MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

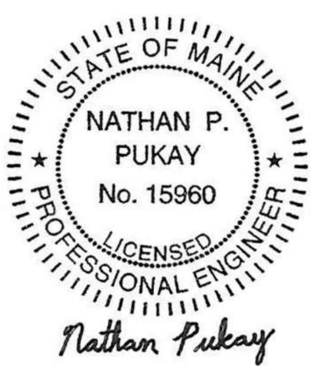
GEOTECHNICAL DESIGN REPORT

For the Replacement of:

HEMLOCK STREAM BRIDGE
STATE ROUTE 116 OVER HEMLOCK STREAM
ARGYLE TOWNSHIP, MAINE

Prepared by:

Nathan Pukay, P.E.
Transportation Engineer II



Reviewed by:

Laura Krusinski, P.E.
Senior Geotechnical Engineer

Penobscot County
WIN 21687.00

Soils Report 2025-19
Bridge No. 3735

Federal Project No. STP-2168(700)
August 11, 2025

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1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present subsurface information and provide geotechnical design recommendations for the replacement of Hemlock Stream Bridge which carries State Route 116 over Hemlock Stream in Argyle Township, Maine. This report presents the subsurface information obtained at the site during the subsurface investigation, geotechnical design recommendations, and construction recommendations for the new substructures.

The existing Hemlock Stream Bridge, constructed in 1940, is a three-sided cast-in-place concrete frame with a 25-foot span and flared cast-in-place wingwalls at all four corners. The abutment footings are founded on bedrock. According to the 2022 Maine Department of Transportation (MaineDOT) Bridge Inspection Report, the bridge superstructure is in poor condition, with extensive longitudinal cracking, stalactite formation, and efflorescence on the underside of the deck slab. The substructure is in fair condition, with minor cracking at the abutments and more pronounced deterioration of the wingwalls.

The proposed replacement structure consists of a 75-foot, single-span, precast concrete Northeast Extreme Tee (NEXT) F beam bridge founded on rock-socketed, pile-supported integral abutments. The abutments will include cantilevered, in-line wingwalls on the upstream ends and cantilevered U-shaped return walls (U-walls) on the downstream ends. 1.75H:1V (horizontal:vertical) riprap slopes will be constructed in front of the new integral abutments and U-walls. The new bridge will be located on a horizontal alignment that closely matches the existing. The vertical alignment will be raised up to 6 inches at Abutment No. 2 to establish a slight longitudinal slope for deck drainage.

Traffic will be maintained on a temporary detour built on the upstream side of the existing bridge.

2.0 GEOLOGIC SETTING

Hemlock Stream Bridge carries State Route 116 over Hemlock Stream as shown on Sheet 1 – Location Map.

The Maine Geological Survey (MGS) Surficial Geology Map of the Passadumkeag Quadrangle, Maine, Open-File No. 81-4 (1981), indicates the surficial soils in the vicinity of the bridge project consist of glacial marine deposits, stream alluvium, and glacial till. Glacial marine deposits consist of silt, clay and sand of the Presumpscot Formation. Stream alluvium is sand, gravel, and silt deposited on flood plains of modern streams. Glacial till is a heterogeneous mixture of sand, silt, clay, and stones deposited by glacial ice.

The MGS Bedrock Geology of Maine (1985) maps the bedrock at the site as calcareous sandstone of the Vassalboro Formation.

3.0 SUBSURFACE INVESTIGATION

Eight test borings and two probes were drilled to explore subsurface conditions at the site. Borings BB-AHS-101, -102, -201, -302 and bridge probe BP-AHS-301 were drilled at or near the location of proposed Abutment No. 1. Borings BB-AHS-103, -104, -202, -304 and bridge probe BP-AHS-303 were drilled at or near the location of proposed Abutment No. 2. The boring locations are shown on Sheet 2 – Boring Location Plan and Interpretive Subsurface Profile.

The 100-series borings were drilled in February 2017 by S.W. Cole Explorations. The 200-series borings were drilled in April 2022 by S.W. Cole Explorations to confirm bedrock elevations and rock quality for a precast concrete arch bridge design. The remaining 300-series borings and probes were drilled in May 2024 by the MaineDOT Drill Crew to investigate bedrock elevations and rock quality at abutment centerlines for an integral abutment bridge design. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring logs provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs.

Bridge probes were performed by advancing a solid stem auger to refusal. Borings were performed by using a combination of solid stem auger, cased wash boring and rock coring techniques. Soil samples were typically obtained 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 sum of the blows for the second and third intervals is the N-value, or standard penetration resistance. The drill rig used by S.W. Cole Explorations for the 100-series borings performed SPT sampling using a 140-lb safety hammer with a rope and cathead. The drill rigs used for the remaining borings were equipped with automatic hammers to drive the split spoon. The hammers were calibrated per ASTM D 4633 "Standard Test Method for Energy Measurement for Dynamic Penetrometers" to establish hammer efficiency factors. All N-values discussed in this report are corrected N-values computed by applying the hammer efficiency factors. The hammer efficiency factors and both the raw field N-value and corrected N-value (N_{60}) are shown on the boring logs.

Bedrock was cored in eight of the borings using NQ-2" core barrels and the Rock Quality Designation (RQD) of the cores calculated. MaineDOT geotechnical engineers selected the boring locations and drilling methods, designated type and depth of sampling techniques, and identified field-testing requirements. Geotechnical engineers from S.W. Cole Engineering (2017) and MaineDOT (2022, 2024) logged the subsurface conditions encountered in the borings. The borings were located in the field using taped measurements at the completion of the drilling program and then located by MaineDOT Survey.

4.0 LABORATORY TESTING

A laboratory testing program was conducted on selected soil and bedrock core samples recovered from the test borings to assist in soil classification, evaluation of engineering properties of the soil and bedrock, and geologic assessment of the project site. Laboratory testing on soil samples consisted of four standard grain size analysis with natural water content and four grain size analyses with hydrometer and natural water content. Two bedrock core samples were tested for unconfined compressive strength and elastic moduli.

Soil laboratory testing was performed at the MaineDOT Lab in Bangor, Maine. Rock core testing was performed by GeoTesting Express (GTX) of Acton, Massachusetts. The results of soil and rock tests are included in Appendix C – Laboratory Test Results. Moisture content information and other soil and rock test results are also shown on the boring logs provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs.

5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered in the test borings generally consisted of Fill, Alluvium, and Glacial Till overlying Bedrock. The boring logs are provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs. A generalized subsurface profile is shown on Sheet 2 – Boring Location Plan and Interpretive Subsurface Profile. The following paragraphs discuss the subsurface conditions encountered.

5.1 Fill

A layer of Fill was encountered in the test borings. The thickness of the Fill unit encountered was approximately 6 to 11 feet. The fill materials encountered consisted of:

- Brown, SAND, trace to some gravel, trace to little silt.

Corrected SPT N-values in the Fill unit ranged from 9 to 12 blows per foot (bpf) indicating the fill is loose to medium dense in consistency.

Two grain size analyses performed on samples recovered from the Fill unit indicated the material is classified as A-1-b under the AASHTO Soil Classification System and SW-SM under the Unified Soil Classification System (USCS). The natural water contents of the samples tested were 5 and 8 percent.

5.2 Alluvium

A deposit of Alluvium was encountered in the 100-series and 200-series borings beneath the fill unit. The encountered thickness was approximately 3 to 7 feet. The deposit consisted of:

- Brown to brown-grey, SAND, trace to some gravel, little to some silt, trace clay;
- Brown to brown-grey, fine to medium Sandy SILT, trace gravel, trace clay;
- Brown, SILT, some fine to medium sand, trace clay, trace gravel; and
- Cobbles and wood.

Corrected SPT N-values within the fine-grained Alluvium ranged from 3 to 5 bpf indicating the fine-grained Alluvium is soft to medium stiff in consistency.

Two corrected SPT N-values within the coarse-grained Alluvium were 4 and 12 bpf indicating the deposit is very loose to medium dense in consistency.

Five grain size analyses conducted on samples of the deposit indicated the material is classified as A-2-4, A-4, and A-1-b under the AASHTO Soil Classification System and SC-SM and CL under the USCS. The natural water contents of the samples tested ranged from 16 to 26 percent.

5.3 Glacial Till

Glacial Till was encountered in all borings underlying either the fill unit or alluvium deposit. The thickness of the Glacial Till deposit encountered was approximately 2 to 14 feet. The Glacial Till varied from:

- Grey, SAND, some silt, trace gravel;
- Grey, Silty SAND, trace gravel;
- Grey, Gravelly SAND, little silt;
- Brown to grey, GRAVEL, little sand, little silt;
- Grey, Silty GRAVEL, little sand; and
- Cobbles and wood chips.

Corrected SPT N-values within the Glacial Till ranged from 33 to greater than 50 bpf indicating the deposit is dense to very dense in consistency.

One grain size analysis performed on a sample recovered from the deposit resulted in the material being classified as A-1-b under the AASHTO Soil Classification System and SM under the USCS. The natural water content of the sample tested was 12 percent.

5.4 Bedrock

Bedrock was encountered and cored in eight of the project borings. The table below summarizes the borings in which bedrock was cored, the depth to bedrock, corresponding top of bedrock elevations and RQD’s.

Boring	Station	Offset (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock Surface (feet)	RQD (%) (R1, R2, R3, R4)
BB-AHS-101	7+76.2	6.0 Rt	21.5	109.0	19, 70, 91
BB-AHS-102	7+81.5	8.1 Lt	18.0	112.6	81, 100, 66
BB-AHS-103	8+19.2	7.2 Rt	17.8	112.7	68
BB-AHS-104	8+26.8	7.8 Lt	18.3	112.4	75, 20, 75
BB-AHS-201	7+79.0	6.9 Lt	16.6	114.1	47, 89
BB-AHS-202	8+24.2	7.0 Lt	17.0	113.8	0, 0, 37, 65
BB-AHS-302	7+62.3	6.1 Rt	21.6	109.0	66
BB-AHS-304	8+39.5	7.7 Rt	21.3	109.4	80

Bedrock at the site generally consisted of grey, fine-grained, GRAYWACKE, moderately hard, slightly weathered to fresh, joint sets dipping at low angles to vertical, spaced very close to moderately close, tight to open, with veins of quartz and calcite. The RQD of the bedrock cores ranged from 0 to 100 percent, corresponding to a Rock Quality of very poor to excellent.

Detailed bedrock descriptions and RQD's are provided in Appendix A – Boring Logs and on Sheets 4 and 5 – Boring Logs. Rock core photographs are provided in Appendix B – Rock Core Photographs.

Unconfined compressive strength (UCS) testing was conducted on two samples of bedrock, the results of which are summarized in the following table.

Boring	Depth Below Ground Surface (ft)	Unconfined Compressive Strength (psi)	Young's Modulus, E[1] (psi)	Unit Weight (pcf)	Rock Type
BB-AHS-302	22.80 - 23.17	6,091	5,880,000	173	Graywacke
BB-AHS-304	22.10 - 22.48	5,920	4,910,000	172	Graywacke

[1] The Young's Modulus values listed in the table are reported at the initial failure or peak stress range. Reference the test reports in Appendix C – Laboratory Test Results for Young's Moduli reported at other stress ranges.

5.5 Groundwater

Groundwater was measured at depths ranging from 6 to 9 feet below the roadway surface during or upon completion of the borings. Note that water was introduced into the boreholes during drilling operations and the measured levels may not represent stabilized groundwater elevations. Groundwater levels will fluctuate with seasonal changes, precipitation, runoff, river levels and construction activities.

6.0 FOUNDATION ALTERNATIVES

Preliminary engineering evaluated a detail-build buried concrete arch design alternative. The concrete arch would have been either precast or a composite system filled with concrete onsite, with both options founded on spread footings cast directly on bedrock. Although the buried arch design was expected to offer slight cost savings, constructability concerns (including excavation depth, water control, and limited contractor experience) ultimately led to the selection of a pile-supported integral abutment bridge. Integral abutment bridges have a proven track record for ease of construction and good performance.

7.0 GEOTECHNICAL DESIGN CONSIDERATIONS AND RECOMMENDATIONS

The following sections provide geotechnical design considerations and recommendations rock-socketed, H-pile supported integral abutments which is the proposed substructure type for the Hemlock Stream Bridge replacement project.

7.1 Integral Abutment H-Piles

Abutments No. 1 and 2 will be integral abutments founded on a single row of rock-socketed H-piles.

Piles may be HP 14x89 or 14x117 depending on the factored design axial loads, bending stresses and ability to resist lateral loads. H-piles shall be 50 ksi, Grade A572 steel. The piles shall be fitted with a minimum 15-inch square steel bearing plate of sufficient thickness to prevent yielding or local failure under the applied loads.

The minimum rock socket diameter will be 36-inch. The rock socket design will include a minimum 3-inch grout base beneath the pile bearing plate and a minimum 3-foot grout column encapsulating the bottom of the H-pile. The top of the grout column shall be a minimum of 1-foot below top of bedrock. In order to control the bending stresses determined by lateral pile analysis, the design shall allow for a minimum of 14-foot free length when measured from the bottom of the abutment stem to the top of the grout column. All grout installed shall achieve a minimum design compressive strength of 5,000 psi.

Pile lengths at the proposed abutments may be estimated based on the following table.

