurements from existing site features. The ground surface elevations of the test borings were provided by EA based on the taped measurements. The approximate exploration locations are shown on the "Boring Location Plan" attached in Appendix B. Logs of the test borings and a Key to Soil and Rock Descriptions and Terms used on the logs are attached as Appendix C.

2.2 Testing

The test borings were drilled using a combination of solid-stem auger and cased wash boring drilling techniques. The soils were sampled at 5-foot intervals using a split-spoon sampler and Standard Penetration Testing (SPT) techniques using a calibrated automatic hammer. The uncorrected SPT blow counts and the uncorrected and corrected SPT N-values are shown on the logs.

Soils samples recovered from the test borings were visually classified in our laboratory and transported to GeoTesting Express of Acton, Massachusetts, for testing to assist soil classification and identification. Laboratory testing was performed on disturbed SPT samples obtained during the explorations. Laboratory testing was performed in accordance with applicable American Association of State Highway and Transportation Officials (AASHTO) testing procedures. Laboratory testing included seven natural water content tests and ten grain size analyses (with and without hydrometer). Laboratory testing results are provided in Appendix D.

3.0 SUBSURFACE CONDITIONS

3.1 Surficial and Bedrock Geology

According to the Maine Geological Survey's (MGS's) mapping of the Farmington Quadrangle, Maine[1], surficial geologic units within the site vicinity consists of artificial fill, stream alluvium and glacial outwash consisting of sand, gravel and silt. The subsurface conditions encountered in the test borings generally consisted of fill soils from previous site development overlying glacial outwash. Stream alluvium was not encountered at the exploration locations.

Bedrock was not encountered at the test borings to the depths drilled. However, according to MGS[2], bedrock in the site vicinity is mapped as Devonian age interbedded pelitic schist, metasiltstone and metasandstone of the Seboomook Formation (Temple Stream and Spruce Mountain Members).

3.2 Subsurface Conditions

The test borings encountered a soils profile generally consisting of a surface layer of pavement overlying fill overlying glacial outwash. The principal strata encountered in the explorations are summarized below. An "Interpretive Subsurface Profile" is attached in Appendix B. Refer to the attached logs for more detailed information of the subsurface findings at the exploration locations.

Fill: Below an approximate 5.5 to 7.5 inch layer of pavement, the borings encountered fill extending to a depth of about 10 feet below ground surface (bgs), corresponding to Elevation (El.) 468.2 to 467.4 feet. Where sampled, the fill generally consisted of:

- Brown, SAND, some silt, trace gravel; and
- Brown, SAND, some gravel, little silt.

The fill was generally medium dense with SPT N_{60} values ranging from 11 to 15 blows per foot (bpf).

Glacial Outwash: Below the fill, the borings generally encountered glacial outwash to depths of about 25 to 30 feet bgs, corresponding to Elevation (El.) 453.2 to 447.4 feet. The glacial outwash generally consisted of:

- Brown, SAND, some silt, trace gravel;
- Brown, Sandy GRAVEL, little silt; and

---

[1] Spigel, Lindsay J., 2018, Surficial Geology of the East Dixfield Quadrangle, Maine, Maine Geological Survey, Open-File Map 18-18, Map, Scale 1:24,000.

[2] Pankiwskyj, Kost A., 1981, Reconnaissance Bedrock Geology of the Northern Part of the Buckfield [15-minute] Quadrangle and Adjoining Dixfield [15-minute] Quadrangle: Maine, Geological Survey, Open-File Map 81-45, Map, Scale 1:62,500.

- Brown, SAND, little gravel, little silt.

The glacial outwash was generally dense to very dense with SPT N_{60} values ranging from 39 to 86 bpf.

Glacial Till: Below the glacial outwash, the borings generally encountered glacial till with cobbles. The borings were terminated in the glacial till at depths of about 55.3 feet bgs, corresponding to El. 422.9 to 422.1 feet.

The glacial till generally consisted of:

- Brown, Silty SAND, little gravel;
- Grey, Gravel and Sand, some silt; and
- Grey, Sandy SILT, trace gravel.

The glacial till was generally hard to very dense with SPT N_{60} values ranging from 39 bpf to 124 blows for 6 inches to 100 blows for 4 inches (sampler refusal).

3.3 Groundwater Conditions

The soils encountered at the test borings were damp to moist from the ground surface. The measured water levels during drilling ranged from 7.1 to 7.5 feet below ground surface. Long term groundwater information is not available. It should be anticipated that groundwater levels will fluctuate seasonally, particularly in response to periods of snowmelt and precipitation, as well as changes in site use and the water level of Hooper/Butterfield Brook.

4.0 PRELIMINARY GEOTECHNICAL EVALUATION

S.W.COLE conducted geotechnical engineering evaluations in accordance with 2017 AASHTO LRFD Bridge Design Specifications, 8th Edition (LRFD) and the MaineDOT Bridge Design Guide, 2003 Edition with revisions through June 2018 (MaineDOT BDG) and offers the following:

4.1 Foundation Options

Proposed replacement structure alternatives include:

- Precast concrete box culvert; and
- Precast concrete three-sided frame supported on strip footings.

We understand the proposed structure span will be about 19 feet and the horizontal alignment and vertical profile will not change.

The site is underlain by dense to very dense glacial outwash consisting of sand with variable amounts of gravel and silt with cobbles overlying very dense glacial till at a depth of about 35 feet bgs. Based on the proposed alternatives, the glacial outwash appears to extend about 25 feet below proposed foundation subgrade elevation.

4.2 Precast Concrete Box Culvert

The precast box culvert option would consist of a 19-foot span precast concrete box culvert with a 0 degree skew. The slopes on the inlet and outlet ends of the culvert shall have 1.75:1(H:V) or flatter riprap slopes. The invert of the box culvert will be embedded approximately 3 feet into the stream bed and about 2 feet of “special fill” will be placed inside the bottom of the culvert to create a natural streambed.

Based on the MaineDOT BDG Section 8.3.1, the precast box culvert shall include toe walls at the inlet and outlet ends to prevent undermining. The toe walls should extend at least 1 foot below the maximum scour depth.

We recommend the box culvert be founded on a minimum 1-foot thick mat of MaineDOT Standard Specification 703.19 Granular Borrow for Underwater Backfill. The culvert backfill shall consist of MaineDOT Standard Specification 703.19 Granular Borrow for Underwater Backfill modified with a maximum particle size of 3 inches.

Based on the subsurface conditions and subgrade preparation described herein, the factored bearing resistance for a precast box culvert with a base width of 19 feet at the strength and service limit states shall not exceed the factored bearing resistance shown in the following table. The service limit state may govern the design. The bearing stress shall not exceed the nominal structural resistance of the structural concrete of $0.3 \times f'_c$.

Footing Width (feet)	Factored Bearing Resistance (ksf)	
	Strength Limit State	Service Limit State
19	10.8	5.0

We recommend the following coefficients of subgrade reaction (k_v) for preliminary analysis for the box culvert bearing on a 1 foot layer of compacted Granular Borrow for Underwater Backfill overlying undisturbed native sands.

Location	Coefficient of Subgrade Reaction (k_v)
Corner of Box Culvert	228 pci
Center of Box Culvert	255 pci

We recommend the bearing resistance and coefficient of subgrade reaction be re-evaluated during the final design.

4.3 Precast Concrete Three-Sided Frame

The precast concrete three-sided frame option will consist of an approximate 19-foot span, precast three-sided rigid-frame supported on spread footings with a 0 degree skew. Considerations for scour and bearing resistance may preclude the use of individual spread footings for structure support. The slopes on the inlet and outlet ends of the three-sided frame will have 1.75:1(H:V) or flatter riprap slopes. Concrete headwalls may be included in the buried structure design to retain riprap slopes and prevent riprap from dropping or eroding into the waterway.

For scour protection, footings which are constructed on soil shall be embedded a minimum of 2 feet below the check flood (Q_{500}) scour elevation: refer to LRFD Article 2.4.4.2 and MaineDOT BDG Section 5.3.4.1 for guidance regarding scour protection. Furthermore, per the MaineDOT BDG Section 2.3.11.1, spread footings on soil within the stream channel shall be located a minimum of 6 feet below the thalweg (lowest elevation) of the waterway.

Individual spread footings for a three-sided frame shall be sized such that the applied contact footing pressures do not exceed the bearing resistances provided in the table below. The applied contact pressures may preclude the use of individual spread footings and may require a mat foundation. Footings and mat foundations shall be founded on a minimum 1-foot thick mat of MaineDOT Standard Specification 703.19 Granular Borrow for Underwater Backfill. The backfill shall consist of MaineDOT Standard Specification 703.19 Granular Borrow for Underwater Backfill modified with a maximum particle size of 3 inches.

Based on the subsurface conditions and subgrade preparation described herein, the factored bearing resistance of footings/mat foundations at the strength and service limit states shall not exceed the factored bearing resistance shown in the following table.

Footing Width (feet)	Factored Bearing Resistance (ksf)	
	Strength Limit State	Service Limit State
8	4.7	5.0
10	5.6	5.0
12	6.4	5.0
14	7.3	5.0
16	8.1	5.0

The service limit state may govern the design. The bearing stress shall not exceed the nominal structural resistance of the structural concrete of $0.3 \times f'_c$.

Spread footings shall be designed for all relevant strength and service limit state load combinations per LRFD Article 10.6. Design of spread footings at the strength limit state shall consider:

- Bearing Resistance;
- Eccentricity;
- Lateral Sliding; and
- Reinforced-concrete structural failure.

4.4 Frost Considerations

Based on the Maine Design Freezing Index Map[3], the design freezing index for the Wilton, Maine area is approximately 1,775 freezing degree-days. Based on Section 5.2.1 of the MaineDOT BDG and subsurface soils encountered, the maximum seasonal frost penetration is estimated to be on the order of about 7.5 feet. Considering this, we recommend foundations should have at least 7.5 feet of soil cover to provide frost protection.

4.5 Seismic Design Considerations

Seismic site class was evaluated in accordance with LRFD Article 3.10.3.1 Method B (average N-value method). Based on the subsurface information, the average N-value for the soil profile was between 15 and 50 bpf corresponding to an AASHTO Site Class D as defined in LRFD Table 3.10.3.1-1.

The United States Geological Survey (USGS) Seismic Design Parameters program (Version 2.1) was used to obtain the seismic design parameters for the site. Based on the assigned site class (AASHTO Site Class D) and site coordinates, the software provides the recommended AASHTO Response Spectrum for a 7 percent probability of exceedance in 75 years (1,000-year return period). The results for the project site are summarized below and program output are provided in Appendix E.

RECOMMENDED SEISMIC DESIGN PARAMETERS	
Site Class	D
PGA	0.084 g
S_s	0.174 g
S_1	0.049 g
F_{pga}	1.6
F_a	1.6
F_v	2.4
A_s	0.135 g
S_{DS}	0.278 g
S_{D1}	0.117 g
Seismic Zone (based on S_{D1})	Zone 1

NOTE: Site Coordinates: N44.572802, W70.300935

[3] Maine Department of Transportation, Bridge Design Guide (BDG), August 2003, with Revisions through 2014, Figure 5-1.

4.6 Recommendations for Scour Evaluation

Based on results of the laboratory grain size analyses, we estimate the average grain diameter corresponding to 50 percent passing by weight (D_{50}) for use in scour evaluations ranges from 0.1 to 0.9 mm. Results of the grain size analyses tests are included in Appendix D and the estimated D_{50} for samples near the channel elevation are summarized in the following table:

Boring No.	Sample No.	Depth (ft)	Sample Elevation (ft)	Estimated D_{50}
BB-WHBB-101	2D	10.0	468.2	0.15 mm
BB-WHBB-102	2D	10.0	467.4	0.89 mm

MaineDOT BDG Sections 2.3.11 and 5.3.4.4 requires footings for bridges on soil be founded at least 2 feet below the scour elevation as determined from the check flood (Q_{500}) event. Furthermore, spread footings supported on soil shall be located a minimum of 6 feet below the thalweg (lowest elevation) of the waterway.

5.0 CLOSURE

We trust this information meets your present needs. Please contact us if you have any questions or need further assistance.

Sincerely,

S. W. Cole Engineering, Inc.

Michael St. Pierre, P.E.
cn=Michael St. Pierre, P.E., o=S. W. Cole Engineering, Inc., ou, email=mst.pierre@swcole.com, c=US
2020.06.15 12:32:21 -04'00'

STATE OF MAINE
MICHAEL A. ST. PIERRE No. 12519
LICENSED PROFESSIONAL ENGINEER

Michael A. St. Pierre, P.E.
Senior Geotechnical Engineer

Robert E. Chaput, Jr., P.E.
Senior Geotechnical Engineer

MAS/tjm-rec

S.W.COLE ENGINEERING, INC.

APPENDIX A
LIMITATIONS

This report has been prepared for the exclusive use of the Erdman Anthony for specific application to the Hall Bridge #2341 Replacement carrying Route 2 over Hooper/Butterfield Brook (MaineDOT WIN 023144.00) in Wilton, Maine. S. W. Cole Engineering, Inc. (S.W.COLE) has endeavored to conduct our services in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made.

The soil profiles described in the report are intended to convey general trends in subsurface conditions. The boundaries between strata are approximate and are based upon interpretation of exploration data and samples.

The analyses performed during this investigation and recommendations presented in this report are based in part upon the data obtained from subsurface explorations made at the site. Variations in subsurface conditions may occur between explorations and may not become evident until construction. If variations in subsurface conditions become evident after submission of this report, it will be necessary to evaluate their nature and to review the recommendations of this report.