Abutment	Offset	Bottom Elevation of Proposed Abutment (ft)	Approximate Top of Bedrock Elevation (ft)	Estimated Top of Grout Elevation (ft)	Estimated Bottom of Pile Elevation (ft)	Estimated Pile Length[1] (ft)
1	LT	120.50	111.4	106.5	103.5	19
1	RT	120.50	109.0	106.5	103.5	19
2	LT	120.90	109.9	106.9	103.9	19
2	RT	120.90	109.4	106.9	103.9	19

7.1.1 Axial and Lateral Pile Resistance

GZA GeoEnvironmental, Inc. (GZA) computed the factored axial geotechnical pile resistances for HP 14x89 and HP 14x117 pile sections at the strength, service, and extreme limit states. Lateral pile resistance analyses were also performed to evaluate pile axial stresses and bending stresses. See Appendix E – Rock-Socketed H-Pile Design Memorandum.

7.1.2 Scour and Pile Buckling Evaluation and Pile Lateral Resistance

In consideration of LRFD Article 3.7.5, it is recommended that the bridge designer evaluate the potential for buckling of the piles due to scour effects. The design shall consider the maximum anticipated depth of scour as per the site-specific scour analysis. The assessment should account for the reduction in lateral support to the pile provided by the surrounding soil as a result of scour.

The design should ensure that the piles remain stable under the combined effects of axial and lateral loads considering the loss of lateral support caused by scour. The bridge designer should refer to LRFD Article 10.7.3.13.1 for guidance on pile buckling analysis.

7.1.3 Rock-Socketed Pile Quality Control

Rock-socketed piles shall be constructed in accordance with Special Provision 501 (Rock-Socketed H-Pile Foundations).

The rock socket shall be detailed such that grout can be reliably placed below and around the pile tip and promote, full, uniform load transfer to end bearing in bedrock. The detail shall include provisions to achieve the required grout base thickness beneath the bearing plate.

[1] Estimated pile lengths include 2-foot embedment into the pile cap.

To prevent caving of existing soil deposits, the holes for rock-socketed pile shall be drilled through the overburden by advancing temporary casing with an inner diameter that is, at a minimum, the design diameter of the bedrock socket. The temporary casing shall be equipped with a cutting shoe capable of establishing a positive seal in bedrock to prevent soil and groundwater infiltration into the bedrock socket.

Rock sockets shall be cleaned of all loose material using an airlift or vacuum truck. The socket shall be inspected for cleanliness immediately prior to grout placement.

Tremie grout tubes detailed to remain permanently as part of the rock socket shall be filled with a non-shrink grout listed on the MaineDOT QPL.

The portion of the rock socket above the grout column shall be backfilled with aggregate meeting for the requirements of Subsection 703.22, Underdrain Backfill Material, Type C.

The rock sockets shall be constructed such that the piles meet the required positioning tolerances when centered in the drilled hole.

7.2 Integral Abutment and Wingwall Design

Integral abutment sections shall be designed for all relevant strength, service, and extreme limit states and load combinations specified in LRFD Articles 3.4.1 and 11.5.5. A resistance factor (ϕ) of 1.0 shall be used to assess abutment design at the service limit state, including: settlement and excessive horizontal movement. The overall stability of the foundation should be investigated at the Service I Load Combination and a resistance factor, ϕ, of 0.65. Resistance factors for extreme limit state shall be taken as 1.0.

The designer may assume Soil Type 4 (MaineDOT Bridge Design Guide (BDG) Section 3.6.1) for abutment backfill material soil properties. The backfill properties are as follows:

- Internal Friction Angle (ϕ) = 32°
- Total Unit Weight (γ) = 125 pcf
- Soil-Concrete Interface Friction Angle (δ) = 17° (ref: LRFD Table 3.11.5.3-1)

Integral abutments and in-line wingwalls shall be designed to withstand a lateral earth load equal to the passive pressure state. Estimation of passive earth pressure should consider LRFD C3.11.5.4, which states that the relative wall movement to induce full passive pressure is approximately 0.05 for dense backfill, and FHWA NHI-06-089 Figure 10-4 which supports a K_p of 6.0 and greater for dense backfills and wall rotations equal to or greater than 0.02. In general, when the calculated ratio of lateral movement to wall height exceeds 0.004, a passive earth pressure coefficient can be estimated using MassDOT LRFD Bridge Design Manual Figure 3.10.8-1 (reproduced in Appendix D – Calculations). The thermal movement at each abutment was estimated by the bridge designer to be 0.301 inch, resulting in an estimated ratio of thermal expansion to abutment height (δ/H) of 0.0024. Therefore, Rankine Theory is recommended to determine the passive earth pressure coefficient. Using Rankine Theory, a lateral earth pressure coefficient of 3.25 is recommended assuming a δ/H of 0.0024 and a level backfill (see Appendix D – Calculations).

A load factor for passive earth pressure is not specified in LRFD. For purposes of the integral abutment backwall reinforcing steel design, use a maximum load factor (γ_{EH}) of 1.50 to calculate factored passive earth pressures.

Additional lateral earth pressure due to live load surcharge is required per Section 3.6.8 of the MaineDOT BDG for abutments if an approach slab is not specified. When a structural approach slab is specified, reduction, not elimination of the surcharge load, is permitted per LRFD Article 3.11.6.5. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) taken from the table, below:

Abutment Height (feet)	h_{eq} (feet)
5	4.0
10	3.0
≥20	2.0

In-line wingwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil of 2.0 feet. An at-rest earth pressure coefficient, K_o, of 0.47 should be used for live load surcharge loads placed upon wingwalls cantilevered off of abutments with the top of the wall restrained from movement.

7.3 Return (U-Shaped) Wingwalls

U-shaped return wingwalls (U-walls) will be constructed monolithically with the downstream ends of the integral abutments. The wingwalls shall be designed for all relevant strength, service limit and extreme states and load combinations specified in LRFD Articles 3.4.1, 11.5 and 11.6. The walls shall be designed to resist lateral earth pressures, vehicular loads, collision loads, and creep and temperature and shrinkage deformations. The wingwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (heq) per LRFD Table 3.11.6.4-2. This table takes into consideration the wall height and the distance of the wall backface to the edge of traffic.

When using the simplified design method outlined in the Integral Abutment Bridge Design Guidelines (VTrans, 2008), the following design criteria for wingwalls are provided under Sections 2.2.1 and 4.5.4:

- The length of monolithic cantilevered wingwalls shall be less than 10 feet, as measured from the back face of the abutment. Wingwalls requiring a length longer than 10 feet should be split into two segments. The first segment of the wall should be monolithically attached to the abutment. The second segment of the wall (that beyond 10 feet) should be designed as a freestanding wall and should be isolated from the movement of the bridge via an expansion joint to allow up to 2 inches of movement.

- Do not install piles or a footing under the first segment of the wingwall which is monolithically attached to the abutment.

Two (2) load cases shall be considered for the design of U-walls. The first load case applies to the first segment of the wall where the wingwall is subjected to passive earth pressure to account for the bridge moving laterally and pushing the wingwall into the fill. This load case is considered under the strength limit state. Calculation of passive earth pressures may assume a Rankine passive earth pressure coefficient, K_p, of 3.25 assuming small wingwall movements.

The second load case applies to the second section of the wall, and considers that the wingwall is subjected to active pressure and to collision loads on bridge rail that is driven in back of the U-walls. This load case is considered under the extreme limit state. Calculation of active earth pressure shall use the Rankine active earth pressure coefficient, K_a, of 0.31 assuming a level backslope. See Appendix C – Calculations for supporting documentation. If there is bridge rail driven in back of the first segment, that segment shall also be checked for a collision load case.

There are no bearing resistances considerations for cantilever U-walls that are constructed monolithically with the integral abutments.

U-walls shall be embedded a minimum of 7.6 feet for frost protection as discussed in Section 7.6, below.

7.4 Abutment Sections

The abutment design shall include a drainage system behind the abutment to intercept any groundwater. Drainage behind the structure shall be in accordance with MaineDOT BDG Section 5.4.2.13. Conventional French Drains are the preferred system compared to other systems.

Backfill within 10 feet of the abutments and side slope fill shall conform to MaineDOT Specification 703.19 – Granular Borrow for Underwater Backfill. The gradation of this material specifies 7 percent or less of the material passing the No. 200 sieve. Limiting the amount of fines is intended to minimize frost action and eliminate the need to design for hydrostatic forces by promoting drainage behind the structure.

Slopes in front of the pile-supported integral abutments should be constructed with riprap and erosion control geotextile. The slopes should not exceed 1.75H:1V in accordance with MaineDOT Standard Detail 610(03).

7.5 Settlement and Embankment Stability

The project calls for the vertical alignment of the new bridge to approximately match the existing at Abutment No. 1 and be raised up to 6 inches at Abutment No. 2. The bridge approach embankments will be constructed using granular borrow placed over loose to medium dense granular fill underlain by dense to very dense Glacial Till. Any loose soils encountered at the subgrade elevation shall be thoroughly compacted prior to backfill operations. With these provisions, any settlement at the proposed bridge approaches is anticipated to be small and immediate.

Conventional earth fill embankments constructed over the existing soils using MaineDOT Standard Specifications, with side slopes of 2H:1V or flatter, are anticipated to satisfy stability requirements. Slopes steeper than 2H:1V shall be treated with riprap using MaineDOT standard details. Slopes shall be no steeper than 1.75H:1V.

Settlement of the steel H-piles bearing in bedrock will be limited to elastic compression of the piles and is anticipated to be minimal.

7.6 Frost Protection

Foundations placed on soil should be designed with an appropriate embedment for frost protection. According to MaineDOT BDG Figure 5-1, Maine Design Freezing Index Map, Argyle Township has a design freezing index (DFI) of approximately 1825 F-degree days. The anticipated coarse-grained fill soil was assigned a water content of 10%. These components correlate to a frost depth of 7.6 feet. Any foundation bearing on soils shall be embedded 7.6 feet for frost protection.

Pile-supported integral abutments shall be embedded a minimum of 4.0 feet for frost protection per MaineDOT BDG Section 5.2.1.

Riprap is not to be considered as contributing to the overall thickness of soils required for frost protection.

7.7 Seismic Design Considerations

The United States Geological Survey Seismic Design CD (Version 2.1) provided with the 2014 LRFD Code (7th Edition), and LRFD Articles 3.10.3.1 and 3.10.6 were used to develop parameters for seismic design. Based on site coordinates, the software provided the recommended AASHTO Response Spectra for a 7 percent probability of exceedance in 75 years. These results are summarized in the following table:

Parameter	Design Value
Peak Ground Acceleration (PGA)	0.070g
Acceleration Coefficient (A_S)	0.112g
S_{DS} (Period = 0.2 sec)	0.241g
S_{D1} (Period = 1.0 sec)	0.109g
Site Class	D
Seismic Zone	1

In conformance with LRFD Table 4.7.4.3-1 seismic analysis is not required for single-span bridges regardless of seismic zone. However, superstructure connections and minimum support length requirements shall be designed per LRFD Articles 3.10.9.2 and 4.7.4.4, respectively.

8.0 CONSTRUCTION RECOMMENDATIONS AND CONSIDERATIONS

Any soft or unsuitable soil encountered at the subgrade elevation at either abutment shall be excavated in its entirety and replaced with Granular Borrow – Material for Underwater Backfill and the exposed subgrade then thoroughly compacted. Similarly, any loose coarse-grained soils encountered at the subgrade level shall be proof compacted.

Excavation for the abutments is anticipated to be accomplished using sloped open cut methods in accordance with MaineDOT and OSHA requirements. Excavations will expose soils that may become saturated and water seepage may occur during construction. There may be localized sloughing and instability in some excavations and cut slopes. The contractor should control groundwater, surface water infiltration, and soil erosion. Water should be controlled by pumping from sumps.

Based on a Q1.1 water level of El. 119.3, a cofferdam may be necessary to successfully dewater and construct the abutments. Evidence of wood was encountered in multiple borings. Bridge substructure types prior to the existing are unknown and without record. There is potential for wood to cause difficulties if constructing a sheet pile cofferdam.

9.0 CLOSURE

This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Hemlock Stream Bridge in Argyle Township, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

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

It is recommended that a geotechnical engineer be provided the opportunity for a review of the final design and specifications in order that the earthwork and foundation recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications.

Sheets

Date:8/14/2025

Division: GEOTECH

Username: Terry.White

ARGYLE TOWNSHIP, MAINE

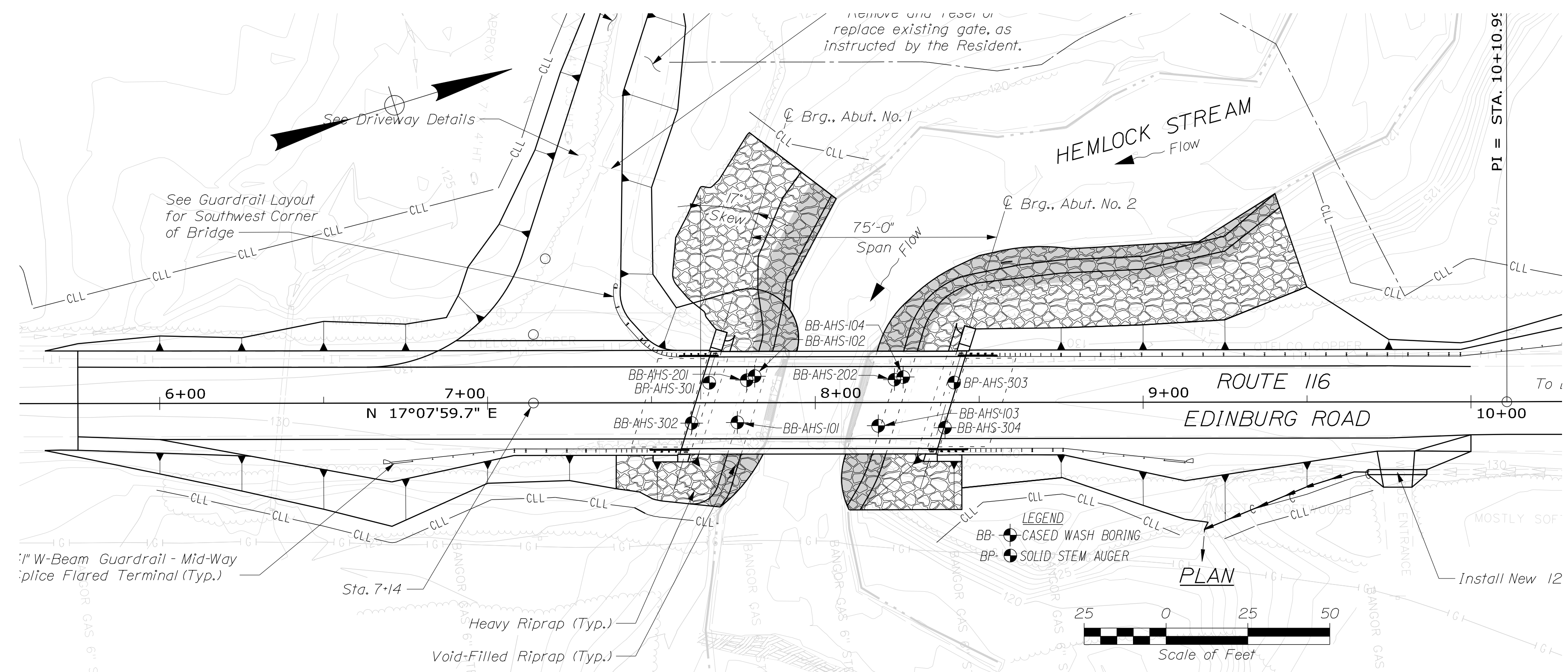
The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch.

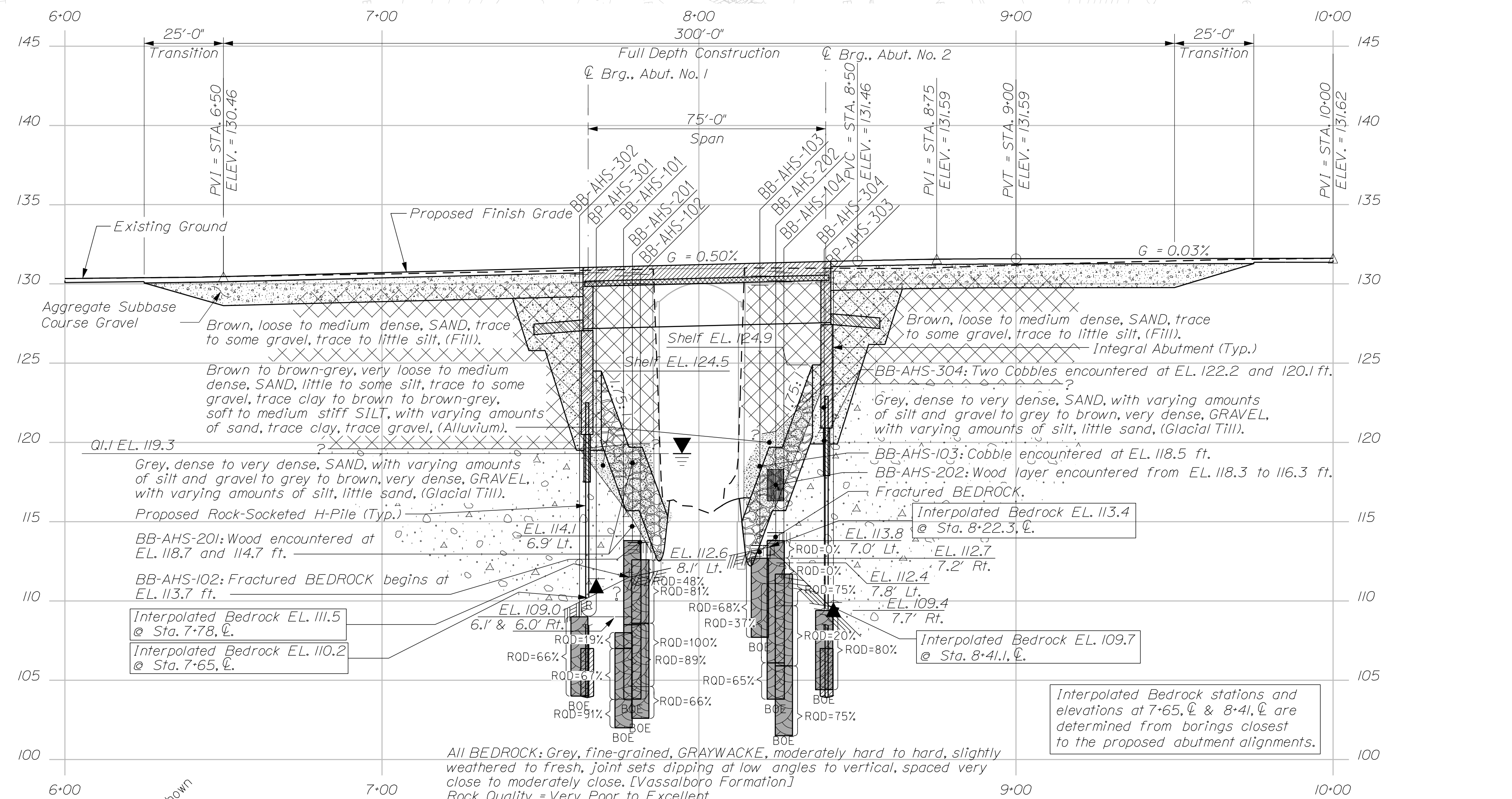
0.25 Miles

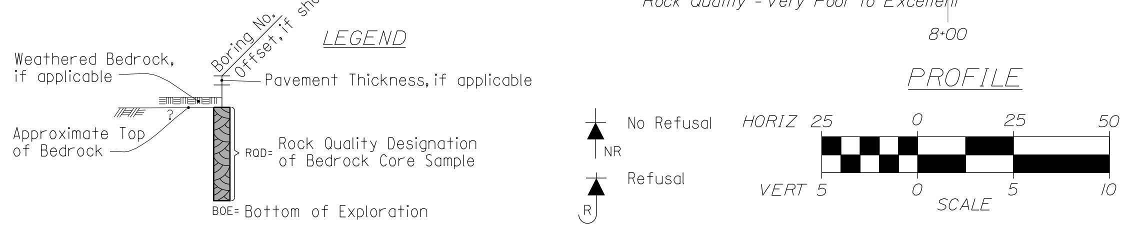
1 inch =0.28 miles

Date: 8/14/2025
Time: 1:46:32 PM

SHEET NUMBER 1 OF 5	HEMLOCK STREAM BRIDGE HEMLOCK STREAM ARGYLE TWP.PENOBSCOT CTY.	STATE OF MAINE DEPARTMENT OF TRANSPORTATION
		STP-2168(700)
	LOCATION MAP	WIN BRIDGE NO. 3735 21687.00 BRIDGE PLANS







Notes: 1. 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 and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

2. "Varying Amounts" term = Portion is 0 to 50 percent of Total.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2168(700)

WIN 21687.00

BRIDGE PLANS

BRIDGE NO. 3735

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	N.PUKAY	
DESIGN3-DETAILED3	T.WHITE	MAR 2022
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

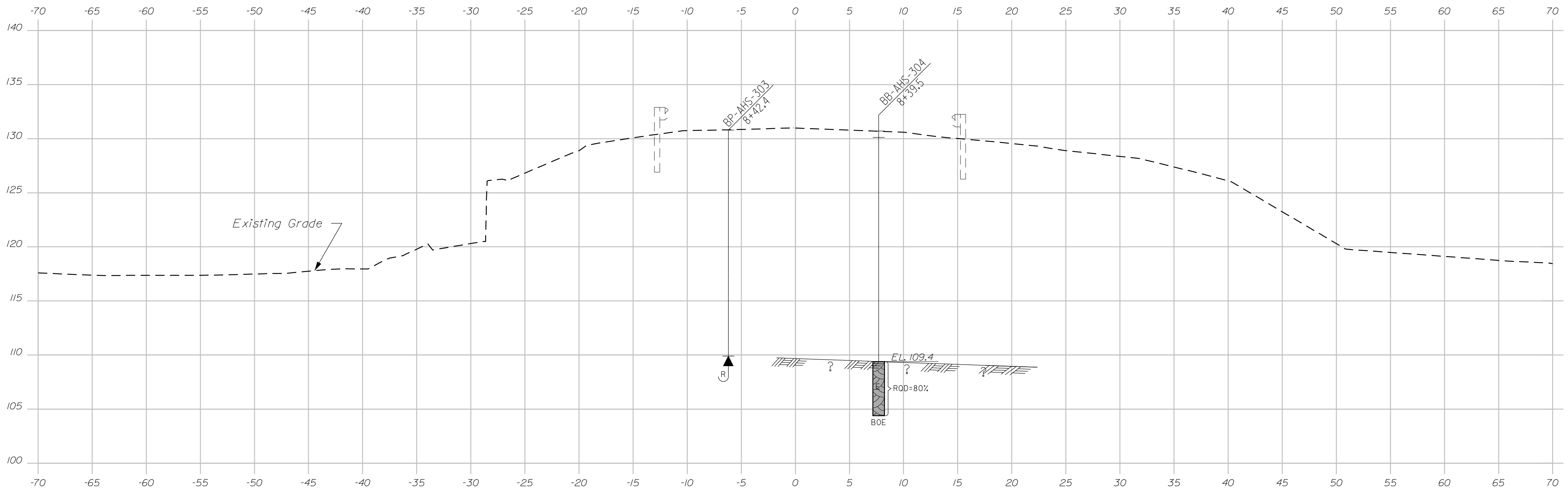
DATE

HEMLOCK STREAM BRIDGE
HEMLOCK STREAM
ARGYLE TOWNSHIP PENOBSCOT COUNTY

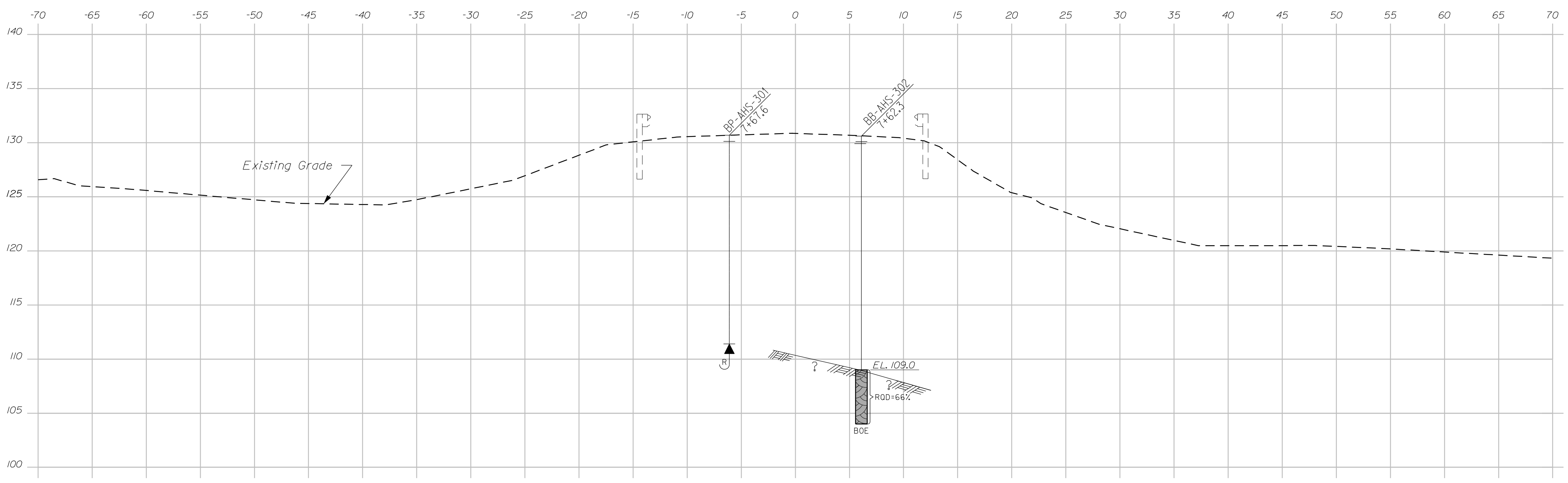
BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
2
OF 5

Filename: ...\GEOTECH\MSTA\006_BLP&ISP1.dgn Division: GEOTECH Username: Nathan.P.Pukay Date:9/22/2025

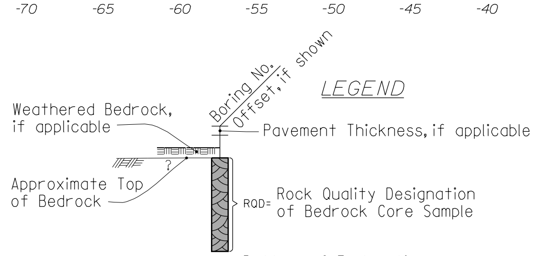


8+40.00



7+65.00

LEGEND



CROSS SECTION

Notes: 1. This generalized interpretive cross section 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 and bedrock transitions may vary and are probably more erratic. For more specific information refer to the boring logs.