Observations have been made during exploration work to assess site groundwater levels. Fluctuations in water levels will occur due to variations in rainfall, temperature, and other factors.

Recommendations contained in this report are based substantially upon information provided by others regarding the proposed project. In the event that any changes are made in the design, nature, or location of the proposed project, S.W.COLE should review such changes as they relate to analyses associated with this report. Recommendations contained in this report shall not be considered valid unless the changes are reviewed by S.W.COLE.

S.W.COLE ENGINEERING, INC.

APPENDIX B
Figures

2,000 0 2,000 4,000

Scale in Feet

N W E S

S.W.COLE ENGINEERING, INC.

ERDMAN ANTHONY

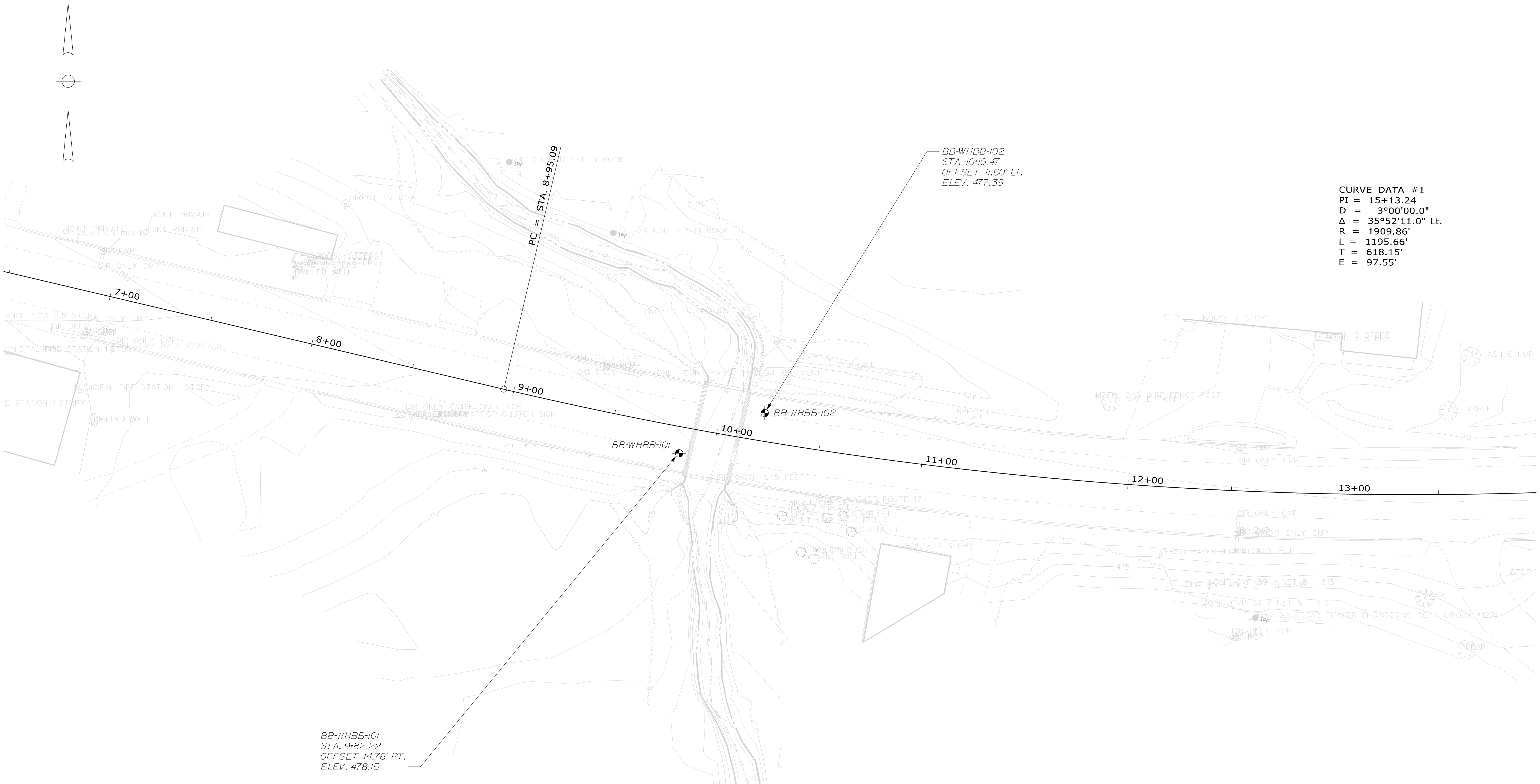
SITE LOCATION MAP

HALL BRIDGE #2341 REPLACEMENT
ROUTE 2 OVER HOOPER / BUTTERFIELD BROOK
WILTON, MAINE
WIN 023144.00

Job No.	19-1434	Scale	1" = 2000'
Date:	03/05/2020	Sheet	1

NOTE:
SITE LOCATION MAP PREPARED FROM ESRI ArcGIS ONLINE AND DATA PARTNERS INCLUDING USGS AND © 2007 NATIONAL GEOGRAPHIC SOCIETY.

R:\2019\19-1434\GIS\Project\19-1434.aprx, 3/5/2020 8:50 AM, 1:24,000, Filename: ...\00\Geotech\MSTA\002_BLP.dgn   Division: BRIDGE   Username: LindoT   Date:3/3/2020



CURVE DATA #1
PI = 15+13.24
D = 3°00'00.0"
Δ = 35°52'11.0" Lt.
R = 1909.86'
L = 1195.66'
T = 618.15'
E = 97.55'

PLAN

25 0 25 50
Scale of Feet

ERDMAN ANTHONY

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS
WIN 23144.00
BRIDGE NO. 2341

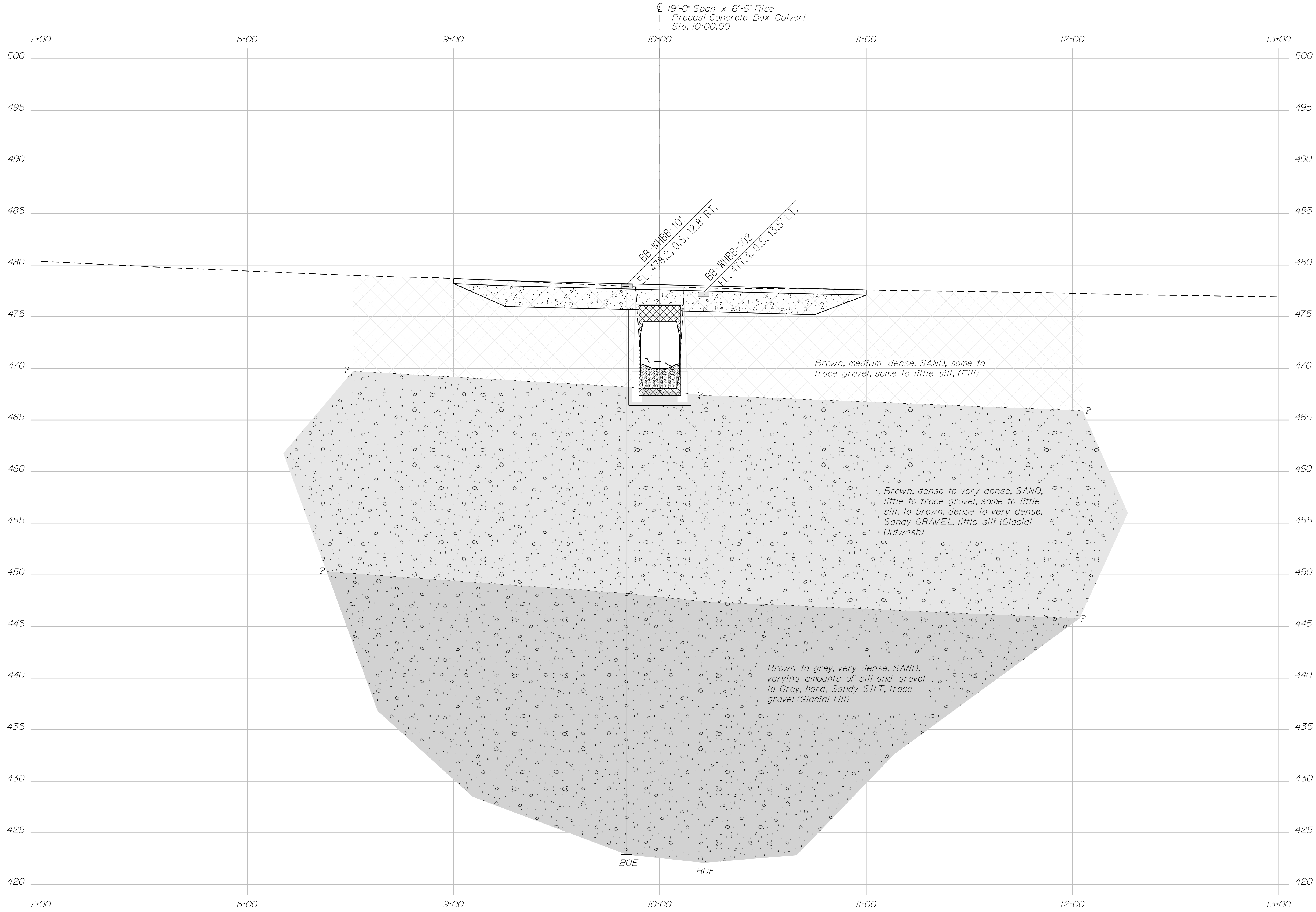
	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	T.C.L.	
CHECKED-REVIEWED	M.A.S.	
DESIGN2-DETAILED2	T.J.M.	
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE
P.E. NUMBER
DATE

HALL BRIDGE
HOOPER(BUTTERFIELD) BRK.
WILTON FRANKLIN COUNTY

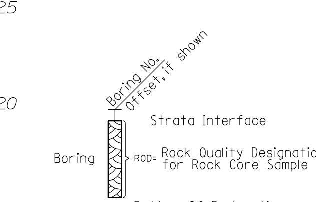
BORING LOCATION PLAN

SHEET NUMBER
2
OF 3



PROFILE

Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.



PROFILE

HORIZ 25 0 25 50
VERT 5 0 5 10
SCALE

ERDMAN ANTHONY

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS

WIN 23144.00

BRIDGE NO. 2341

PROJ. MANAGER	MICHAEL WIGHT	BY	DATE
DESIGN-DETAILED	M.A.S.	T.C.L.	
CHECKED-REVIEWED	J.M.		
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE
P.E. NUMBER
DATE

HALL BRIDGE
HOOPER(BUTTERFIELD) BRK.
WILTON FRANKLIN COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
3
OF 3

Filename: ...\00\Geotech\MSTA\003_ISP.dgn Division: BRIDGE Username: LindoT Date:3/3/2020

S.W.COLE ENGINEERING, INC.

APPENDIX C

Boring Logs & Key to Soil and Rock Descriptions and Terms

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, if applicable):
Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
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.,)
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

MODIFIED BURMISTER SYSTEM

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

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. Density is rated according to standard penetration resistance (N-value).

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 undrained 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):

$$RQD\ (\%) = \frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$$

*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, if applicable):
Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, 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 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
- -spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
- -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: ASTM D6032 and AASHTO Standard Specification for Highway Bridges, 17th Ed. Table 4.4.8.1.2A
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

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

Sample Container Labeling Requirements:

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hall Bridge #2341 carries Route 2 over Hooper/Butterfield Brook
Location: Wilton, Maine

Boring No.: BB-WHBB-101
WIN: 023144

Driller:	S. W. Cole Explorations, LLC	**Elevation (ft.)**	478.2	**Auger ID/OD:**	5" Solid Stem
Operator:	K. Hanscom	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Gorczynski	**Rig Type:**	Diedrich D-50 Tracked	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	11/15/2019	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	Sta. 9+82.22, 14.8 ft Rt.	**Casing ID/OD:**	HW 4.5"/4" NW 3.5"/3"	**Water Level*:**	7.1' (during drilling)
Hammer Efficiency Factor:	0.977	**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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	477.6		7.5" of Pavement. 0.6	
5	1D	24/12	5.00 - 7.00	4/4/3/4	7	11				Brown, moist, medium dense, SAND, some silt, trace gravel, (Fill).	GTX#534384 A-2-4, SM
10	2D	24/13	10.00 - 12.00	15/17/15/13	32	52	97	468.2		10.0 Brown, wet, very dense, SAND, some silt, trace gravel, (Glacial Outwash).	GTX#534392 A-2-4, SM
							72				
							80				
							103				
							48				
15	3D	24/12	15.00 - 17.00	6/19/34/53	53	86	74			Brown, wet, very dense, Sandy GRAVEL, little silt, (Glacial Outwash).	
							92				
							144				
							122				
							77				
20	4D	24/12	20.00 - 22.00	27/23/20/26	43	70	86			Similar to above.	GTX#534385 A-1-a, GM WC=8.0%
							124				
							177				
							92				
							40				
25											

Remarks:

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Water level taken prior to placement of drill casing.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hall Bridge #2341 carries Route 2 over Hooper/Butterfield Brook
Location: Wilton, Maine