2. Borings BB-AHS-101, BB-AHS-102, BB-AHS-103, BB-AHS-104, BB-AHS-201, and BB-AHS-202 are not shown for clarity. Refer to the BLP, ISP, and Boring Logs for information omitted.

Sta. 7+65.00 to Sta. 8+40.00

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2168(700)

BRIDGE NO. 3735

WIN 21687.00

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	N.PUKAY	
DESIGN3-DETAILED3	T.WHITE	AUG 2025
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

HEMLOCK STREAM BRIDGE
HEMLOCK STREAM
ARGYLE TOWNSHIP PENOBSCOT COUNTY

INTERPRETIVE SUBSURFACE
CROSS SECTIONS

SHEET NUMBER

3

OF 5

Filename: ...\MSTA\008_BORING LOGS1.dgn Division: GEOTECH Username: Nathan.P.Pukay Date:9/24/2025

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-101 WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	Elevation (ft.)	130.5	Auger ID/OD:	SSA 2.25" OD
Operator:	Kevin Hanscom	Datum:	NAVD 88	Sampler:	Split-Spoon
Logged By:	Nathan Strout	Rig Type:	Diedrich D-50	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	2/14/2017	Drilling Method:	Cased-Wash	Core Barrel:	NQ 2"
Boring Location:	7+76.2, 6.0 ft. Rt.	Casing ID/OD:	NW 3"/3.5"	Water Level*:	5.8' (after drilling)
Hammer Efficiency Factor: 0.60		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	129.9	7" of Pavement 0.6	
	1D	2/2	1.00 - 1.17	100-2"	- -				Brown, frozen, SAND, little gravel, little silt, (Fill).	
5	2D	24/10	5.00 - 7.00	4/4/5/5	9	9	16		Brown, moist, loose, SAND, some gravel, trace silt, (Fill).	G#271096 A-1-b, SW-SM WC=7.9%
							28			
							38			
							30			
							23			
10	MD	24/0	10.00 - 12.00	10/7/4/2	11	11	5	120.0	10.5	
							15			
	3D	24/8	12.00 - 14.00	2/2/2/2	4	4	7		Brown-grey, wet, very loose, fine to medium SAND, little silt, trace clay, trace gravel, (Alluvium).	G#271097 A-2-4, SC-SM WC=26.4%
							7			
							9			
15	4D	24/7	15.00 - 17.00	3/2/1/2	3	3	5		Brown-grey, wet, soft, fine Sandy SILT, trace gravel, (Alluvium).	
							6			
							30	113.2	17.3	
							60			
							49			
20	5D	17/12	20.00 - 21.42	13/26/100-5"	- -		40		5D(A) Grey, wet, very dense, SAND, some silt, trace gravel, (Glacial Till). 5D(B) Bedrock Chips. a135 blows for 0.5 ft.	
							a135	109.0	21.5	
	R1	32/8	22.50 - 25.17	RQD = 19%			NQ-2		Top of Bedrock at EL. 109.0 ft. Roller coned ahead to 22.5 ft bgs. R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, preserved distorted bedding, joints dip at low angles, closely spaced, tight, rough, undulating, with calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Very Poor. R1 Core Times (min:sec): 22.5-23.5 ft (2:21) 23.5-24.5 ft (3:33) 24.5-25.2 ft (3:45) 25% Recovery	
25	R2	17/17	25.20 - 26.62	RQD = 67%					R2:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, breaks along foliation and low angle orthogonal joints, healed to tight, with calcite and quartz infilling, occasional nonsystematic undulating breaks along calcite and quartz veins. [Vassalboro Formation] Rock Quality = Fair. R2 Core Times (min:sec): 25.2-25.5 ft (2:32) 25.5-26.5 ft (9:49) 26.5-26.7 ft (2:28) 100% Recovery	
	R3	22/20	26.70 - 28.53	RQD = 91%				102.0	R3:Bedrock: Similar to R2. [Vassalboro Formation] Rock Quality = Excellent. R3 Core Times (min:sec): 26.7-27.5 ft (4:19) 27.5-28.5 ft (6:04) 91% Recovery 28.5	
									Bottom of Exploration at 28.5 feet below ground surface.	

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

Remarks:
Casing driven using rope and cathead with 140# safety hammer

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: BB-AHS-101

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-102 WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	Elevation (ft.)	130.6	Auger ID/OD:	SSA 2.25" OD
Operator:	Kevin Hanscom	Datum:	NAVD 88	Sampler:	Split-Spoon
Logged By:	Nathan Strout	Rig Type:	Diedrich D-50	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	2/17/2017 - 2/20/2017	Drilling Method:	Cased-Wash	Core Barrel:	NQ 2"
Boring Location:	7+81.5, 8.1 ft Lt.	Casing ID/OD:	NW 3"/3.5"	Water Level*:	8.6' (after drilling)
Hammer Efficiency Factor: 0.60		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.0	7" of Pavement 0.6	
	1D	5/4	2.00 - 2.42	100-5"	- -				Brown, frozen, SAND, some gravel, trace silt (Fill).	
5	2D	24/13	5.00 - 7.00	8/3/2/2	5	5	9		Brown, moist, loose, SAND, some gravel, trace silt, (Fill).	
							18			
							24			
							27			
							21			
10	3D	24/14	10.00 - 12.00	4/3/2/3	5	5	12	120.6	10.0 Brown, wet, medium stiff, SILT, some fine to medium sand, trace clay, trace gravel, (Alluvium).	G#271098 A-4, CL WC=26.2%
							20			
							26			
							22			
							50			
15	4D	23/4	15.00 - 16.92	15/28/28/100-5"	56	56	62	115.6	15.0 Grey, wet, very dense, GRAVEL, little sand, little silt, (Glacial Till). a170 blows for 0.9 ft	
							a170	113.7	16.9 Fractured Bedrock. Roller coned ahead to 18.0 ft bgs.	
								112.6	18.0	
	R1	48/48	18.00 - 22.00	RQD = 81%			NQ-2		Top of Bedrock at El. 112.6. R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, sheared, steep foliation, preserved distorted bedding, joints are steeply dipping, undulating, closely spaced, tight, rough, with calcite and quartz veins. Upper 10" is moderately fractured, then competent and massive rock. [Vassalboro Formation] Rock Quality = Good. R1 Core Times (min:sec): 18.0-19.0 ft (6:05) 19.0-20.0 ft (8:12) 20.0-21.0 ft (5:44) 21.0-22.0 ft (5:11) 100% Recovery	
20										
	R2	48/48	22.00 - 26.00	RQD = 100%					R2:Bedrock: Similar to R1 except massive throughout entirety of run. [Vassalboro Formation] Rock Quality = Excellent. R2 Core Times (min:sec): 22.0-23.0 ft (4:14) 23.0-24.0 ft (4:35) 24.0-25.0 ft (4:55) 25.0-26.0 ft (4:05) 100% Recovery	
25	R3	24/23	26.00 - 28.00	RQD = 66%				102.6	R3:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, with a single steeply dipping joint, undulating, tight, rough, with calcite and quartz veins. [Vassalboro Formation] Rock Quality = Fair. R3 Core Times (min:sec): 26.0-27.0 ft (6:58) 27.0-28.0 ft (5:25) 96% Recovery 28.0	
									Bottom of Exploration at 28.0 feet below ground surface.	

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

Remarks:
Casing driven using rope and cathead with 140# safety hammer

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: BB-AHS-102

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-103 WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	Elevation (ft.)	130.5	Auger ID/OD:	SSA 2.25" OD
Operator:	Kevin Hanscom	Datum:	NAVD 88	Sampler:	Split-Spoon
Logged By:	Robert Chaput	Rig Type:	Diedrich D-50	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	2/20/2017	Drilling Method:	Cased-Wash	Core Barrel:	NQ 2"
Boring Location:	8+19.2, 7.2 ft Rt.	Casing ID/OD:	NW 3"/3.5"	Water Level*:	Caved at 11.5', Dry
Hammer Efficiency Factor: 0.60		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	129.9	7" of Pavement 0.6	
	1D	12/9	2.00 - 3.00	86/100	- -				Brown, frozen, SAND, some gravel, trace silt, (Fill).	
5	2D	24/9	5.00 - 7.00	7/8/4/4	12	12	10		Brown, wet, medium dense, SAND, some gravel, little silt, (Fill).	G#271099 A-1-b, SW-SM WC=4.9%
							27			
							26			
							32			
							40			
10	3D	24/1	10.00 - 12.00	8/8/7/8	15	15	17	120.5	10.0 Rock in tip of spoon.	
							44			
							a155		a155 blows for 0.9 ft Roller cone through cobble to 13.0'.	
							110			
							117			
15	4D	24/10	15.00 - 17.00	29/16/17/33	33	33	85	115.5	15.0 Grey, wet, dense, Gravelly SAND, little silt, (Glacial Till).	G#271100 A-1-b, SM WC=12.4%
							273	113.5	17.0 Fractured Bedrock. Roller cone to 17.8 ft bgs.	
	R1	60/48	17.80 - 22.80	RQD = 68%			NQ-2	112.7	17.8 Top of Bedrock at EL. 112.7 ft. R1 Bedrock: Grey, GRAYWACKE, hard, fresh, laminated, steep foliation, joints at steep angles, closely spaced, tight, calcite and quartz veins. Upper 18" is minimally fractured, then competent and massive rock. [Vassalboro Formation] Rock Quality = Fair. R1 Core Times (min:sec): 17.8-18.8 ft (4:45) 18.8-19.8 ft (5:12) 19.8-20.8 ft (6:46) 20.8-21.8 ft (5:22) 21.8-22.8 ft (5:16) 80% Recovery	
20										
								107.7	22.8	
									Bottom of Exploration at 22.8 feet below ground surface.	

Depth scale: 0, 5, 10, 15, 20, 25

Remarks:
Casing driven using rope and cathead with 140# safety hammer

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: BB-AHS-103

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-104 WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	Elevation (ft.)	130.7	Auger ID/OD:	SSA 2.25" OD
Operator:	Kevin Hanscom	Datum:	NAVD 88	Sampler:	Split-Spoon
Logged By:	Nathan Strout	Rig Type:	Diedrich D-50	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	2/17/2017	Drilling Method:	Cased-Wash	Core Barrel:	NQ 2"
Boring Location:	8+26.8, 7.8 ft Lt.	Casing ID/OD:	NW 3"/3.5"	Water Level*:	8.7' (after drilling)
Hammer Efficiency Factor: 0.60		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.1	7" of Pavement 0.6	
	1D	3/2	1.00 - 1.25	100-3"	- -				Brown, frozen, SAND, little gravel, trace silt, (Fill).	
5	2D	24/9	5.00 - 7.00	5/4/5/4	9	9	9		Similar to 1D, except moist and loose.	
							20			
							18			
							18			
							28			
10	3D	24/14	10.00 - 12.00	5/3/2/3	5	5	5	120.7	10.0 Brown, wet, medium stiff, fine to medium, Sandy SILT, trace gravel, (Alluvium).	G#304299 A-4, CL WC=23.0%
							6			
							26			
							21			
							60	116.7	14.0	
15	4D	24/15	15.00 - 17.00	16/36/31/22	67	67	35		Brown, wet, very dense, GRAVEL, little sand, little silt, (Glacial Till).	
							81			
							95			
							71/4"	112.4	18.3	
	R1	24/24	19.00 - 21.00	RQD = 75%			NQ-2		Top of Bedrock at EL. 112.4 ft. Roller cone through Bedrock to 19.0 ft bgs. R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, moderate to steep foliation, breaks along foliation and low angle conjugate joints, spaced moderately close, healed to tight, calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Fair. R1 Core Times (min:sec): 19.0-20.0 ft (5:30) 20.0-21.0 ft (5:52) 100% Recovery	
20										
	R2	46/45	21.00 - 24.83	RQD = 20%					R2:Bedrock: Similar to R1, except more fractured. [Vassalboro Formation] Rock Quality = Very Poor. R2 Core Times (min:sec): 21.0-22.0 ft (4:31) 22.0-23.0 ft (4:16) 23.0-24.0 ft (4:51) 24.0-24.8 ft (4:48) 98% Recovery	
25	R3	53/50	24.80 - 29.22	RQD = 75%				101.5	R3:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, moderate to steep foliation, joints dip at low angles, closely spaced, healed to tight, significant calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Fair. R3 Core Times (min:sec): 24.8-25.0 ft (0:27) 25.0-26.0 ft (6:36) 26.0-27.0 ft (7:06) 27.0-28.0 ft (7:05) 28.0-29.0 ft (5:44) 29.0-29.2 ft (0:39) 94% Recovery 29.2	
									Bottom of Exploration at 29.2 feet below ground surface.	

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

Remarks:
Casing driven using rope and cathead with 140# safety hammer

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1 Boring No.: BB-AHS-104

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2168(700)

WIN 21687.00

BRIDGE PLANS

BRIDGE NO. 3735

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	N.PUKAY	
DESIGN3-DETAILED3	T.WHITE	SEP 2025
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE
P.E. NUMBER
DATE

HEMLOCK STREAM BRIDGE
HEMLOCK STREAM
ARGYLE TOWNSHIP PENOBSCOT COUNTY

BORING LOGS

SHEET NUMBER 4 OF 5

Filename: ...\MSTA\009_BORING LOGS2.dgn Division: GEOTECH Username: Nathan.P.Pukay Date:9/24/2025

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-201
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	Elevation (ft.)	130.7	Auger ID/OD:	5" Solid Stem
Operator:	Kevin/Brian	Datum:	NAVD 88	Sampler:	Standard Split Spoon
Logged By:	Nathan Pukay	Rig Type:	Diedrich D-50	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	4/6/2022; 11:30-13:15	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	7+79, 6.9 ft Lt.	Casing ID/OD:	NW-3"	Water Level*:	None Observed
Hammer Efficiency Factor: 0.91		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
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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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.0	8" HMA. (0.7)	
5	1D	24/12	5.00 - 7.00	4/4/4/7	8	12			Brown, damp, medium dense, SAND, trace gravel, trace silt, (Fill).	
10	2D/A	24/13	10.00 - 12.00	2/3/4/2	7	11	HP		2D (10.0-11.5 ft bgs.) Brown, wet, medium dense, SAND, trace gravel, trace silt, (Fill).	
							HP	119.2	2D/A (11.5-12.0 ft bgs.) Grey-brown, wet, fine to medium, Sandy SILT, trace clay, trace gravel, (Alluvium). Wood observed in wash water. (11.5)	G#241517 A-4, CL WC=24.2%
							102			
							21			
	3D	24/13	14.00 - 16.00	20/17/17/11	34	52	32	116.7	Grey, wet, very dense, Silty SAND, trace gravel, (Glacial Till). (14.0)	
15							45			
	4D/A R1	9/9 63.6/ 63.6	16.00 - 16.75 16.90 - 22.20	16/54(3") RQD = 47%	---		a53 NQ-2	114.1	a53 blows for 0.6 ft. 4D (16.0-16.6) Similar to above, except very dense, with wood chips. 4D/A (16.6-16.75) Bedrock Chips. (16.6)	
									Top of Bedrock at Elev. 114.1 ft. Roller Coned ahead to 16.9 ft bgs. R1: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, steep foliation paralleling thin bedding, joints are low angle to vertical and are not parallel to bedding or foliation, joint spacing is close, fresh to slightly weathered, tight to open, some rock flour. [Vassalboro Formation] Rock Quality = Poor. R1: Core Times (min:sec) 16.9-17.9 ft (3:54) 17.9-18.9 ft (3:21) 18.9-19.9 ft (2:52) 19.9-20.9 ft (2:45) 20.9-21.9 ft (3:02) 21.9-22.2 ft (1:01) 100% Recovery	
	R2	56.4/ 56.4	22.20 - 26.90	RQD = 89%					R2: Bedrock: Similar to R1, except less fractured, more competent. [Vassalboro Formation] Rock Quality = Good. R2: Core Times (min:sec) 22.2-23.2 ft (2:53) 23.2-24.2 ft (2:33) 24.3-25.2 ft (3:01) 25.2-26.2 ft (2:54) 26.2-26.9 ft (1:40) 100% Recovery	
								103.8	Bottom of Exploration at 26.9 feet below ground surface. (26.9)	

Remarks:
Hammer # 367
HP = Hydraulic Push

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1
Boring No.: BB-AHS-201

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-202
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	Elevation (ft.)	130.8	Auger ID/OD:	5" Solid Stem
Operator:	Kevin/Brian	Datum:	NAVD 88	Sampler:	Standard Split Spoon
Logged By:	Nathan Pukay	Rig Type:	Diedrich D-50	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	4/6/2022; 08:30-11:15	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	8+24.2, 7.0 ft Lt.	Casing ID/OD:	NW-3"	Water Level*:	None Observed
Hammer Efficiency Factor: 0.91		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.2	7" HMA. (0.6)	
5	1D	24/14	5.00 - 7.00	4/4/4/3	8	12			Brown, dry, medium dense, SAND, little gravel, trace silt, (Fill).	
	2D	28.8/10	9.90 - 12.30	4/4/4/2	8	12	aHP			
10							HP	120.9	aHP for 0.1 ft. Brown, moist, medium dense, SAND, some gravel, some silt, trace clay, (Alluvium). (9.9)	G#241516 A-1-b, SC-SM WC=16.4%
							HP			
	3D	24/5	12.50 - 14.50	1/1/16/7	17	26	HP		WOOD, trace sand. aHP for 0.8 ft.	
							aHP a23		Wood 13.8-15.0 ft bgs. a23 blows for 0.2 ft.	
							54			
15	4D MD	6/5 6/0	15.00 - 15.50 15.50 - 16.00	17(6") 16(6")	--- ---		88 a40	115.8	Grey, wet, Silty GRAVEL, little sand, (Glacial Till). a40 blows for 0.5 ft. (15.0)	
	5D	12/8	16.00 - 17.00	18/50(5.5")	---			114.3	Grey, wet, very dense, rock fragments, trace silt, trace fine to coarse sand, (Fractured Rock). (16.5)	
	R1	13.2/ 13.2	17.00 - 18.10	RQD = 0%			NQ-2	113.8	Top of Bedrock at Elev. 113.8 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, very fractured, steep to vertical joints broken along bedding planes, joints very close and tight with no infilling. [VASSALBORO FORMATION] Rock Quality = Very Poor. R1: Core Times (min:sec) 17.0-18.0 ft (3:16) 18.0-18.1 ft (0:40) Core Blocked 100% Recovery (17.0)	
	R2	19.2/ 19.2	18.10 - 19.70	RQD = 0%					R2: Bedrock: Similar to R1. [Vassalboro Formation] Rock Quality = Very Poor. R2: Core Times (min:sec) 18.1-19.1 ft (3:20) 19.1-19.7 ft (3:18) Core Blocked 100% Recovery	
	R3	60/60	19.70 - 24.70	RQD = 37%					R3: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, steep to vertical joints, closely spaced with infrequent quartz infilling. Quartz discontinuity from 20.7' to 21.8' with open, moderately weathered fractures at each end. Upper 2' moderately fractured, then more competent and massive. [Vassalboro Formation] Rock Quality = Poor. R3: Core Times (min:sec) 19.7-20.7 ft (4:32) 20.7-21.7 ft (4:48) 21.7-22.7 ft (4:17) 22.7-23.7 ft (3:50) 23.7-24.7 ft (3:11) 100% Recovery	
	R4	27.6/ 27.6	24.70 - 27.00	RQD = 65%				103.8	R4: Bedrock: Grey, fine-grained, GRAYWACKE with frequent annealed quartz intrusions, hard, slightly weathered, moderately fractured, joints are steeply dipping to horizontal, closely spaced. [Vassalboro Formation] Rock Quality = Fair. R4: Core Times (min:sec) 24.7-25.7 ft (3:33) 25.7-26.7 ft (3:42) 26.7-27.0 ft (1:04) 100% Recovery	
									Bottom of Exploration at 27.0 feet below ground surface. (27.0)	

Remarks:
Hammer # 367
HP = Hydraulic Push

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
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Page 1 of 1
Boring No.: BB-AHS-202

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BP-AHS-301
WIN: 21687.00

Driller:	MaineDOT	Elevation (ft.)	130.7	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrle	Datum:	NAVD 88	Sampler:	N/A
Logged By:	Nathan Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	N/A
Date Start/Finish:	5/6/2024; 13:30-14:00	Drilling Method:	Solid Stem Auger	Core Barrel:	N/A
Boring Location:	7+67.6, 6.1 ft Lt.	Casing ID/OD:	N/A	Water Level*:	None Observed
Hammer Efficiency Factor: 0.962		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.1	7" HMA. (0.6) No material descriptions.	
								111.4	Bottom of Exploration at 19.3 feet below ground surface. Auger REFUSAL, presumed Top of Rock Elev. at 111.4 ft. Grey rock dust on tip of auger. (19.3)	

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Page 1 of 1
Boring No.: BP-AHS-301

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BP-AHS-303
WIN: 21687.00

Driller:	MaineDOT	Elevation (ft.)	130.8	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrle	Datum:	NAVD 88	Sampler:	N/A
Logged By:	Nathan Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	N/A
Date Start/Finish:	5/6/2024; 12:55-13:30	Drilling Method:	Solid Stem Auger	Core Barrel:	N/A
Boring Location:	8+42.4, 6.2 ft Lt.	Casing ID/OD:	N/A	Water Level*:	None Observed
Hammer Efficiency Factor: 0.962		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA		No material descriptions.	
								109.9	Bottom of Exploration at 20.9 feet below ground surface. Auger REFUSAL, presumed Top of Rock Elev. at 109.9 ft. Grey rock dust on tip of auger. (20.9)	

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.
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Page 1 of 1
Boring No.: BP-AHS-303

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-302
WIN: 21687.00

Driller:	MaineDOT	Elevation (ft.)	130.6	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrle	Datum:	NAVD 88	Sampler:	N/A
Logged By:	Nathan Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	5/6/2024; 08:05-10:15	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	7+62.3, 6.1 ft Rt.	Casing ID/OD:	NW 3"/3.5"	Water Level*:	None Observed
Hammer Efficiency Factor: 0.962		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.2	5" HMA. (0.4)	
5							20		(FILL).	
							13			
							8			
							31			
							71			
10							41			
							98	119.6	(11.0)	
							138			
							235			
							209		(GLACIAL TILL).	
							RC			
	R1	60/60	21.60 - 26.60	RQD = 66%			NQ-2	109.0	Top of Bedrock at Elev. 109.0 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation. Joints low angle to moderately dipping, closely spaced, with significant quartz or calcite infilling. [Vassalboro Formation] Rock Quality = Fair R1: Core Times (min:sec) 21.6-22.6 ft (2:40) 22.6-23.6 ft (3:01) 23.6-24.6 ft (3:36) 24.6-25.6 ft (4:07) 25.6-26.6 ft (4:55) 100% Recovery (21.6)	#319158 22.80-23.17 q_p=6,051 psi
								104.0	Bottom of Exploration at 26.6 feet below ground surface. (26.6)	

Remarks:

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Page 1 of 1
Boring No.: BB-AHS-302

Maine Department of Transportation — Soil/Rock Exploration Log — US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock
Location: Argyle TWP, Maine

Boring No.: BB-AHS-304
WIN: 21687.00

Driller:	MaineDOT	Elevation (ft.)	130.7	Auger ID/OD:	5" Solid Stem
Operator:	Daggett/Andrle	Datum:	NAVD 88	Sampler:	N/A
Logged By:	Nathan Pukay	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	5/6/2024; 10:30-12:45	Drilling Method:	Cased Wash Boring	Core Barrel:	NQ-2"
Boring Location:	8+39.5, 7.7 ft Rt.	Casing ID/OD:	NW 3"/3.5"	Water Level*:	None Observed
Hammer Efficiency Factor: 0.962		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.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class
0							SSA	130.1	7" HMA. (0.6)	
									(FILL).	
5							22			
							31			
							242	123.7	(7.0)	
							RC		Cobble at 8.5 ft bgs.	
10									Cobble at 10.6 ft bgs.	
15									(GLACIAL TILL).	
	R1	60/60	21.30 - 26.30	RQD = 80%			NQ-2	109.4	Top of Bedrock at 109.7 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, massive. [Vassalboro Formation] Rock Quality = Good R1: Core Times (min:sec) 21.3-22.3 ft (2:27) 22.3-23.3 ft (2:30) 23.3-24.3 ft (2:27) 24.3-25.3 ft (2:34) 25.3-26.3 ft (3:04) 100% Recovery (21.3)	#319158 22.10-22.48 q_p=5,920 psi
								104.4	Bottom of Exploration at 26.3 feet below ground surface. (26.3)	

Remarks:

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Page 1 of 1
Boring No.: BB-AHS-304

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2168(700)

WIN 21687.00

BRIDGE PLANS

BRIDGE NO. 3735

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED		
DESIGN2-DETAILED2	N.PUKAY	
DESIGN3-DETAILED3	T.WHITE	SEP 2025
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

HEMLOCK STREAM BRIDGE
HEMLOCK STREAM
ARGYLE TOWNSHIP PENOBSCOT COUNTY

BORING LOGS

SHEET NUMBER 5 OF 5

Appendix A

Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

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

Desired Soil Observations (in this order, 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

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

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_{60}-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_{60}-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)

Rock Quality Based on RQD

Rock 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 quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