Boring No.: BB-WHBB-101
WIN: 023144

Driller:	S. W. Cole Explorations, LLC	**Elevation (ft.)**	478.2	**Auger ID/OD:**	5" Solid Stem
Operator:	K. Hanscom	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Gorczynski	**Rig Type:**	Diedrich D-50 Tracked	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	11/15/2019	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	Sta. 9+82.22, 14.8 ft Rt.	**Casing ID/OD:**	HW 4.5"/4" NW 3.5"/3"	**Water Level*:**	7.1' (during drilling)
Hammer Efficiency Factor:	0.977	**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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	5D	24/10	25.00 - 27.00	6/11/16/14	27	44	31	453.2		25.0 Brown, moist, dense, Silty SAND, little gravel, (Glacial Till).	
							77				
							104				
							210				
							177				
30	6D	6/5	30.00 - 30.50	109-6"	- -		56			Grey, moist, very dense, Gravel and Sand, some silt, (Glacial Till).	GTX#534386 A-1-a, GM WC=7.8%
							71				
							94				
							110				
							107				
35	7D	12/10	35.00 - 36.00	68/124-6"	- -		117			Grey, moist, hard, Sandy SILT, trace gravel, moderately bonded, (Glacial Till).	GTX#534387 A-4, ML WC=8.4%
							289				
							94a OPEN			a = Casing refused at 37.3 ft bgs. Wash and drive NW casing.	
40	8D	2/2	40.00 - 40.17	100-6"	- -					Similar to above.	
45	9D	10/9	45.00 - 45.83	80/100-4"	- -					Similar to above.	
50											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hall Bridge #2341 carries Route 2 over Hooper/Butterfield Brook
Location: Wilton, Maine

Boring No.: BB-WHBB-101
WIN: 023144

Driller:	S. W. Cole Explorations, LLC	**Elevation (ft.)**	478.2	**Auger ID/OD:**	5" Solid Stem
Operator:	K. Hanscom	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Gorczynski	**Rig Type:**	Diedrich D-50 Tracked	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	11/15/2019	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	Sta. 9+82.22, 14.8 ft Rt.	**Casing ID/OD:**	HW 4.5"/4" NW 3.5"/3"	**Water Level*:**	7.1' (during drilling)
Hammer Efficiency Factor:	0.977	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	10/8	50.00 - 50.83	51/100-4"	- -					Grey, wet, very dense, Silty SAND, trace gravel, (Glacial Till).	GTX#534388 A-4, SM WC=13.3%
55	11D	4/2	55.00 - 55.33	100-4"	- -			422.9		Similar to above. 55.3	
										Bottom of Exploration at 55.3 feet below ground surface.	
60											
65											
70											
75											

Remarks:

Autohammer SN 367 Calibrated 7/29/2019.
Water level taken prior to placement of drill casing.
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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hall Bridge #2341 carries Route 2 over Hooper/Butterfield Brook
Location: Wilton, Maine

Boring No.: BB-WHBB-102
WIN: 023144

Driller:	S. W. Cole Explorations, LLC	**Elevation (ft.)**	477.4	**Auger ID/OD:**	5" Solid Stem
Operator:	K. Hanscom	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Gorczynski	**Rig Type:**	Diedrich D-50 Tracked	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	11/14/2019	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	Sta. 10+19.47, 11.6 ft Lt.	**Casing ID/OD:**	HW 4.5"/4" NW 3.5"/3"	**Water Level*:**	7.5' (during drilling)
Hammer Efficiency Factor:	0.977	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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 = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	476.9		5.5" of Pavement — 0.5	
5	1D	24/5	5.00 - 7.00	5/4/5/3	9	15				Brown, damp, medium dense, SAND, some gravel, little silt, (Fill).	
10	2D	24/24	10.00 - 12.00	38/27/17/23	44	72	185	467.4		10.0 — Brown, wet, very dense, SAND, little gravel, little silt, (Glacial Outwash).	GTX#534393 A-1-b, SM WC=7.6%
							119				
							285				
							257				
							85				
15	3D	24/19	15.00 - 17.00	21/19/15/19	34	55	65			Similar to above.	
							89				
							91				
							61				
							78				
20	4D	24/7	20.00 - 22.00	9/13/11/5	24	39	63			Similar to above, except dense.	
							63				
							50				
							54				
							65				
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hall Bridge #2341 carries Route 2 over Hooper/Butterfield Brook
Location: Wilton, Maine

Boring No.: BB-WHBB-102
WIN: 023144

Driller:	S. W. Cole Explorations, LLC	**Elevation (ft.)**	477.4	**Auger ID/OD:**	5" Solid Stem
Operator:	K. Hanscom	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Gorczynski	**Rig Type:**	Diedrich D-50 Tracked	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	11/14/2019	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	Sta. 10+19.47, 11.6 ft Lt.	**Casing ID/OD:**	HW 4.5"/4" NW 3.5"/3"	**Water Level*:**	7.5' (during drilling)
Hammer Efficiency Factor:	0.977	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	5D	24/4	25.00 - 27.00	9/16/18/25	34	55	59			Similar to above, except very dense.	
							113				
							117				
							201				
							97				
30	6D	10/4	30.00 - 30.83	21/100-4"	- -		44	447.4		30.0 Brown, moist, very dense, SAND, some silt, some gravel, (Glacial Till).	GTX#534389 A-2-4, SM WC=11.6%
							67				
							55				
							103				
							152				
35	7D	12/5	35.00 - 36.00	42/100-6"	- -		63			Grey, moist, very dense, Sandy SILT, trace gravel, fine to medium sand, (Glacial Till).	
							59				
							103				
							284				
							133				
40	8D	12/9	40.00 - 41.00	58/100-6"	- -		118			Similar to above.	GTX#534390 A-4, ML WC=9.7%
							203				
							380				
							258				
							128a OPEN			a = Casing refused at 44.5 ft bgs. Wash and drive NW casing.	
45	9D	5/5	45.00 - 45.42	100-5"	- -					Grey, moist, very dense, Sandy SILT, trace gravel, (Glacial Till).	
50											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hall Bridge #2341 carries Route 2 over Hooper/Butterfield Brook
Location: Wilton, Maine

Boring No.: BB-WHBB-102
WIN: 023144

Driller:	S. W. Cole Explorations, LLC	**Elevation (ft.)**	477.4	**Auger ID/OD:**	5" Solid Stem
Operator:	K. Hanscom	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	J. Gorczynski	**Rig Type:**	Diedrich D-50 Tracked	**Hammer Wt./Fall:**	140 lbs/30"
Date Start/Finish:	11/14/2019	**Drilling Method:**	Cased Wash	**Core Barrel:**	N/A
Boring Location:	Sta. 10+19.47, 11.6 ft Lt.	**Casing ID/OD:**	HW 4.5"/4" NW 3.5"/3"	**Water Level*:**	7.5' (during drilling)
Hammer Efficiency Factor:	0.977	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane 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	5/5	50.00 - 50.42	100-5"	- -					Similar to above.	GTX#534391 A-2-4, SM WC=7.3%
55	11D	4/4	55.00 - 55.33	100-4"	- -			422.1		Similar to above. 55.3	
										Bottom of Exploration at 55.3 feet below ground surface.	
60											
65											
70											
75											

Remarks:

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Water level taken prior to placement of drill casing.
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Boring No.: BB-WHBB-102

S.W.COLE ENGINEERING, INC.

APPENDIX D
Laboratory Test Results

Client:	S.W. Cole Engineering, Inc.				
Project:	Hall Bridge #2341 Replace.				
Location:	Witton, ME			Project No:	GTX-311079
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	12/23/19	Checked By:	jsc
Depth :	---	Test Id:	534403		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-WHBB-101	4D	20-22	Moist, olive brown silty gravel with sand	8.0
BB-WHBB-101	6D	30-30.5	Moist, gray silty gravel with sand	7.8
BB-WHBB-101	7D	35-36	Moist, dark gray sandy silt	8.4
BB-WHBB-101	10D	50-50.8	Moist, gray silty sand	13.3
BB-WHBB-102	2D	10-12	Moist, light olive brown silty sand with gravel	7.6
BB-WHBB-102	6D	30-30.7	Moist, yellowish brown silty sand with gravel	11.6
BB-WHBB-102	8D	40-41	Moist, gray sandy silt	9.7
BB-WHBB-102	10D	50-50.4	Moist, gray silty sand	7.3

Notes: Temperature of Drying : 110º Celsius

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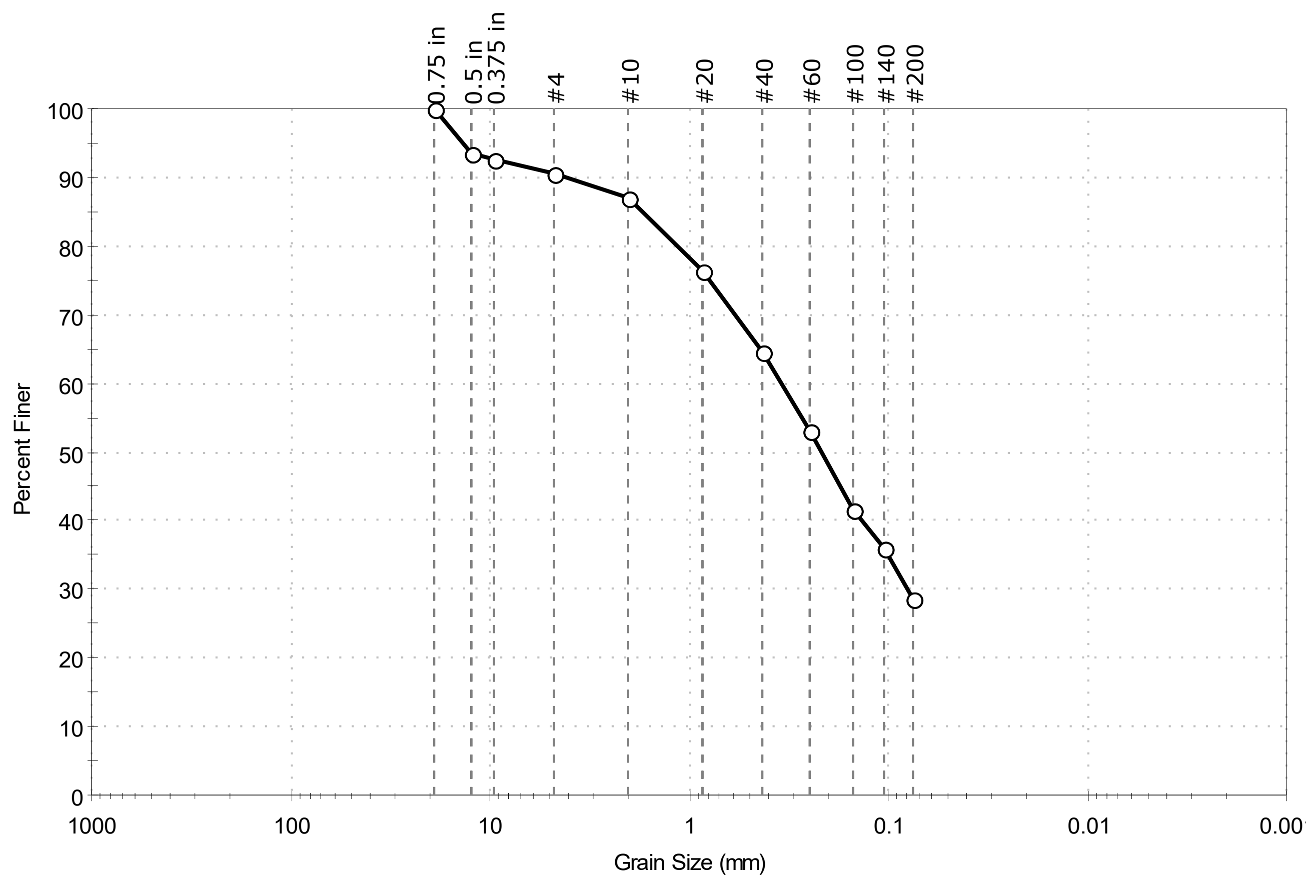
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID:	BB-WHBB-101	Sample Type: jar	Tested By: ckg
Sample ID:	1D	Test Date: 12/19/19	Checked By: jsc
Depth :	5-7	Test Id: 534384	
Test Comment:	---		
Visual Description:	Moist, yellowish brown silty sand		
Sample Comment:	Sample contains glass		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	9.4	61.9	28.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	94		
0.375 in	9.50	93		
#4	4.75	91		
#10	2.00	87		
#20	0.85	76		
#40	0.42	65		
#60	0.25	53		
#100	0.15	42		
#140	0.11	36		
#200	0.075	29		