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: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-101
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/14/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+76.2, 6.0 ft. Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	5.8' (after drilling)
Hammer Efficiency Factor: 0.60		**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	129.9		7" of Pavement 0.6	
	1D	2/2	1.00 - 1.17	100-2"	- -					Brown, frozen, SAND, little gravel, little silt, (Fill).	
5	2D	24/10	5.00 - 7.00	4/4/5/5	9	9	16			Brown, moist, loose, SAND, some gravel, trace silt, (Fill).	G#271096 A-1-b, SW-SM WC=7.9%
							28				
							38				
							30				
							23				
10	MD	24/0	10.00 - 12.00	10/7/4/2	11	11	5	120.0		10.5	
							15				
	3D	24/8	12.00 - 14.00	2/2/2/2	4	4	7			Brown-grey, wet, very loose, fine to medium SAND, little silt, trace clay, trace gravel, (Alluvium).	G#271097 A-2-4, SC-SM WC=26.4%
							7				
							9				
15	4D	24/7	15.00 - 17.00	3/2/1/2	3	3	5			Brown-grey, wet, soft, fine Sandy SILT, trace gravel, (Alluvium).	
							6				
							30	113.2		17.3	
							60				
							49				
20	5D	17/12	20.00 - 21.42	13/26/100-5"	- -		40			5D(A) Grey, wet, very dense, SAND, some silt, trace gravel, (Glacial Till). 5D(B) Bedrock Chips.	
							a135	109.0		a135 blows for 0.5 ft. 21.5	
	R1	32/8	22.50 - 25.17	RQD = 19%			NQ-2			Top of Bedrock at EL. 109.0 ft. Roller coned ahead to 22.5 ft bgs R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, preserved distorted bedding, joints dip at low angles, closely spaced, tight, rough, undulating, with calcite and quartz infilling. [Vassalboro Formation]	
25											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-101
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/14/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+76.2, 6.0 ft. Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	5.8' (after drilling)
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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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	R2	17/17	25.20 - 26.62	RQD = 67%						Rock Quality = Very Poor. R1 Core Times (min:sec): 22.5-23.5 ft (2:21) 23.5-24.5 ft (3:33) 24.5-25.2 ft (3:45) 25% Recovery	
	R3	22/20	26.70 - 28.53	RQD = 91%				102.0		R2:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, breaks along foliation and low angle orthogonal joints, healed to tight, with calcite and quartz infilling, occasional nonsystematic undulating breaks along calcite and quartz veins. [Vassalboro Formation] Rock Quality = Fair. R2 Core Times (min:sec): 25.2-25.5 ft (2:32) 25.5-26.5 ft (9:49) 26.5-26.7 ft (2:28) 100% Recovery R3:Bedrock: Similar to R2. [Vassalboro Formation] Rock Quality = Excellent. R3 Core Times (min:sec): 26.7-27.5 ft (4:19) 27.5-28.5 ft (6:04) 91% Recovery 28.5 **Bottom of Exploration at 28.5 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-102
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.6	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017 - 2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+81.5, 8.1 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.6' (after drilling)
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
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MU = Unsuccessful Thin Wall Tube Sample Attempt
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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 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	130.0		7" of Pavement — 0.6	
	1D	5/4	2.00 - 2.42	100-5"	- -					Brown, frozen, SAND, some gravel, trace silt (Fill).	
5	2D	24/13	5.00 - 7.00	8/3/2/2	5	5	9			Brown, moist, loose, SAND, some gravel, trace silt, (Fill).	
							18				
							24				
							27				
							21				
10	3D	24/14	10.00 - 12.00	4/3/2/3	5	5	12	120.6		10.0 — Brown, wet, medium stiff, SILT, some fine to medium sand, trace clay, trace gravel, (Alluvium).	G#271098 A-4, CL WC=26.2%
							20				
							26				
							22				
							50				
15	4D	23/4	15.00 - 16.92	15/28/28/100-5"	56	56	62	115.6		15.0 — Grey, wet, very dense, GRAVEL, little sand, little silt, (Glacial Till).	
							a170			a170 blows for 0.9 ft	
								113.7		16.9 — Fractured Bedrock. Roller coned ahead to 18.0 ft bgs.	
	R1	48/48	18.00 - 22.00	RQD = 81%			NQ-2	112.6		18.0 — Top of Bedrock at El. 112.6. R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, sheared, steep foliation, preserved distorted bedding, joints are steeply dipping, undulating, closely spaced, tight, rough, with calcite and quartz veins. Upper 10" is moderately fractured, then competent and massive rock. [Vassalboro Formation] Rock Quality = Good. R1 Core Times (min:sec): 18.0-19.0 ft (6:05) 19.0-20.0 ft (8:12) 20.0-21.0 ft (5:44) 21.0-22.0 ft (5:11) 100% Recovery	
20											
	R2	48/48	22.00 - 26.00	RQD = 100%							
25											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-102
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.6	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017 - 2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+81.5, 8.1 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.6' (after drilling)
Hammer Efficiency Factor:	0.60	**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
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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										R2:Bedrock: Similar to R1 except massive throughout entirety of run. [Vassalboro Formation] Rock Quality = Excellent. R2 Core Times (min:sec): 22.0-23.0 ft (4:14) 23.0-24.0 ft (4:35) 24.0-25.0 ft (4:55) 25.0-26.0 ft (4:05) 100% Recovery	
	R3	24/23	26.00 - 28.00	RQD = 66%				102.6		R3:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, with a single steeply dipping joint, undulating, tight, rough, with calcite and quartz veins. [Vassalboro Formation] Rock Quality = Fair. R3 Core Times (min:sec): 26.0-27.0 ft (6:58) 27.0-28.0 ft (5:25) 96% Recovery	
										28.0 **Bottom of Exploration at 28.0 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-103
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Robert Chaput	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+19.2, 7.2 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	Caved at 11.5', Dry
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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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	129.9		7" of Pavement (0.6)	
	1D	12/9	2.00 - 3.00	86/100	- -					Brown, frozen, SAND, some gravel, trace silt, (Fill).	
5	2D	24/9	5.00 - 7.00	7/8/4/4	12	12	10			Brown, wet, medium dense, SAND, some gravel, little silt, (Fill).	G#271099 A-1-b, SW-SM WC=4.9%
							27				
							26				
							32				
							40			(10.0)	
10	3D	24/1	10.00 - 12.00	8/8/7/8	15	15	17	120.5		Rock in tip of spoon.	
							44				
							a155			a155 blows for 0.9 ft Roller cone through cobble to 13.0'.	
							110				
							117			(15.0)	
15	4D	24/10	15.00 - 17.00	29/16/17/33	33	33	85	115.5		Grey, wet, dense, Gravelly SAND, little silt, (Glacial Till).	G#271100 A-1-b, SM WC=12.4%
							273	113.5		(17.0)	
	R1	60/48	17.80 - 22.80	RQD = 68%			NQ-2	112.7		Fractured Bedrock. Roller cone to 17.8 ft bgs. (17.8)	
										Top of Bedrock at EL. 112.7 ft. R1 Bedrock: Grey, GRAYWACKE, hard, fresh, laminated, steep foliation, joints dip at steep angles, closely spaced, tight, calcite and quartz veins. Upper 18" is minimally fractured, then competent and massive rock. [Vassalboro Formation] Rock Quality = Fair. R1 Core Times (min:sec): 17.8-18.8 ft (4:45) 18.8-19.8 ft (5:12) 19.8-20.8 ft (6:46) 20.8-21.8 ft (5:22) 21.8-22.8 ft (5:16) 80% Recovery	
20											
								107.7		(22.8)	
25											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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-AHS-103

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-103
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Robert Chaput	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+19.2, 7.2 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	Caved at 11.5', Dry
Hammer Efficiency Factor:	0.60	**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
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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										**Bottom of Exploration at 22.8 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-104
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+26.8, 7.8 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.7' (after drilling)
Hammer Efficiency Factor:	0.60	**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	130.1		7" of Pavement	
										0.6	
	1D	3/2	1.00 - 1.25	100-3"	- -					Brown, frozen, SAND, little gravel, trace silt, (Fill).	
5	2D	24/9	5.00 - 7.00	5/4/5/4	9	9	9			Similar to 1D, except moist and loose.	
							20				
							18				
							18				
							28				
10								120.7		10.0	
	3D	24/14	10.00 - 12.00	5/3/2/3	5	5	5			Brown, wet, medium stiff, fine to medium, Sandy SILT, trace gravel, (Alluvium).	G#304299 A-4, CL WC=23.0%
							6				
							26				
							21				
								116.7		14.0	
							60				
15	4D	24/15	15.00 - 17.00	16/36/31/22	67	67	35			Brown, wet, very dense, GRAVEL, little sand, little silt, (Glacial Till).	
							81				
							95				
							71/4"	112.4		18.3	
	R1	24/24	19.00 - 21.00	RQD = 75%			NQ-2			Top of Bedrock at EL. 112.4 ft. Roller cone through Bedrock to 19.0 ft bgs. R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, moderate to steep foliation, breaks along foliation and low angle conjugate joints, spaced moderately close, healed to tight, calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Fair. R1 Core Times (min:sec): 19.0-20.0 ft (5:30) 20.0-21.0 ft (5:52) 100% Recovery	
20											
	R2	46/45	21.00 - 24.83	RQD = 20%							
25	R3	53/50	24.80 - 29.22	RQD = 75%							

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-104
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+26.8, 7.8 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.7' (after drilling)
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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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.
25										R2:Bedrock: Similar to R1, except more fractured. [Vassalboro Formation] Rock Quality = Very Poor. R2 Core Times (min:sec): 21.0-22.0 ft (4:31) 22.0-23.0 ft (4:16) 23.0-24.0 ft (4:51) 24.0-24.8 ft (4:48) 98% Recovery	
								101.5			
30										R3:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, moderate to steep foliation, joints dip at low angles, closely spaced, healed to tight, significant calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Fair. R3 Core Times (min:sec): 24.8-25.0 ft (0:27) 25.0-26.0 ft (6:36) 26.0-27.0 ft (7:06) 27.0-28.0 ft (7:05) 28.0-29.0 ft (5:44) 29.0-29.2 ft (0:39) 94% Recovery	
35										29.2 **Bottom of Exploration at 29.2 feet below ground surface.**	
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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Boring No.: BB-AHS-104

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-201
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 11:30-13:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+79, 6.9 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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 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	130.0		8" HMA. 0.7	
5	1D	24/12	5.00 - 7.00	4/4/4/7	8	12				Brown, damp, medium dense, SAND, trace gravel, trace silt, (Fill).	
10	2D/A	24/13	10.00 - 12.00	2/3/4/2	7	11	HP			2D (10.0-11.5 ft bgs.) Brown, wet, medium dense, SAND, trace gravel, trace silt, (Fill).	
							HP	119.2		11.5 2D/A (11.5-12.0 ft bgs.) Grey-brown, wet, fine to medium, Sandy SILT, trace clay, trace gravel, (Alluvium).	G#241517 A-4, CL WC=24.2%
							102			Wood observed in wash water.	
							21	116.7		14.0	
	3D	24/13	14.00 - 16.00	20/17/17/11	34	52	32			Grey, wet, very dense, Silty SAND, trace gravel, (Glacial Till).	
15							45				
	4D/A	9/9	16.00 - 16.75	16/54(3")	---		a53	114.1		a53 blows for 0.6 ft. 4D (16.0-16.6) Similar to above, except very dense, with wood chips. 4D/A (16.6-16.75) Bedrock Chips. 16.6	
	R1	63.6/63.6	16.90 - 22.20	RQD = 47%			NQ-2			Top of Bedrock at Elev. 114.1 ft. Roller Coned ahead to 16.9 ft bgs. R1: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, steep foliation paralleling thin bedding, joints are low angle to vertical and are not parallel to bedding or foliation, joint spacing is close, fresh to slightly weathered, tight to open, some rock flour. [Vassalboro Formation] Rock Quality = Poor. R1: Core Times (min:sec) 16.9-17.9 ft (3:54) 17.9-18.9 ft (3:21) 18.9-19.9 ft (2:52) 19.9-20.9 ft (2:45) 20.9-21.9 ft (3:02) 21.9-22.2 ft (1:01)	
20											
	R2	56.4/56.4	22.20 - 26.90	RQD = 89%							
25											

Remarks:

Hammer # 367
HP = Hydraulic Push

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-201

WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 11:30-13:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+79, 6.9 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.91	**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										100% Recovery	
								103.8		R2: Bedrock: Similar to R1, except less fractured, more competent. [Vassalboro Formation] Rock Quality = Good. R2: Core Times (min:sec) 22.2-23.2 ft (2:53) 23.2-24.2 ft (2:33) 24.3-25.2 ft (3:01) 25.2-26.2 ft (2:54) 26.2-26.9 ft (1:40) 100% Recovery	
30										26.9	
										Bottom of Exploration at 26.9 feet below ground surface.	
35											
40											
45											
50											

Remarks:

Hammer # 367
HP = Hydraulic Push

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Boring No.: BB-AHS-201

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-202
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 08:30-11:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+24.2, 7.0 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor: 0.91		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
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RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
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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	130.2		7" HMA. 0.6	
5	1D	24/14	5.00 - 7.00	4/4/4/3	8	12				Brown, dry, medium dense, SAND, little gravel, trace silt, (Fill).	
	2D	28.8/10	9.90 - 12.30	4/4/4/2	8	12	aHP	120.9		9.9	
10							HP			aHP for 0.1 ft. Brown, moist, medium dense, SAND, some gravel, some silt, trace clay, (Alluvium).	G#241516 A-1-b, SC-SM WC=16.4%
							HP				
	3D	24/5	12.50 - 14.50	1/1/16/7	17	26	HP			WOOD, trace sand. aHP for 0.8 ft.	
							aHP a23			Wood 13.8-15.0 ft bgs.	
							54			a23 blows for 0.2 ft.	
15	4D	6/5	15.00 - 15.50	17(6")	---		88	115.8		15.0 Grey, wet, Silty GRAVEL, little sand, (Glacial Till). a40 blows for 0.5 ft.	
	~~MD~~	~~6/0~~	~~15.50 - 16.00~~	~~16(6")~~	~~---~~		~~a40~~				
	5D	12/8	16.00 - 17.00	18/50(5.5")	---			114.3		16.5	
	R1	13.2/13.2	17.00 - 18.10	RQD = 0%			NQ-2	113.8		Grey, wet, very dense, rock fragments, trace silt, trace fine to coarse sand, (Fractured Rock). 17.0	
	R2	19.2/19.2	18.10 - 19.70	RQD = 0%						Top of Bedrock at Elev. 113.8 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, very fractured, steep to vertical joints broken along bedding planes, joints very close and tight with no infilling. [VASSALBORO FORMATION] Rock Quality = Very Poor. R1: Core Times (min:sec) 17.0-18.0 ft (3:16) 18.0-18.1 ft (0:40) Core Blocked 100% Recovery	
	R3	60/60	19.70 - 24.70	RQD = 37%							
20											
	R4	27.6/27.6	24.70 - 27.00	RQD = 65%						R2: Bedrock: Similar to R1. [Vassalboro Formation] Rock Quality = Very Poor. R2: Core Times (min:sec)	
25											