Coefficients

D_{85} =1.7129 mm | D_{30} =0.0798 mm

D_{60} =0.3443 mm | D_{15} =N/A

D_{50} =0.2189 mm | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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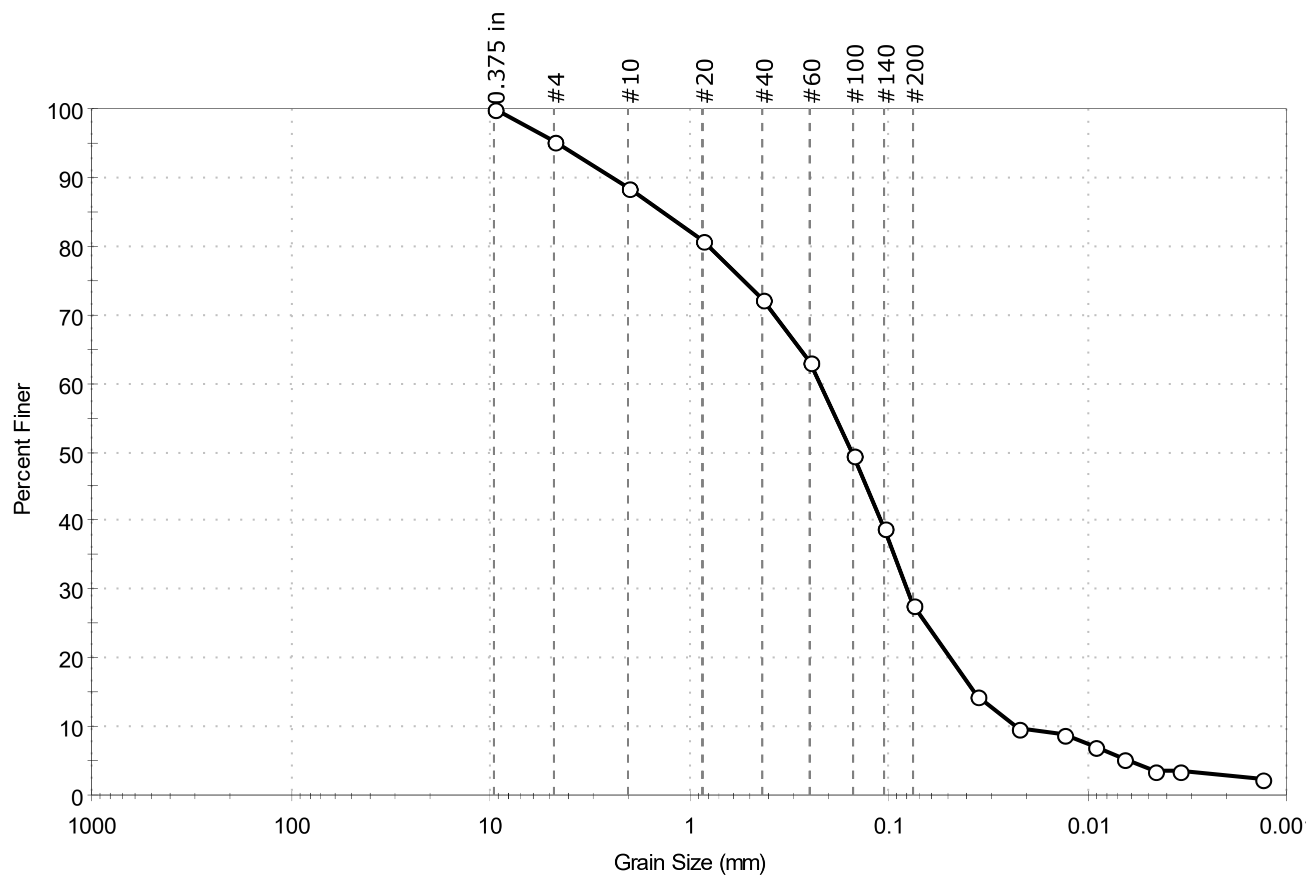
GeoTesting EXPRESS

Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-101	Sample Type: jar	Tested By:	ckg
Sample ID: 2D	Test Date: 12/19/19	Checked By:	jsc
Depth : 10-12	Test Id: 534392		
Test Comment:	---		
Visual Description:	Moist, light olive brown silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	4.7	67.4	27.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	95		
#10	2.00	89		
#20	0.85	81		
#40	0.42	72		
#60	0.25	63		
#100	0.15	50		
#140	0.11	39		
#200	0.075	28		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0356	14		
---	0.0225	10		
---	0.0131	9		
---	0.0091	7		
---	0.0065	5		
---	0.0046	4		
---	0.0034	4		
---	0.0013	2		

Coefficients

D_{85} =1.3461 mm D_{30} =0.0802 mm

D_{60} =0.2222 mm D_{15} =0.0369 mm

D_{50} =0.1528 mm D_{10} =0.0227 mm

C_u =9.789 C_c =1.275

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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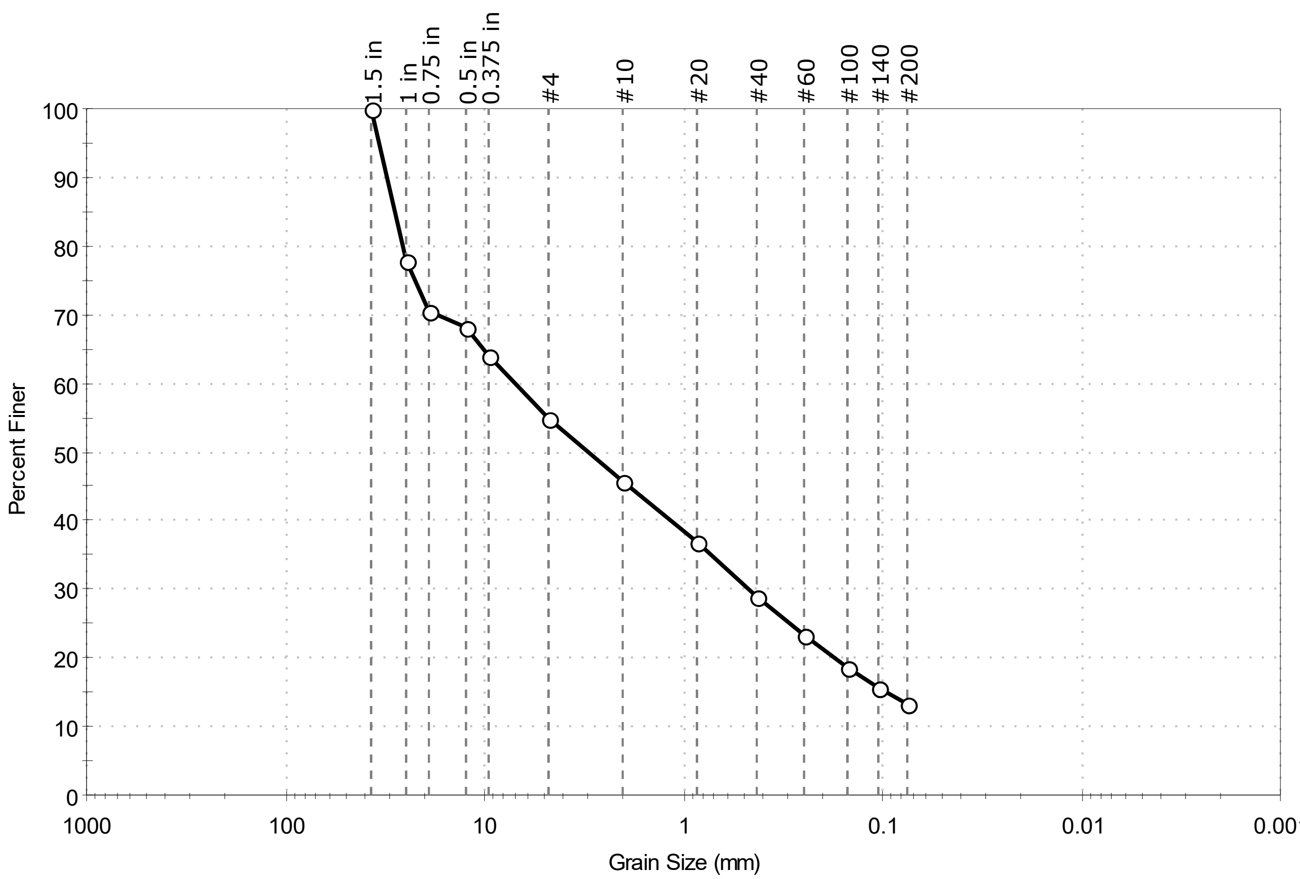
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-101	Sample Type: jar	Tested By:	ckg
Sample ID: 4D	Test Date: 12/19/19	Checked By:	jsc
Depth : 20-22	Test Id: 534385		
Test Comment:	---		
Visual Description:	Moist, olive brown silty gravel with sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	45.2	41.5	13.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	78		
0.75 in	19.00	71		
0.5 in	12.50	68		
0.375 in	9.50	64		
#4	4.75	55		
#10	2.00	46		
#20	0.85	37		
#40	0.42	29		
#60	0.25	23		
#100	0.15	19		
#140	0.11	16		
#200	0.075	13		

Coefficients

D_{85} =28.4744 mm
D_{30} =0.4682 mm
D_{60} =7.0556 mm
D_{15} =0.0964 mm
D_{50} =2.9799 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

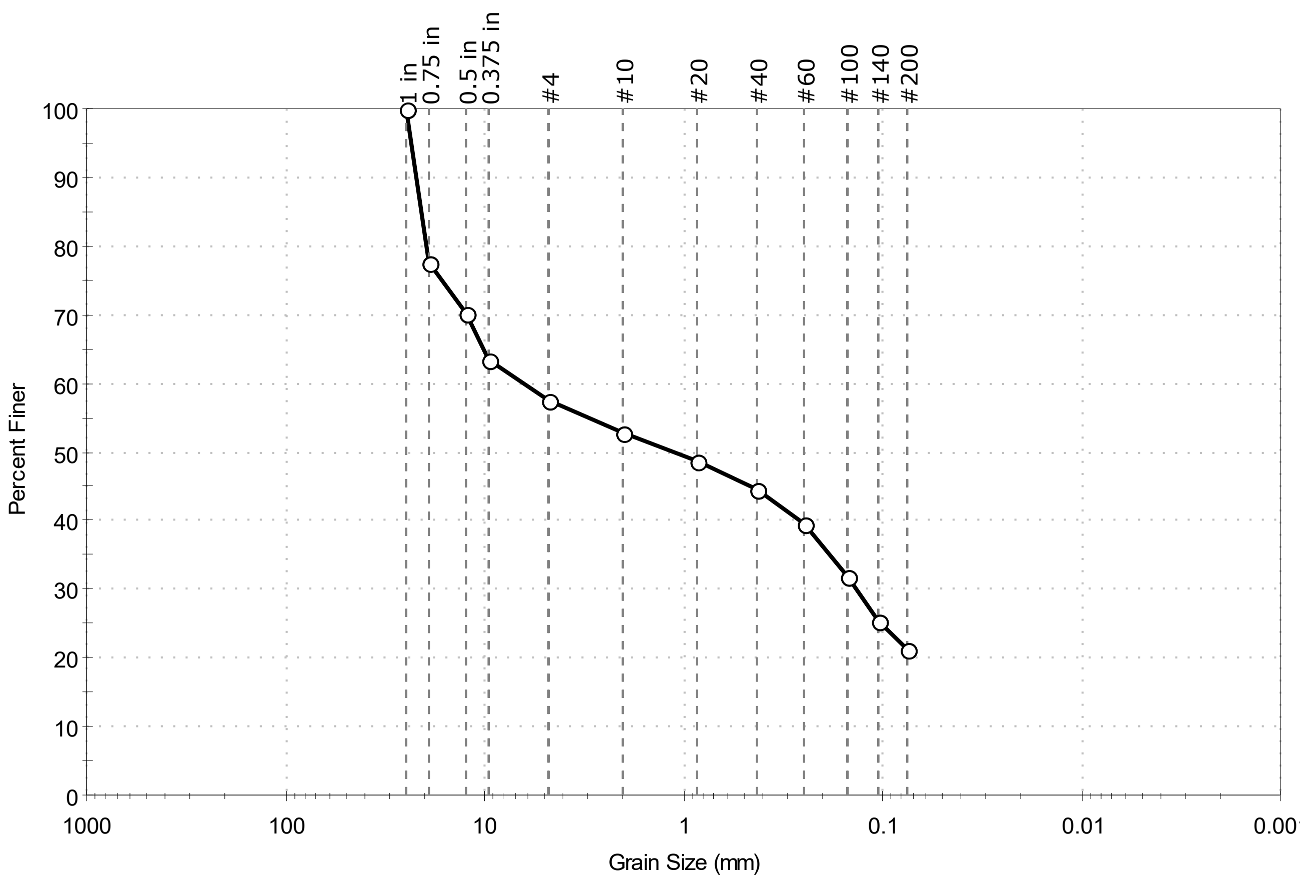
Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-101	Sample Type: jar	Tested By:	ckg
Sample ID: 6D	Test Date: 12/19/19	Checked By:	jsc
Depth : 30-30.5	Test Id: 534386		
Test Comment:	---		
Visual Description:	Moist, gray silty gravel with sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	42.6	36.1	21.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	78		
0.5 in	12.50	70		
0.375 in	9.50	63		
#4	4.75	57		
#10	2.00	53		
#20	0.85	49		
#40	0.42	45		
#60	0.25	39		
#100	0.15	32		
#140	0.11	26		
#200	0.075	21		

Coefficients

D_{85} =20.8171 mm
D_{30} =0.1357 mm
D_{60} =6.3851 mm
D_{15} =N/A
D_{50} =1.1256 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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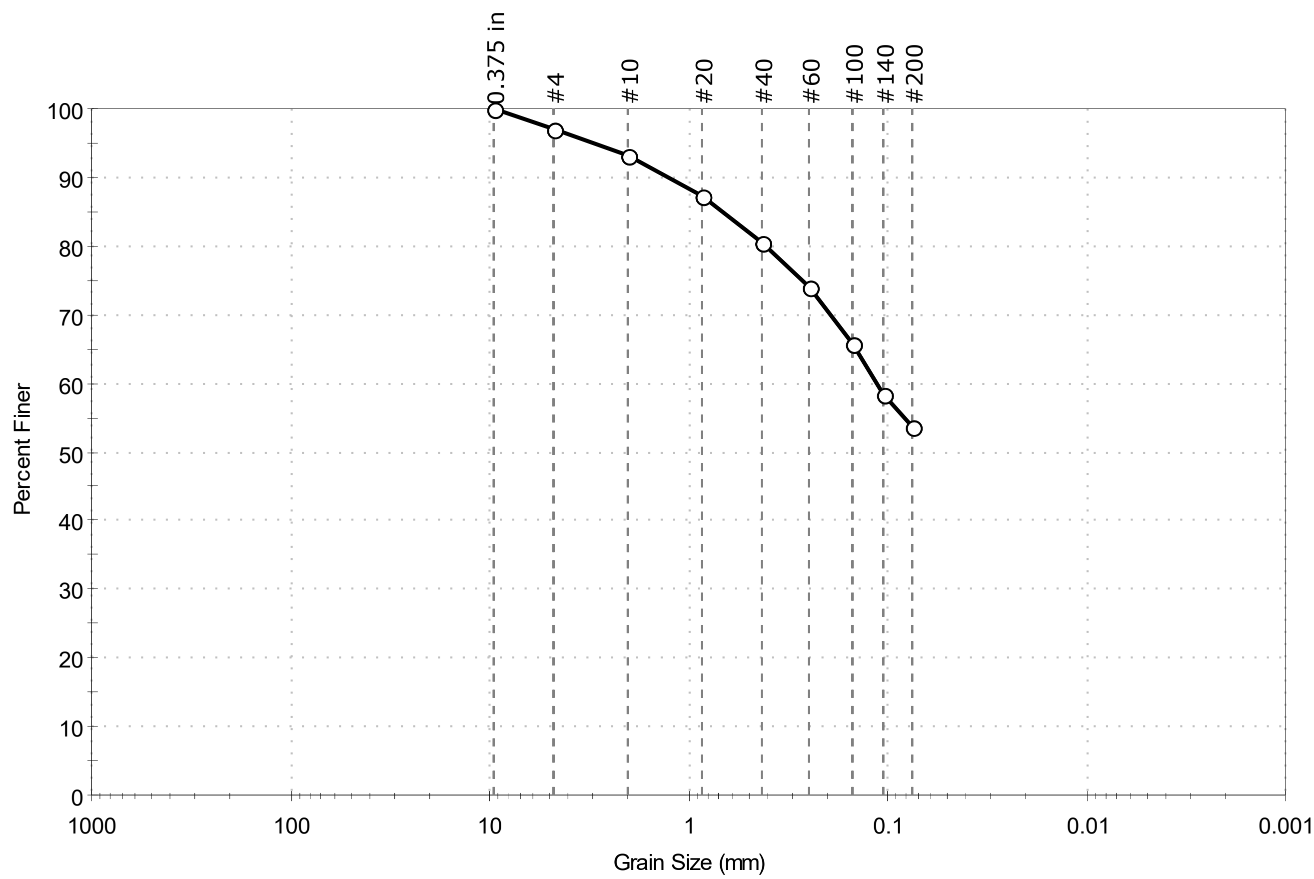
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID:	BB-WHBB-101	Sample Type: jar	Tested By: ckg
Sample ID:	7D	Test Date: 12/20/19	Checked By: jsc
Depth :	35-36	Test Id: 534387	
Test Comment:	---		
Visual Description:	Moist, dark gray sandy silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	2.8	43.5	53.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	97		
#10	2.00	93		
#20	0.85	87		
#40	0.42	81		
#60	0.25	74		
#100	0.15	66		
#140	0.11	58		
#200	0.075	54		

Coefficients

D_{85} =0.6650 mm | D_{30} =N/A

D_{60} =0.1140 mm | D_{15} =N/A

D_{50} =N/A | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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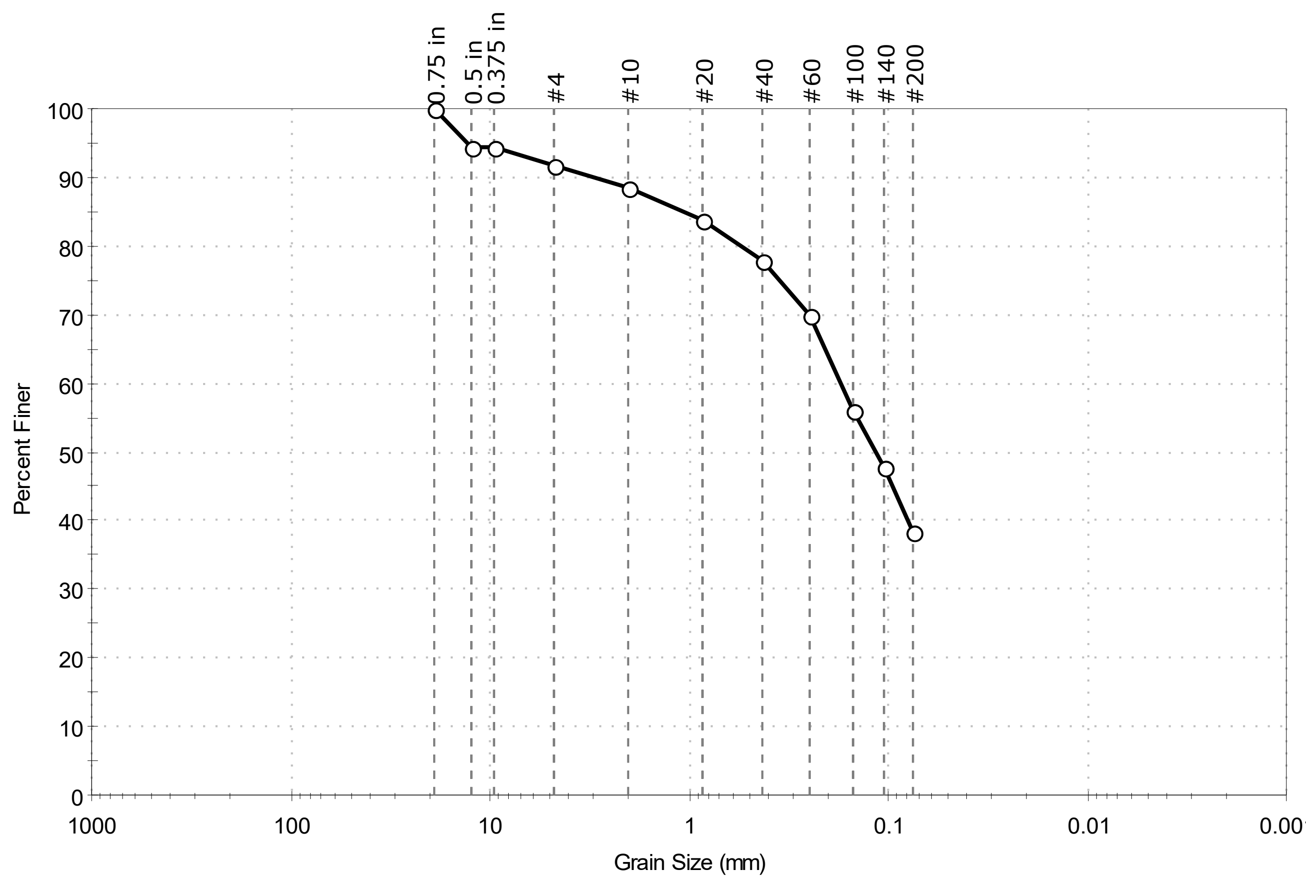
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID:	BB-WHBB-101	Sample Type: jar	Tested By: ckg
Sample ID:	10D	Test Date: 12/20/19	Checked By: jsc
Depth :	50-50.8	Test Id: 534388	
Test Comment:	---		
Visual Description:	Moist, gray silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	8.3	53.4	38.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	94		
0.375 in	9.50	94		
#4	4.75	92		
#10	2.00	88		
#20	0.85	84		
#40	0.42	78		
#60	0.25	70		
#100	0.15	56		
#140	0.11	48		
#200	0.075	38		

Coefficients

D_{85} =1.0645 mm D_{30} =N/A
D_{60} =0.1742 mm D_{15} =N/A
D_{50} =0.1166 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM   N/A

AASHTO   Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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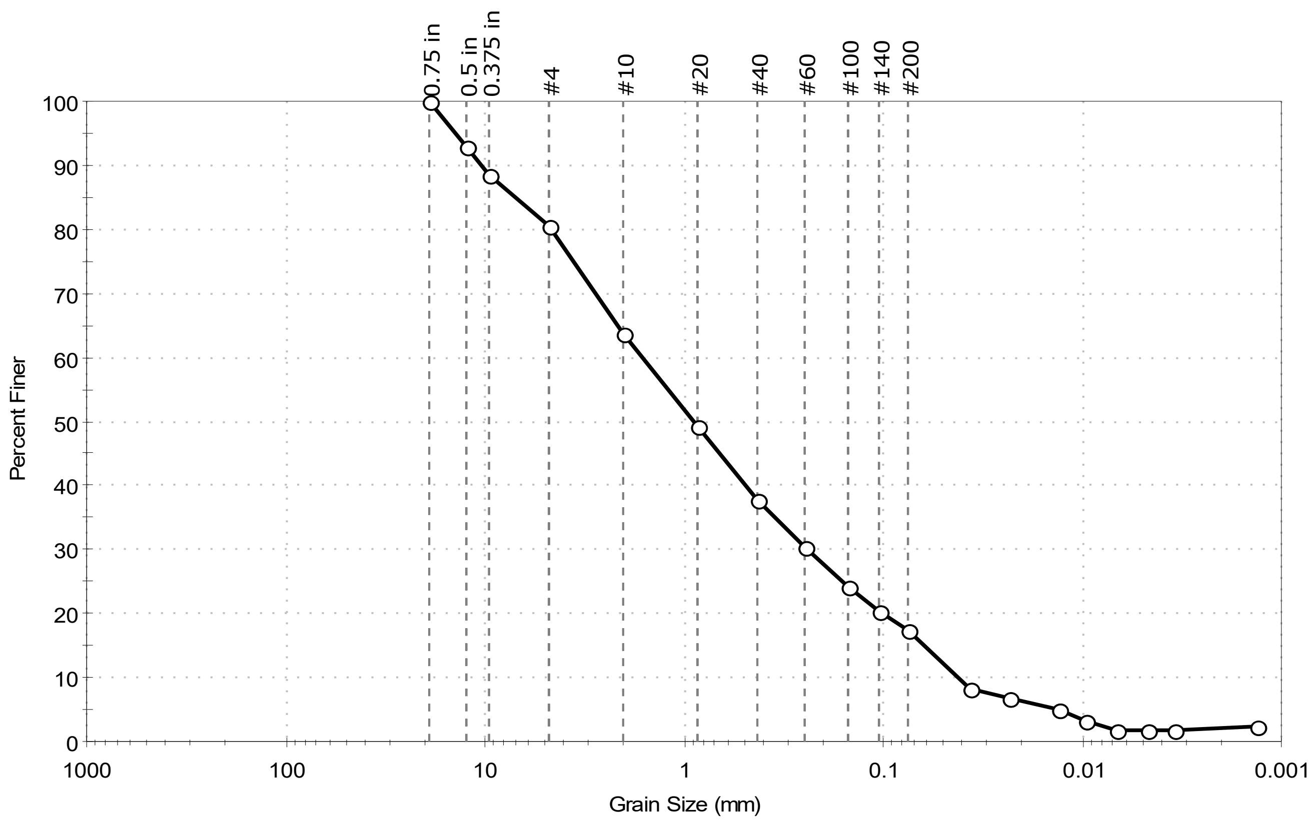
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-102	Sample Type: jar	Tested By:	ckg
Sample ID: 2D	Test Date: 12/19/19	Checked By:	jsc
Depth : 10-12	Test Id: 534393		

Test Comment: ---
Visual Description: Moist, light olive brown silty sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	19.6	62.9	17.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	93		
0.375 in	9.50	88		
#4	4.75	80		
#10	2.00	64		
#20	0.85	49		
#40	0.42	38		
#60	0.25	30		
#100	0.15	24		
#140	0.11	20		
#200	0.075	18		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0363	8		
---	0.0236	7		
---	0.0132	5		
---	0.0096	3		
---	0.0067	2		
---	0.0047	2		
---	0.0034	2		
---	0.0013	2		

Coefficients

D_{85} =7.0754 mm
D_{30} =0.2410 mm
D_{60} =1.6061 mm
D_{15} =0.0615 mm
D_{50} =0.8912 mm
D_{10} =0.0414 mm
C_u =38.795
C_c =0.873