Remarks:

Hammer # 367
HP = Hydraulic Push

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-202
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 08:30-11:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+24.2, 7.0 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
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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										18.1-19.1 ft (3:20) 19.1-19.7 ft (3:18) Core Blocked 100% Recovery	
								103.8		R3: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, steep to vertical joints, closely spaced with infrequent quartz infilling. Quartz discontinuity from 20.7' to 21.8' with open, moderately weathered fractures at each end. Upper 2' moderately fractured, then more competent and massive. [Vassalboro Formation] Rock Quality = Poor. R3: Core Times (min:sec) 19.7-20.7 ft (4:32) 20.7-21.7 ft (4:48) 21.7-22.7 ft (4:17) 22.7-23.7 ft (3:50) 23.7-24.7 ft (3:11) 100% Recovery	
30											
										R4: Bedrock: Grey, fine-grained, GRAYWACKE with frequent annealed quartz intrusions, hard, slightly weathered, moderately fractured, joints are steeply dipping to horizontal, closely spaced. [Vassalboro Formation] Rock Quality = Fair. R4: Core Times (min:sec) 24.7-25.7 ft (3:33) 25.7-26.7 ft (3:42) 26.7-27.0 ft (1:04) 100% Recovery	
35											
										27.0	
										Bottom of Exploration at 27.0 feet below ground surface.	
40											
45											
50											

Remarks:

Hammer # 367
HP = Hydraulic Push

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Boring No.: BB-AHS-202

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream **Location:** Argyle TWP, Maine	**Boring No.:** BP-AHS-301 **WIN:** 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	5/6/2024; 13:30-14:00	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	7+67.6, 6.1 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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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	130.1		7" HMA. (0.6)	
										No material descriptions.	
5											
10											
15											
								111.4		(19.3) **Bottom of Exploration at 19.3 feet below ground surface.** Auger REFUSAL, presumed Top of Rock Elev. at 111.4 ft. Grey rock dust on tip of auger.	
20											
25											

Remarks:

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

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

Boring No.: BP-AHS-301

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-302
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.6	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 08:05-10:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 6.1 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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	130.2		5" HMA. 0.4	
5							20			(FILL).	
							13				
							8				
							31				
							71				
10							41	119.6		11.0	
							98				
							138				
							235				
							209				
15							RC			(GLACIAL TILL).	
20											
	R1	60/60	21.60 - 26.60	RQD = 66%			NQ-2	109.0		21.6 Top of Bedrock at Elev. 109.0 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, joints low angle to moderately dipping, closely spaced, with significant quartz or calcite infilling. [Vassalboro Formation] Rock Quality = Fair R1: Core Times (min:sec)	#319158 22.80-23.17 q_p=6,091 psi
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-302

WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.6	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 08:05-10:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 6.1 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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
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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								104.0		21.6-22.6 ft (2:40) 22.6-23.6 ft (3:01) 23.6-24.6 ft (3:36) 24.6-25.6 ft (4:07) 25.6-26.6 ft (4:55) 100% Recovery	
										26.6 **Bottom of Exploration at 26.6 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BP-AHS-303
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	5/6/2024; 12:55-13:30	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	8+42.4, 6.2 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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			No material descriptions.	
5											
10											
15											
20								109.9		20.9	
										Bottom of Exploration at 20.9 feet below ground surface. Auger REFUSAL, presumed Top of Rock Elev. at 109.9 ft. Grey rock dust on tip of auger.	
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-304
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 10:30-12:45	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+39.5, 7.7 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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	130.1		7" HMA. — 0.6	
										(FILL).	
5							22				
							31	123.7		— 7.0	
							242				
							RC			Cobble at 8.5 ft bgs.	
10										Cobble at 10.6 ft bgs.	
15										(GLACIAL TILL).	
20											
	R1	60/60	21.30 - 26.30	RQD = 80%			NQ-2	109.4		Top of Bedrock at 109.7 ft. — 21.3 R1: Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, massive. [Vassalboro Formation] Rock Quality = Good R1: Core Times (min:sec) 21.3-22.3 ft (2:27) 22.3-23.3 ft (2:30)	#319158 22.10-22.48 q_p=5,920 psi
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-304
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 10:30-12:45	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+39.5, 7.7 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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
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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								104.4		23.3-24.3 ft (2:27) 24.3-25.3 ft (2:34) 25.3-26.3 ft (3:04) 100% Recovery	
										26.3 **Bottom of Exploration at 26.3 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

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

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

<u>Appendix B</u>

Rock Core Photographs

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-101	R1	22.5-25.2	32	8	6	19	GRAYWACKE	1
BB-AHS-101	R2	25.2-26.7	17	17	12	70	GRAYWACKE	1
BB-AHS-101	R3	26.7-28.5	22	20	20	91	GRAYWACKE	1
BB-AHS-104	R1	19.0-21.0	24	24	18	75	GRAYWACKE	2
BB-AHS-104	R2	21.0-24.8	46	45	9	20	GRAYWACKE	2+3
BB-AHS-104	R3	24.8-29.2	53	50	40	75	GRAYWACKE	3+4

Notes: 1. “Box row” indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.
3. Transition between core runs is marked by pink flagging.

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-102	R1	18.0-22.0	48	48	39	81	GRAYWACKE	1
BB-AHS-102	R2	22.0-26.0	48	48	48	100	GRAYWACKE	2
BB-AHS-102	R3	26.0-28.0	24	23	16	66	GRAYWACKE	3
BB-AHS-103	R1	17.8-22.8	60	48	41	68	GRAYWACKE	4

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-201	R1	16.9-22.2	63.6	63.6	30	47	GRAYWACKE	1+2
BB-AHS-201	R2	22.2-26.9	56.4	56.4	50	89	GRAYWACKE	2+3

Notes: 1. “Box row” indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Top of each core run is on the left and increases with depth to the right.

3. Transition between core runs is marked by wooden blocks.

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-202	R1	17.0-18.1	13.2	13.2	0	0	GRAYWACKE	1
BB-AHS-202	R2	18.1-19.7	19.2	19.2	0	0	GRAYWACKE	1
BB-AHS-202	R3	19.7-24.7	60	60	22	37	GRAYWACKE	1+2
BB-AHS-202	R4	24.7-27.0	27.6	27.6	18	65	GRAYWACKE	2+3

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.
3. Transition between core runs is marked by wooden blocks.

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-302	R1	21.6-26.6	60	60	40	66	GRAYWACKE	1
BB-AHS-304	R1	21.3-26.3	60	60	48	80	GRAYWACKE	2

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Top of each core run is on the left and increases with depth to the right.

Appendix C

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Argyle   Work Number: 21687.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification Unified	AASHTO	Frost
BB-AHS-101, 2D	7+76.2	6.0 Rt.	5.0-7.0	271096	1	7.9			SW-SM	A-1-b	0
BB-AHS-101, 3D	7+76.2	6.0 Rt.	12.0-14.0	271097	1	26.4			SC-SM	A-2-4	II
BB-AHS-102, 3D	7+81.5	8.1 Lt.	10.0-12.0	271098	1	26.2			CL	A-4	IV
BB-AHS-103, 2D	8+19.2	7.2 Rt.	5.0-7.0	271099	1	4.9			SW-SM	A-1-b	0
BB-AHS-103, 4D	8+19.2	7.2 Rt.	15.0-17.0	271100	1	12.4			SM	A-1-b	II
BB-AHS-104, 3D	8+26.8	7.8 Lt.	10.0-12.0	304299	1	23.0			CL	A-4	IV
BB-AHS--201, 2D/A	7+79	6.9 Lt.	11.5-12.0	241517	2	24.2			CL	A-4	IV
BB-AHS-202, 2D	8+24.2	7.0 Lt.	9.9-12.3	241516	2	16.4			SC-SM	A-1-b	II
BB-AHS-302, R1	7+62.3	6.1 Rt.	22.80-23.17	319158	Peak Compressive Stress = 6,091 psi						
BB-AHS-304, R1	8+39.5	7.7 Rt	22.10-22.48	319158	Peak Compressive Stress = 5,920 psi						

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

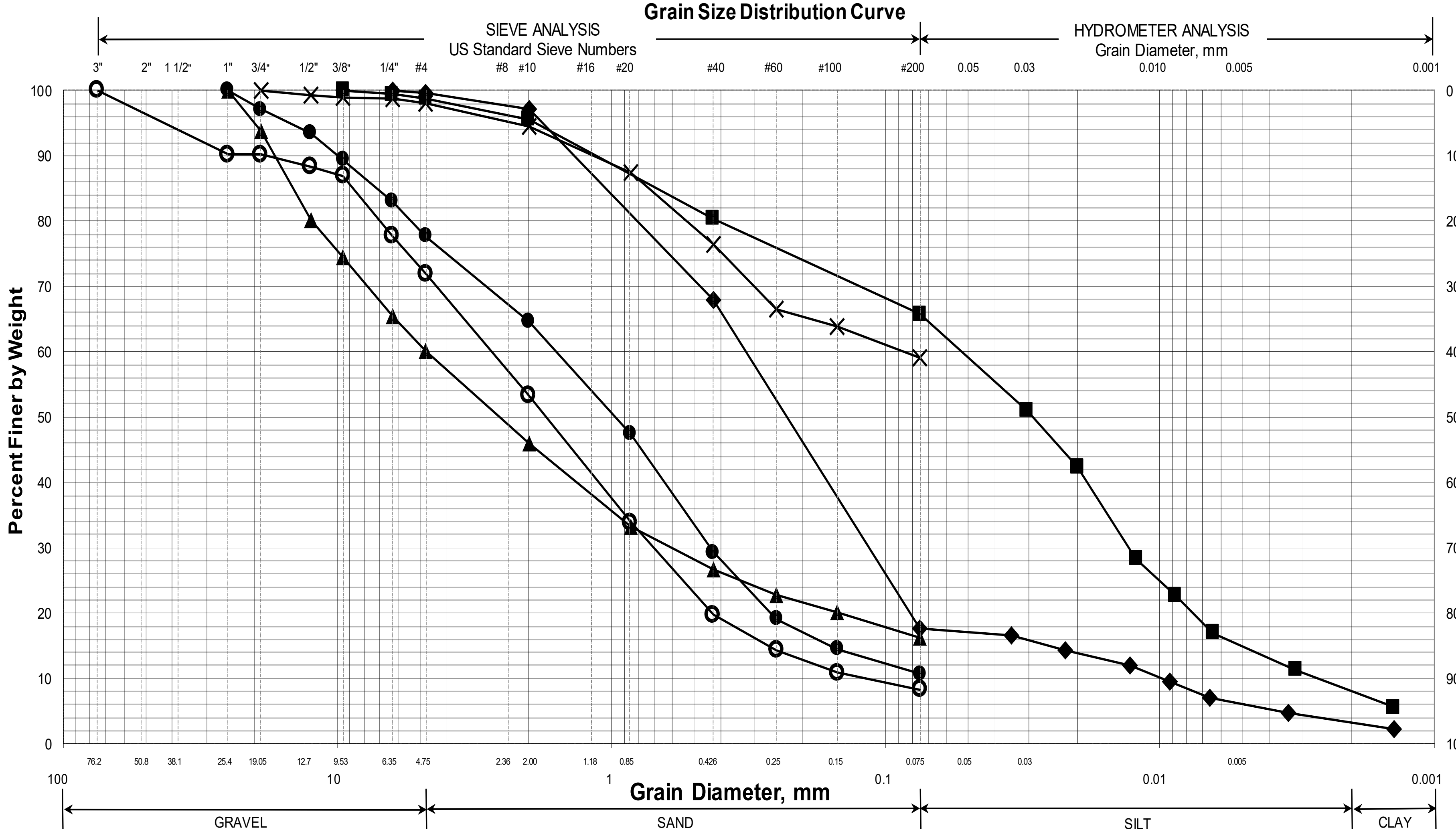
GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98   NP = Non Plastic