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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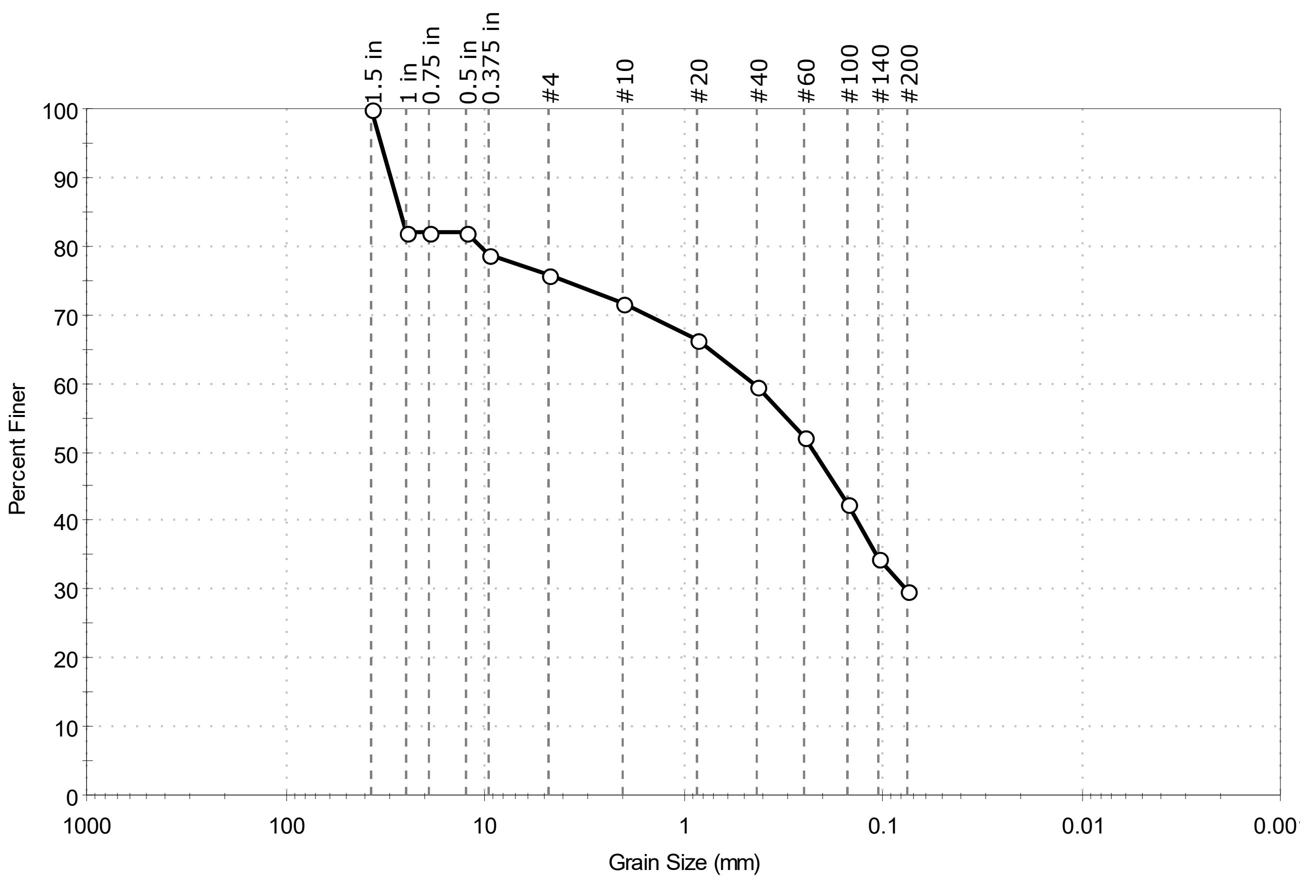
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-102	Sample Type: jar	Tested By:	ckg
Sample ID: 6D	Test Date: 12/20/19	Checked By:	jsc
Depth : 30-30.7	Test Id: 534389		
Test Comment:	---		
Visual Description:	Moist, yellowish brown silty sand with gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	24.3	46.0	29.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	82		
0.75 in	19.00	82		
0.5 in	12.50	82		
0.375 in	9.50	79		
#4	4.75	76		
#10	2.00	72		
#20	0.85	66		
#40	0.42	60		
#60	0.25	52		
#100	0.15	42		
#140	0.11	35		
#200	0.075	30		

Coefficients

D_{85} =26.7132 mm | D_{30} =0.0765 mm

D_{60} =0.4424 mm | D_{15} =N/A

D_{50} =0.2232 mm | D_{10} =N/A

C_u =N/A | C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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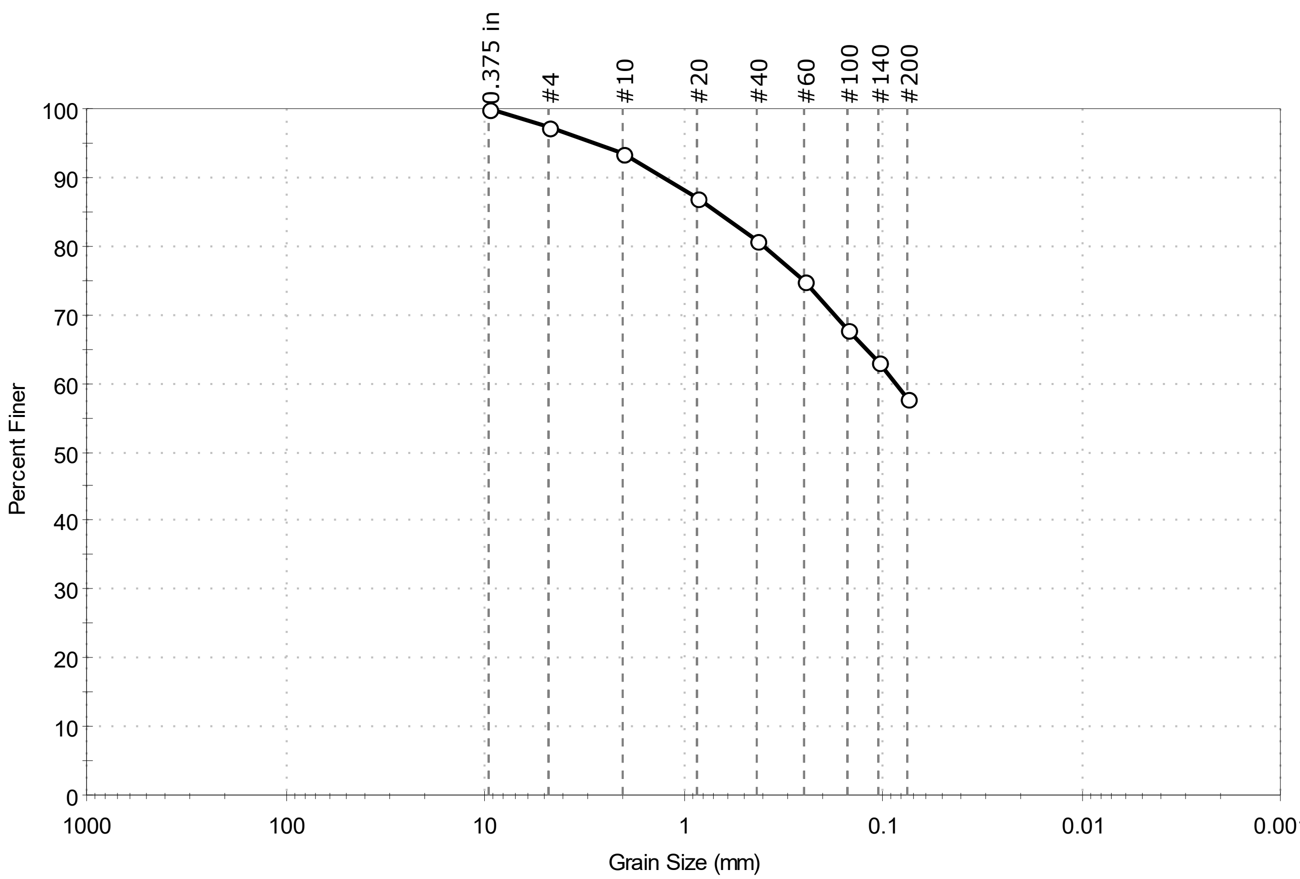
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-102	Sample Type: jar	Tested By:	ckg
Sample ID: 8D	Test Date: 12/20/19	Checked By:	jsc
Depth : 40-41	Test Id: 534390		
Test Comment:	---		
Visual Description:	Moist, gray sandy silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	2.7	39.6	57.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	97		
#10	2.00	93		
#20	0.85	87		
#40	0.42	81		
#60	0.25	75		
#100	0.15	68		
#140	0.11	63		
#200	0.075	58		

Coefficients

D_{85} =0.6743 mm D_{30} =N/A

D_{60} =0.0865 mm D_{15} =N/A

D_{50} =N/A D_{10} =N/A

C_u =N/A C_c =N/A

Classification

ASTM   N/A

AASHTO   Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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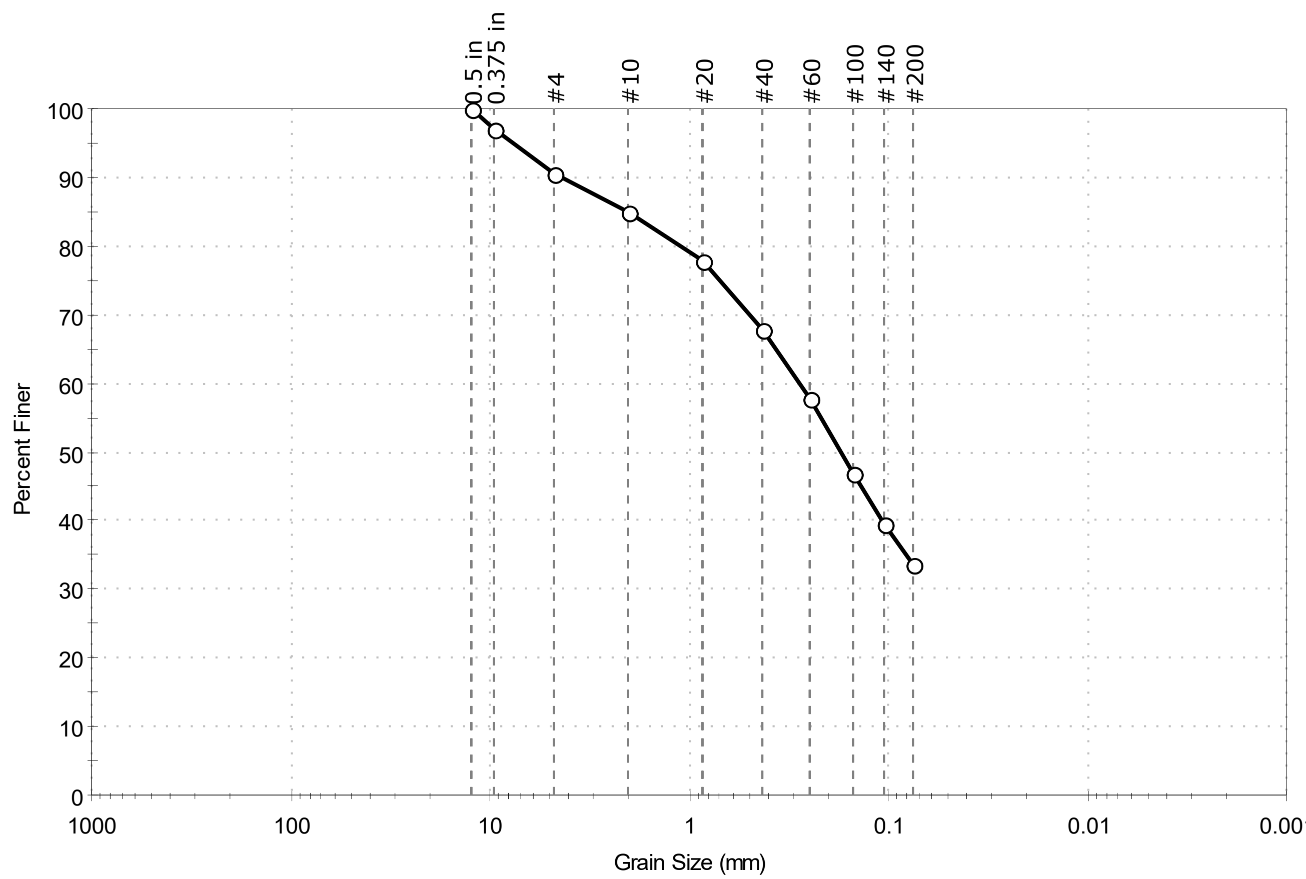
Client:	S.W. Cole Engineering, Inc.		
Project:	Hall Bridge #2341 Replace.		
Location:	Witton, ME	Project No:	GTX-311079
Boring ID: BB-WHBB-102	Sample Type: jar	Tested By:	ckg
Sample ID: 10D	Test Date: 12/20/19	Checked By:	jsc
Depth : 50-50.4	Test Id: 534391		
Test Comment:	---		
Visual Description:	Moist, gray silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	9.5	56.9	33.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	97		
#4	4.75	91		
#10	2.00	85		
#20	0.85	78		
#40	0.42	68		
#60	0.25	58		
#100	0.15	47		
#140	0.11	39		
#200	0.075	34		

Coefficients

D_{85} =2.0534 mm　D_{30} =N/A
D_{60} =0.2810 mm　D_{15} =N/A
D_{50} =0.1726 mm　D_{10} =N/A
C_u =N/A　C_c =N/A

Classification

ASTM　N/A

AASHTO　Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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S.W.COLE ENGINEERING, INC.

APPENDIX E
Calculations

SPT BLOW COUNT CONVERSION AND FRICTION ANGLE CORRELATION FOR GRANULAR SOILS

Project Name: Hall Bridge #2341 Replacement
Project No.: 19-1434
Evaluated By/Date: MAS / January 2020
Reviewed By/Date: TJM

97.7 Hammer Efficiency
u = 7.1 Depth to Water

		Boring	BB-WHBB-101				Correction Factors							
Soil Layer	Stratum	Sample No.	Top of Sample Depth (ft)	Field N-Value N_m	Total Stress at Sample Depth (psf)	Effective Stress at Sample Depth (psf)	Overburden Stress[1] C_N	Hammer Efficiency C_E	Borehole Diameter[2] C_B	Rod Length[2] C_R	Sampler[2] C_S	N_{60}	$(N1)_{60}$	Friction Angle[3] (degrees)
1	Fill	1D	5	7	625	625	1.39	1.63	1.0	0.75	1.0	12	17	31
2	Glacial Outwash	2D	10	32	1253	1072	1.21	1.63	1.0	0.75	1.0	53	65	41
2	Glacial Outwash	3D	15	53	1893	1400	1.12	1.63	1.0	0.85	1.0	87	98	49
2	Glacial Outwash	4D	20	43	2533	1728	1.05	1.63	1.0	0.95	1.0	71	75	46
2	Glacial Outwash	5D	25	44	3173	2056	0.99	1.63	1.0	0.95	1.0	72	72	46
2	Glacial Outwash	6D	30	R	3813	2384	0.94	1.63	1.0	0.95	1.0	100		52
3	Glacial Till	7D	35	R	4460	2719	0.90	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	8D	40	R	5135	3082	0.86	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	9D	45	R	5810	3445	0.82	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	10D	50	R	6485	3808	0.79	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	11D	55	R	7160	4171	0.76	1.63	1.0	1.00	1.0	100		52

1. Determination of overburden stress correction factor (CN) based on Peck, Hanson and Thornburn (1974) and guidance from AASHTO LRFD Section 10.4.6.2.4 (AASHTO LRFD 8th Ed., 2017).
2. Determination of correction factors (CB, CR, CS) based on guidance from Seed et al. (1985) and Skempton (1986) as presented in Das (2014) Principles of Foundation Engineering, 8th Ed. Table 3.5.
3. Estimated friction angle based on guidance from Peck, Hanson and Thornburn (1974)
4. Refusal field N-values reported as N60 = 100 bpf.

SPT BLOW COUNT CONVERSION AND FRICTION ANGLE CORRELATION FOR GRANULAR SOILS

S.W.COLE ENGINEERING, INC.

Project Name: Hall Bridge #2341 Replacement
Project No.: 19-1434
Evaluated By/Date: MAS / January 2020
Reviewed By/Date: TJM

97.7 Hammer Efficiency
u = 7.5 Depth to Water

		Boring	BB-WHBB-102				Correction Factors							
Soil Layer	Stratum	Sample No.	Top of Sample Depth (ft)	Field N-Value N_m	Total Stress at Sample Depth (psf)	Effective Stress at Sample Depth (psf)	Overburden Stress[1] C_N	Hammer Efficiency C_E	Borehole Diameter[2] C_B	Rod Length[2] C_R	Sampler[2] C_S	N_{60}	$(N1)_{60}$	Friction Angle[3] (degrees)
1	Fill	1D	5	9	625	625	1.39	1.63	1.0	0.75	1.0	15	21	31
2	Glacial Outwash	2D	10	44	1253	1097	1.20	1.63	1.0	0.75	1.0	72	87	46
2	Glacial Outwash	3D	15	34	1893	1425	1.12	1.63	1.0	0.85	1.0	56	63	42
2	Glacial Outwash	4D	20	24	2533	1753	1.05	1.63	1.0	0.95	1.0	40	42	38
2	Glacial Outwash	5D	25	34	3173	2081	0.99	1.63	1.0	0.95	1.0	56	56	42
2	Glacial Outwash	6D	30	R	3813	2409	0.94	1.63	1.0	0.95	1.0	100		52
3	Glacial Till	7D	35	R	4460	2744	0.90	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	8D	40	R	5135	3107	0.85	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	9D	45	R	5810	3470	0.82	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	10D	50	R	6485	3833	0.78	1.63	1.0	1.00	1.0	100		52
3	Glacial Till	11D	55	R	7160	4196	0.75	1.63	1.0	1.00	1.0	100		52

1. Determination of overburden stress correction factor (CN) based on Peck, Hanson and Thornburn (1974) and guidance from AASHTO LRFD Section 10.4.6.2.4 (AASHTO LRFD 8th Ed., 2017).
2. Determination of correction factors (CB, CR, CS) based on guidance from Seed et al. (1985) and Skempton (1986) as presented in Das (2014) Principles of Foundation Engineering, 8th Ed. Table 3.5.
3. Estimated friction angle based on guidance from Peck, Hanson and Thornburn (1974)
4. Refusal field N-values reported as N60 = 100 bpf.

Bearing Resistance of Precast Box Culvert

Foundation Soil Parameters: dense SAND, some to little silt, little to trace gravel (SM)

$\gamma_{sat} := 125\ pcf$ Saturated Unit Weight

$\phi := 32\ deg$ Undrained Friction Angle

$c_s := 0\ psf$ Undrained Shear Strength

Foundation Parameters:

$B := 19\ ft$ Foundation Width

$D_f := 3\ ft$ Embedment Depth 3 ft below streambed or design scour elevation

$D_w := 0\ ft$ Depth of Water Below Foundation (box recessed below streambed)

Service Limit State Bearing Resistance

From AASHTO LRFD Table 10.6.2.6.1-1, Presumptive Bearing Resistance for Spread Footing Foundations at the Service Limit State Modified after U.S. Department of the Navy (1982)

Bearing Material: fine sand, silty or clayey medium to fine sand (SP, SM, SC)

Consistency in Place: dense

Bearing Resistance Range: 4 to 8 ksf (medium dense to dense)

Recommended Bearing Resistance: 5 ksf

For dense, SAND, some to little silt, little to trace gravel (SM)

Recommended Nominal Bearing Resistance (Service Limit) = 5 ksf

Strength Limit State Bearing Resistance

From AASHTO LRFD Section 10.6.3.1.2a

LRFD Eq. 10.6.3.1.2a-1

$$q_n = c_s \cdot N_c + \gamma_{sat} \cdot D_f \cdot N_q \cdot C_{wq} + 0.5 \cdot \gamma_{sat} \cdot B \cdot N_\gamma \cdot C_{w\gamma}$$

From LRFD Table 10.6.3.1.2a-1

$N_c := 35.5$ $N_q := 23.2$ $N_\gamma := 30.2$

From Table 10.6.3.1.2a-2, for Dw = 0.0

$C_{wq} := 0.5$ $C_{w\gamma} := 0.5$

Nominal Bearing Resistance

LRFD Eqn 10.6.3.1.2a-1

$$q_n := c_s \cdot N_c + \gamma_{sat} \cdot D_f \cdot N_q \cdot C_{wq} + 0.5 \cdot \gamma_{sat} \cdot B \cdot N_\gamma \cdot C_{w\gamma}$$

$q_n = 22.3\ ksf$

Factored Bearing Resistance

From AASHTO LRFD Table 10.5.5.2.2-1, Resistance Factor for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

$\varphi_b := 0.45$

$q_r := \varphi_b \cdot q_n = 10\ ksf$

Factored Bearing Resistance (Strength Limit) = 10 ksf
for 19-foot wide precast box culvert

10.6.2.6—Bearing Resistance at the Service Limit State

10.6.2.6.1—Presumptive Values for Bearing Resistance

The use of presumptive values shall be based on knowledge of geological conditions at or near the structure site.

C10.6.2.6.1

Unless more appropriate regional data are available, the presumptive values given in Table C10.6.2.6.1-1 may be used. These bearing resistances are settlement limited, e.g., 1.0 in., and apply only at the service limit state.

Table C10.6.2.6.1-1—Presumptive Bearing Resistance for Spread Footing Foundations at the Service Limit State Modified after U.S. Department of the Navy (1982)

Type of Bearing Material	Consistency in Place	Bearing Resistance (ksf) Ordinary Range	Bearing Resistance (ksf) Recommended Value of Use
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks)	Very hard, sound rock	120–200	160
Foliated metamorphic rock: slate, schist (sound condition allows minor cracks)	Hard sound rock	60–80	70
Sedimentary rock: hard cemented shales, siltstone, sandstone, limestone without cavities	Hard sound rock	30–50	40
Weathered or broken bedrock of any kind, except highly argillaceous rock (shale)	Medium hard rock	16–24	20
Compaction shale or other highly argillaceous rock in sound condition	Medium hard rock	16–24	20
Well-graded mixture of fine- and coarse-grained soil: glacial till, hardpan, boulder clay (GW-GC, GC, SC)	Very dense	16–24	20
Gravel, gravel-sand mixture, boulder-gravel mixtures (GW, GP, SW, SP)	Very dense Medium dense to dense Loose	12–20 8–14 4–12	14 10 6
Coarse to medium sand, and with little gravel (SW, SP)	Very dense Medium dense to dense Loose	8–12 4–8 2–6	8 6 3
Fine to medium sand, silty or clayey medium to coarse sand (SW, SM, SC)	Very dense Medium dense to dense Loose	6–10 4–8 2–4	6 5 3
Fine sand, silty or clayey medium to fine sand (SP, SM, SC)	Very dense Medium dense to dense Loose	6–10 4–8 2–4	6 5 3
Homogeneous inorganic clay, sandy or silty clay (CL, CH)	Very dense Medium dense to dense Loose	6–12 2–6 1–2	8 4 1
Inorganic silt, sandy or clayey silt, varved silt-clay-fine sand (ML, MH)	Very stiff to hard Medium stiff to stiff Soft	4–8 2–6 1–2	6 3 1

10.6.2.6.2—Semiempirical Procedures for Bearing Resistance

Bearing resistance on rock shall be determined using empirical correlation to the Geomechanic Rock Mass Rating System, RMR. Local experience should be considered in the use of these semi-empirical procedures.

If the recommended value of presumptive bearing resistance exceeds either the unconfined compressive strength of the rock or the nominal resistance of the

Modulus of Subgrade Reaction

Reference: Bowles (1996) Foundation Analysis and Design, 5th Ed.
Das (2010) Principles of Foundation Engineering, 7th Ed.

Determine Foundation and Soil Properties

Foundation Soil: dense SAND, some to little silt, little to trace gravel (SM)
Assumed Subgrade El. = 471 ft (stream El) - 3 ft (emb) - 1 ft (bedding thickness) = 467 ft

$\mu_s := 0.35$ Poisson's Ratio (Bowles Table 2-7, pg 123)
typical value 0.3-0.4 - sand, gravelly sand

$N_{60} := 40$ N60 Range 40 bpf to Refusal (See SPT Correction Worksheets)

$N_{55} := N_{60} \cdot \frac{0.6}{0.55} = 44$

Young's Modulus
(from Bowles Table 5-6, pg 316)

$E_s := \begin{bmatrix} 2600 \\ 2900 \end{bmatrix} kPa \cdot N_{55} = \begin{bmatrix} 2370 \\ 2643 \end{bmatrix} ksf$ Sands, all (normally consolidated)

$E_s := 1200\ kPa\ (N_{55} + 6) = 1244\ ksf$ Gravelly sand

$E_s := 600\ kPa \cdot (N_{55} + 6) + 2000\ kPa = 664\ ksf$ Gravelly sand with N>15

Use $E_s := 1200\ ksf$ From Bowles Table 2-8
for dense sand Es = 1044-1691 ksf (50-81 MPa)

Foundation Parameters:

$B := 19\ ft$ Foundation Width

$L_f := 52\ ft$ Length of Box Culvert ***ASSUMED***

$D_f := 3\ ft$ Base Embedment Depth

$B' := 0.5 \cdot B = 10\ ft$

$L'_f := 0.5 \cdot L_f = 26\ ft$

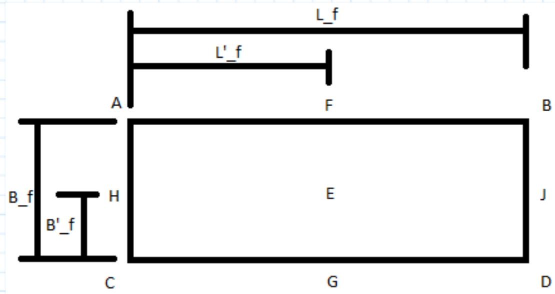
Determine Steinbrenner Influence Factors

$H_s := 25\ ft$ Thickness of stratum 25 ft

$\frac{D_f}{B} = 0.16$ Depth Ratio

Corner at Points A, B, C & D

Center at Point E



$M_{corner} := \frac{L_f}{B} = 2.7$ $N_{corner} := \frac{H_s}{B} = 1.3$

$M_{center} := \frac{L'_f}{B'} = 2.7$ $N_{center} := \frac{H_s}{B'} = 2.6$

From Bowles Table 5-2 (pg 304 and 305)

$I_{1\_corner} := 0.171$ $I_{2\_corner} := 0.118$

$I_{1\_center} := 0.353$ $I_{2\_center} := 0.107$

$$I_{s\_corner} := I_{1\_corner} + \frac{1 - 2\ \mu_s}{1 - \mu_s} \cdot I_{2\_corner} = 0.225$$

$$I_{s\_center} := I_{1\_center} + \frac{1 - 2\ \mu_s}{1 - \mu_s} \cdot I_{2\_center} = 0.402$$

From Bowles Figure 5-7 (pg 303)

$I_{F\_corner} := 0.64$ $I_{F\_center} := 0.64$

$$E'_s := \frac{\left(1 - {\mu_s}^2\right)}{E_s}$$

$$k_{1\_corner} := \frac{1}{B \cdot E'_s \cdot I_{s\_corner} \cdot I_{F\_corner}} = 289\ pci$$

$$k_{1\_center} := \frac{1}{B' \cdot E'_s \cdot I_{s\_center} \cdot I_{F\_center}} = 323\ pci$$

From Das Principles of Foundation Engineering, 7th Ed. Eqn. 6.44

$$k_{s\_corner} := \frac{k_{1\_corner} \cdot \left(1 + 0.5 \frac{B}{L_f}\right)}{1.5} = 228 \ pci$$

$$k_{s\_center} := \frac{k_{1\_center} \cdot \left(1 + 0.5 \frac{B'}{L'_f}\right)}{1.5} = 255 \ pci$$

Bearing Resistance of 3-sided Frame

Foundation Soil Parameters: dense SAND, some to little silt, little to trace gravel (SM)

$\gamma_{sat} := 125\ pcf$ Saturated Unit Weight

$\phi := 32\ deg$ Undrained Friction Angle

$c_s := 0\ psf$ Undrained Shear Strength

Foundation Parameters:

$$B := \begin{bmatrix} 8 \\ 10 \\ 12 \\ 14 \\ 16 \end{bmatrix} ft$$ Foundation Width(s)

$D_f := 2\ ft$ Embedment Depth 3 ft below streambed or design scour elevation

$D_w := 0\ ft$ Depth of Water Below Foundation

Service Limit State Bearing Resistance

From AASHTO LRFD Table 10.6.2.6.1-1, Presumptive Bearing Resistance for Spread Footing Foundations at the Service Limit State Modified after U.S. Department of the Navy (1982)

Bearing Material: fine sand, silty or clayey medium to fine sand (SP, SM, SC)

Consistency in Place: dense

Bearing Resistance Range: 4 to 8 ksf (medium dense to dense)

Recommended Bearing Resistance: 5 ksf

For dense, SAND, some to little silt, little to trace gravel (SM)

Recommended Nominal Bearing Resistance (Service Limit) = 5 ksf

Strength Limit State Bearing Resistance

From AASHTO LRFD Section 10.6.3.1.2a

LRFD Eq. 10.6.3.1.2a-1

$$q_n = c_s \cdot N_c + \gamma_{sat} \cdot D_f \cdot N_q \cdot C_{wq} + 0.5 \cdot \gamma_{sat} \cdot B \cdot N_\gamma \cdot C_{w\gamma}$$

From LRFD Table 10.6.3.1.2a-1

$N_c := 35.5$ $N_q := 23.2$ $N_\gamma := 30.2$

From Table 10.6.3.1.2a-2, for Dw = 0.0

$C_{wq} := 0.5$ $C_{w\gamma} := 0.5$

Nominal Bearing Resistance

LRFD Eqn 10.6.3.1.2a-1

$$q_n := c_s \cdot N_c + \gamma_{sat} \cdot D_f \cdot N_q \cdot C_{wq} + 0.5 \cdot \gamma_{sat} \cdot B \cdot N_\gamma \cdot C_{w\gamma}$$

$$q_n = \begin{bmatrix} 10.5 \\ 12.3 \\ 14.2 \\ 16.1 \\ 18 \end{bmatrix} ksf \quad \text{for} \quad B = \begin{bmatrix} 8 \\ 10 \\ 12 \\ 14 \\ 16 \end{bmatrix} ft$$

Factored Bearing Resistance

From AASHTO LRFD Table 10.5.5.2.2-1, Resistance Factor for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

$\varphi_b := 0.45$

$$q_r := \varphi_b \cdot q_n = \begin{bmatrix} 4.7 \\ 5.6 \\ 6.4 \\ 7.3 \\ 8.1 \end{bmatrix} ksf \quad \text{for} \quad B = \begin{bmatrix} 8 \\ 10 \\ 12 \\ 14 \\ 16 \end{bmatrix} ft$$

Factored Bearing Resistance (Strength Limit)

Estimated Frost Penetration Depth

Based on MaineDOT Bridge Design Guide Section 5.2.1

Site Location: Wilton, Maine

Soil Conditions: SAND, some to little silt, little to trace gravel (SM)
(Coarse Grained)

Step 1. From Figure 5-1: Design Freezing Index = ±1875 freezing degree-days

Step 2. From laboratory test results:
natural soil water content: 7.3 to 13.3%
USE WC = 10%

Step 3. From Table 5-1: Interpolate frost penetration for w = 10%

$$DFI := 1775$$

$$DFI_1 := 1700 \quad d_1 := 87.5\ in$$

$$DFI_2 := 1800 \quad d_2 := 90.1\ in$$

$$d_{frost} := d_1 + (d_2 - d_1) \cdot \left(\frac{DFI - DFI_1}{DFI_2 - DFI_1} \right)$$

$$d_{frost} = 89.5\ in$$

$$d_{frost} = 7.5\ ft$$

Calculated by / Date: MAS / January 2020
Checked by: TJM

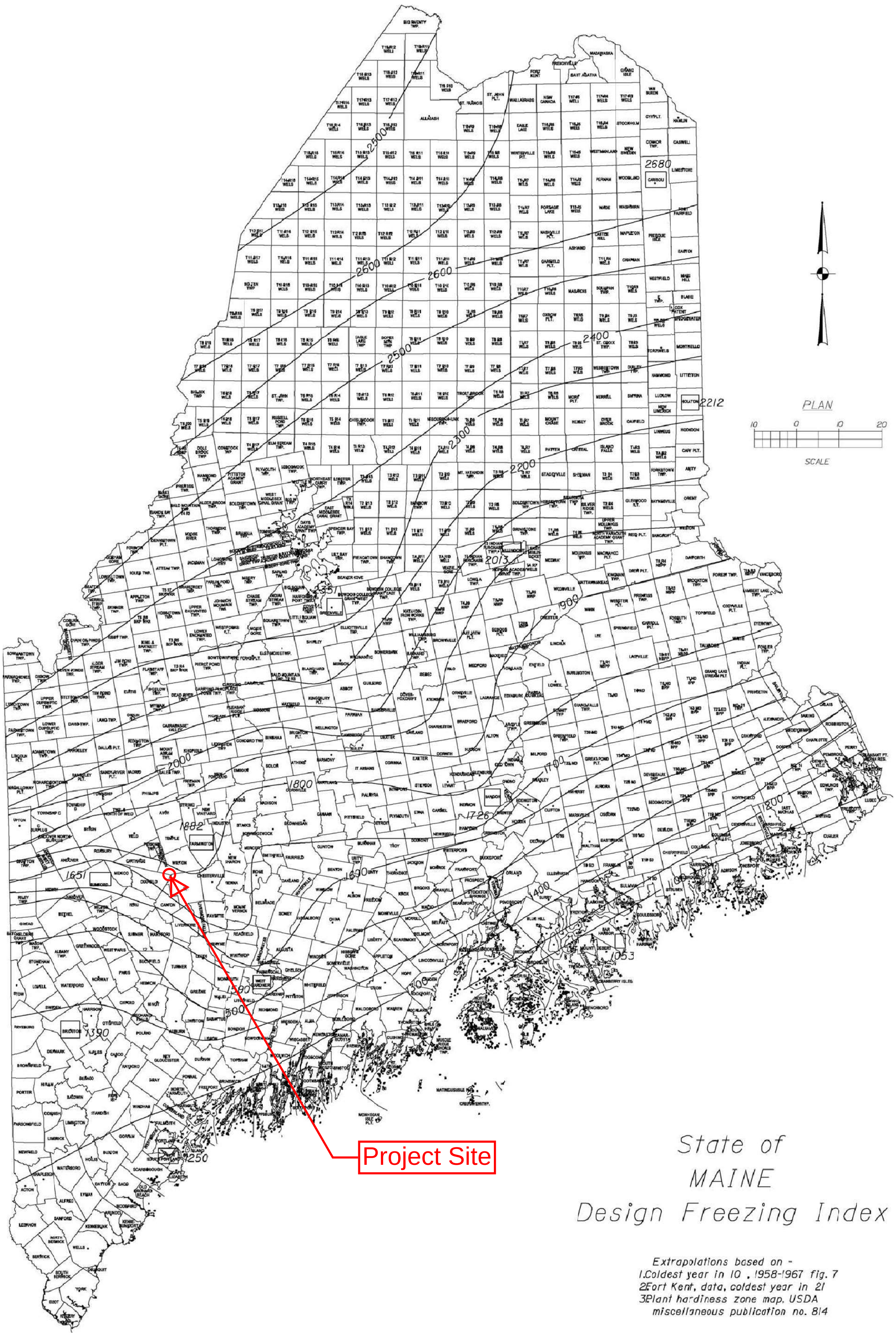


Figure 5-1 Maine Design Freezing Index Map

5.2 General

5.2.1 Frost

Any foundation placed on seasonally frozen soils must be embedded below the depth of frost penetration to provide adequate frost protection and to minimize the potential for freeze/thaw movements. Fine-grained soils with low cohesion tend to be most frost susceptible. Soils containing a high percentage of particles smaller than the No. 200 sieve also tend to promote frost penetration.

In order to estimate the depth of frost penetration at a site, Table 5-1 has been developed using the Modified Berggren equation and Figure 5-1 Maine Design Freezing Index Map. The use of Table 5-1 assumes site specific, uniform soil conditions where the Geotechnical Designer has evaluated subsurface conditions. Coarse-grained soils are defined as soils with sand as the major constituent. Fine-grained soils are those having silt and/or clay as the major constituent. If the make-up of the soil is not easily discerned, consult the Geotechnical Designer for assistance. In the event that specific site soil conditions vary, the depth of frost penetration should be calculated by the Geotechnical Designer.

Table 5-1 Depth of Frost Penetration

Design Freezing Index	Frost Penetration (in)					
	Coarse Grained			Fine Grained		
	w=10%	w=20%	w=30%	w=10%	w=20%	w=30%
1000	66.3	55.0	47.5	47.1	40.7	36.9
1100	69.8	57.8	49.8	49.6	42.7	38.7
1200	73.1	60.4	52.0	51.9	44.7	40.5
1300	76.3	63.0	54.3	54.2	46.6	42.2
1400	79.2	65.5	56.4	56.3	48.5	43.9
1500	82.1	67.9	58.4	58.3	50.2	45.4
1600	84.8	70.2	60.3	60.2	51.9	46.9
1700	87.5	72.4	62.2	62.2	53.5	48.4
1800	90.1	74.5	64.0	64.0	55.1	49.8
1900	92.6	76.6	65.7	65.8	56.7	51.1
2000	95.1	78.7	67.5	67.6	58.2	52.5
2100	97.6	80.7	69.2	69.3	59.7	53.8
2200	100.0	82.6	70.8	71.0	61.1	55.1
2300	102.3	84.5	72.4	72.7	62.5	56.4
2400	104.6	86.4	74.0	74.3	63.9	57.6
2500	106.9	88.2	75.6	75.9	65.2	58.8
2600	109.1	89.9	77.1	77.5	66.5	60.0

Notes: 1. w = water content
2. Where the Freezing Index and/or water content is between the presented values, linear interpretation may be used to determine the frost penetration.

Determine Seismic Site Classification per AASHTO LRFD Table C3.10.3.1-1 - Method B

Data From Boring BB-WHBB-101

Layer No.	Layer Description	Depth Range (ft)		N_{60} values recorded within layer								Average N_{60} value	Layer Thickness	d_i/N_i
		Top	End									Ni	di	
1	Fill	0	10	11								11.0	10	0.91
2	Glacial Outwash	10	35	52	86	70	44	100				70.4	25	0.36
3	Glacial Till	35	55.3	100	100	100	100	100				100.0	20.3	0.20
												Σ =	55.3	1.47

N_bar = di/di/Ni = 37.69
Site Class D

Data From Boring BB-WHBB-102

Layer No.	Layer Description	Depth Range (ft)		N_{60} values recorded within layer								Average N_{60} value	Layer Thickness	d_i/N_i
		Top	End									Ni	di	
1	Fill	0	10	15								15.0	10	0.67
2	Glacial Outwash	10	35	72	55	39	55	100				64.2	25	0.39
3	Glacial Till	10	55.3	100	100	100	100	100				100.0	45.3	0.45
												Σ =	80.3	1.51

N_bar = di/di/Ni = 53.21
Site Class C

NOTES:
1. Weight of rod (WOR) and weight of hammer (WOH) values taken as N=1
2. N60 values > 100 taken as N=100
3. N60 value for bedrock taken as N=100

Calculated by / Date: MAS / January 2020
Checked by: TJM

WIN 023144 - Hall Bridge #2341 Replacement

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 44.572802
Longitude = -070.300935
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.084	PGA - Site Class B
0.2	0.174	Ss - Site Class B
1.0	0.049	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 44.572802
Longitude = -070.300935
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class D - Fpga = 1.60, Fa = 1.60, Fv = 2.40
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.135	As - Site Class D
0.2	0.278	SDs - Site Class D
1.0	0.117	SD1 - Site Class D

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Design Response Spectra for Site Class D
Latitude = 44.572802
Longitude = -070.300935
As = FpgaPGA, SDs = FaSs, SD1 = FvS1
Site Class D - Fpga = 1.60, Fa = 1.60, Fv = 2.40
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	Sd in.	
0.000	0.135	0.000	T = 0.0, Sa = As
0.084	0.278	0.019	
0.200	0.278	0.109	T = 0.2, Sa = SDs
0.419	0.278	0.477	T = Ts, Sa = SDs
0.500	0.233	0.569	
0.600	0.194	0.683	
0.800	0.146	0.911	
1.000	0.117	1.139	T = 1.0, Sa = SD1
1.200	0.097	1.367	
1.400	0.083	1.594	
1.600	0.073	1.822	
1.800	0.065	2.050	
2.000	0.058	2.278	
2.200	0.053	2.505	
2.400	0.049	2.733	
2.600	0.045	2.961	
2.800	0.042	3.189	
3.000	0.039	3.416	

3.200	0.036	3.644
3.400	0.034	3.872
3.600	0.032	4.100
3.800	0.031	4.327
4.000	0.029	4.555