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

Maine Department of Transportation
Grain Size Distribution Curve



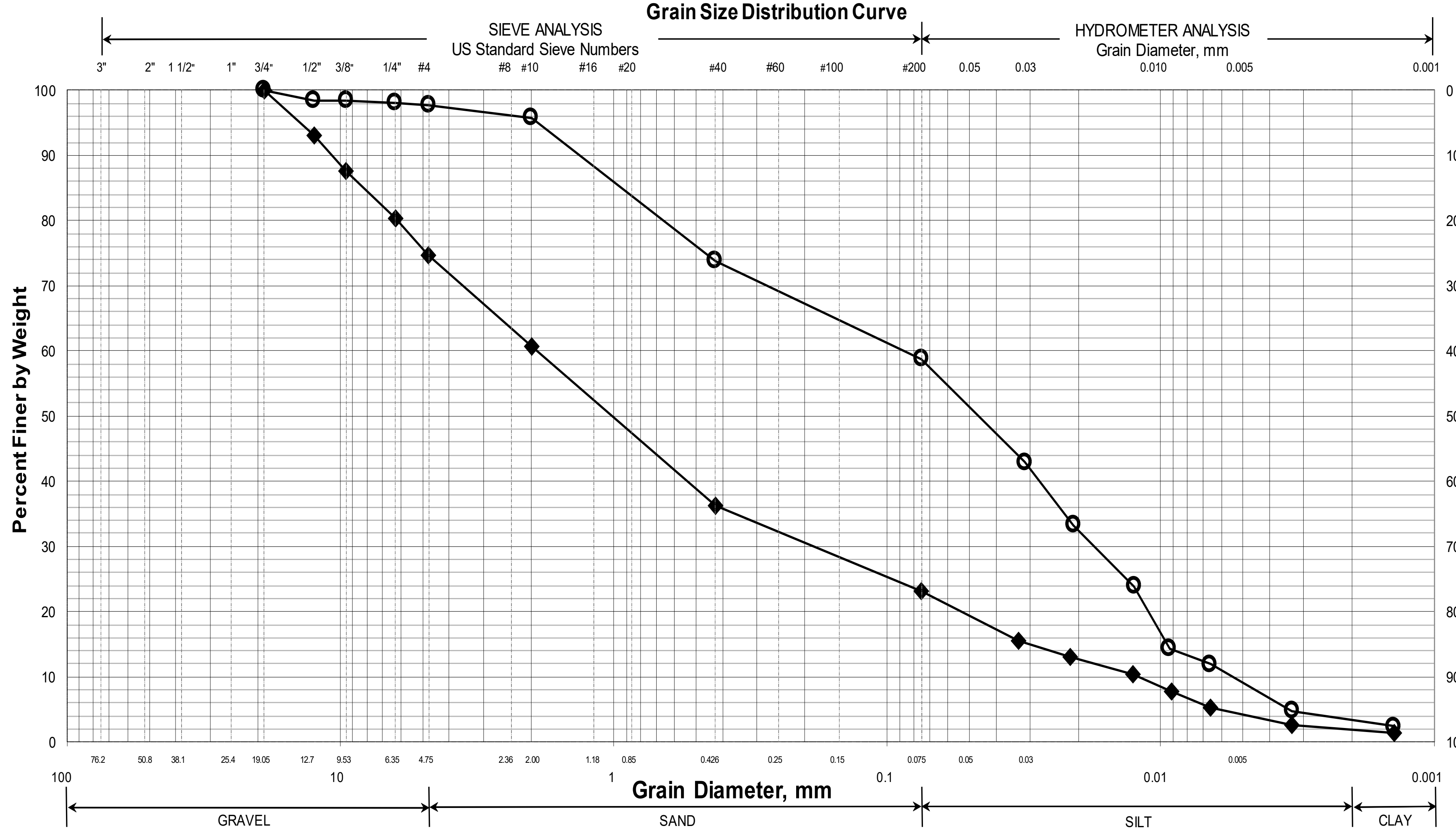
UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	BB-AHS-101/2D	7+76.2	6.0 RT	5.0-7.0	SAND, some gravel, trace silt.	7.9			
◆	BB-AHS-101/3D	7+76.2	6.0 RT	12.0-14.0	SAND, little silt, trace clay, trace gravel.	26.4			
■	BB-AHS-102/3D	7+81.5	8.1 LT	10.0-12.0	SILT, some sand, trace clay, trace gravel.	26.2			
●	BB-AHS-103/2D	8+19.2	7.2 RT	5.0-7.0	SAND, some gravel, little silt.	4.9			
▲	BB-AHS-103/4D	8+19.2	7.2 RT	15.0-17.0	Gravelly SAND, little silt.	12.4			
×	BB-AHS-104/3D	8+26.8	7.8 LT	10.0-12.0	Sandy SILT, trace gravel.	23			

WIN	
021687.00	
Town	
Argyle Twp	
Reported by/Date	
WHITE, TERRY A	3/10/2022

SHEET 1

Maine Department of Transportation
Grain Size Distribution Curve



UNIFIED CLASSIFICATION

	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	WC, %	LL	PL	PI
○	BB-AHS-201/2DA	7+79	6.9 LT	11.5-12.0	Sandy SILT, trace clay, trace gravel.	24.2			
◆	BB-AHS-202/2D	8+24.2	7.0 LT	9.9-12.3	SAND, some gravel, some silt, trace clay.	16.4			
■									
●									
▲									
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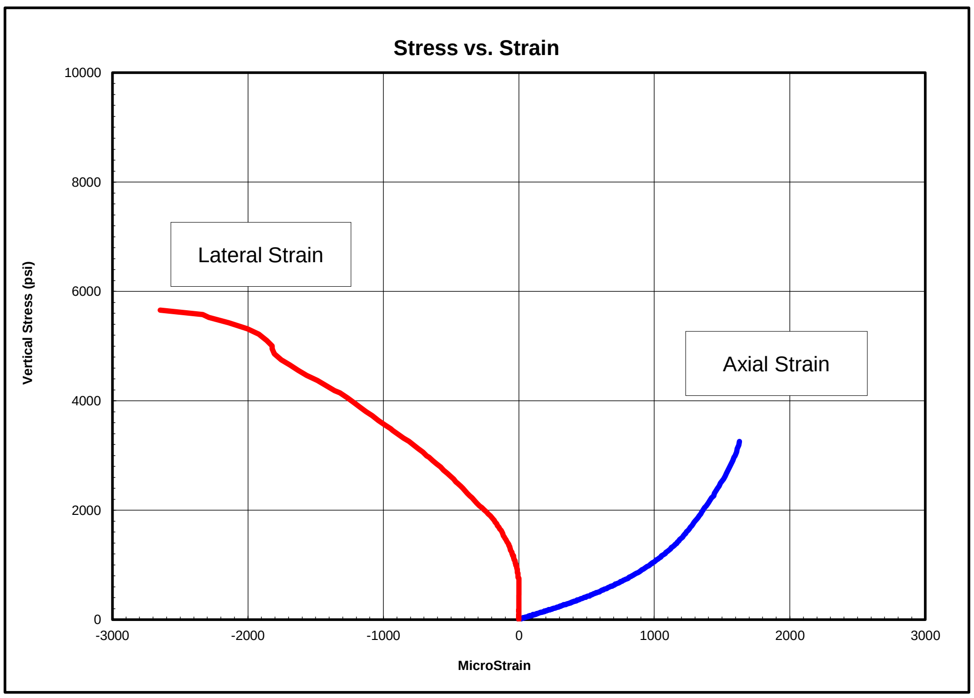
WIN
021687.00
Town
Argyle Twp
Reported by/Date
WHITE, TERRY A 5/26/2022

SHEET 2

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-AHS-302
Sample ID:	R1
Depth, ft:	22.80-23.17
Sample Type:	rock core
Sample Description:	See photographs Intact material and discontinuity failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 6,091 psi

The axial strain gauges failed before the peak value was attained. Young's Modulus could not be determined within the third stress range. Poisson's Ratio could not be determined within the second and third stress range.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
600-2200	2,050,000	0.41
2200-3900	5,880,000	---
3900-5500	---	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-302		
Sample ID:	R1		
Depth (ft):	22.80-23.17		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.45	4.45	4.45		
Specimen Diameter, in:	1.97	1.97	1.97		
Specimen Mass, g:	618.82				
Bulk Density, lb/ft^3	173	**Minimum Diameter Tolerence Met?**		**YES**	
Length to Diameter Ratio:	2.3	**Length to Diameter Ratio Tolerance Met?**		**YES**	

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap ≤ 0.02 in.? NO

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? **NO**

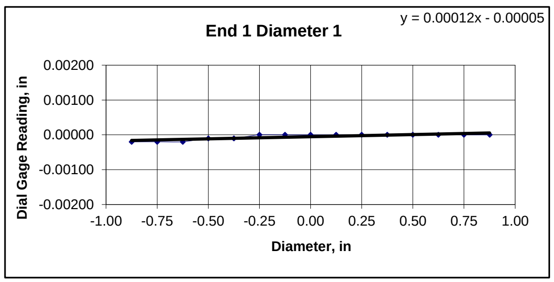
END FLATNESS AND PARALLELISM (Procedure FP1)

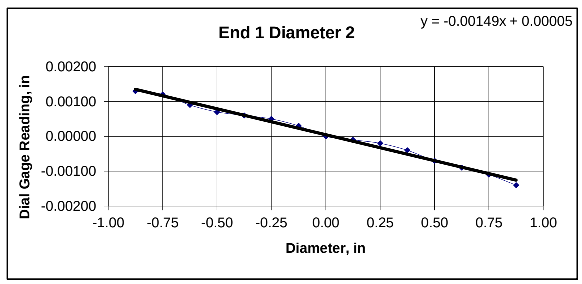
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00020	-0.00020	-0.00020	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	0.00130	0.00120	0.00090	0.00070	0.00060	0.00050	0.00030	0.00000	-0.00010	-0.00020	-0.00040	-0.00070	-0.00090	-0.00110	-0.00140

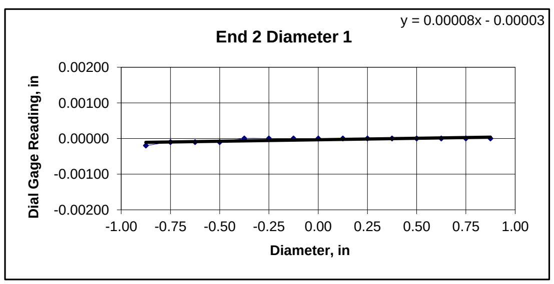
Difference between max and min readings, in:
0° = 0.00020 90° = 0.00270

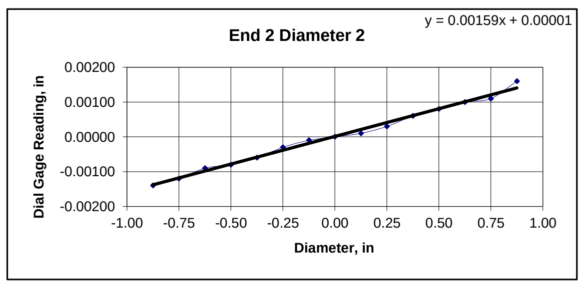
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00020	-0.00010	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	-0.00140	-0.00120	-0.00090	-0.00080	-0.00060	-0.00030	-0.00010	0.00000	0.00010	0.00030	0.00060	0.00080	0.00100	0.00110	0.00160

Difference between max and min readings, in:
0° = 0.0002 90° = 0.003
Maximum difference must be < 0.0020 in. Difference = ± 0.00150
Flatness Tolerance Met? **NO**









DIAMETER 1

End 1:	
Slope of Best Fit Line	0.00012
Angle of Best Fit Line:	0.00704
End 2:	
Slope of Best Fit Line	0.00008
Angle of Best Fit Line:	0.00475
Maximum Angular Difference:	0.00229

Parallelism Tolerance Met? **YES**
Spherically Seated

DIAMETER 2

End 1:	
Slope of Best Fit Line	0.00149
Angle of Best Fit Line:	0.08529
End 2:	
Slope of Best Fit Line	0.00159
Angle of Best Fit Line:	0.09118
Maximum Angular Difference:	0.00589

Parallelism Tolerance Met? **NO**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00020	1.970	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00270	1.970	0.00137	0.079	YES
END 2					
Diameter 1, in	0.00020	1.970	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00300	1.970	0.00152	0.087	YES

Maximum angle of departure must be ≤ 0.25°
Perpendicularity Tolerance Met? **YES**

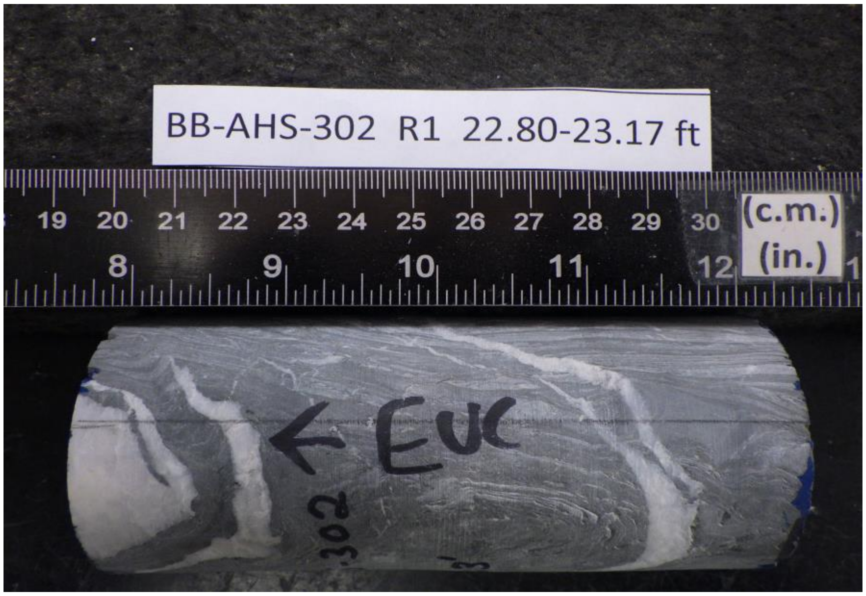
Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-302	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	22.80-23.17		
Visual Description:	See photographs		

BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

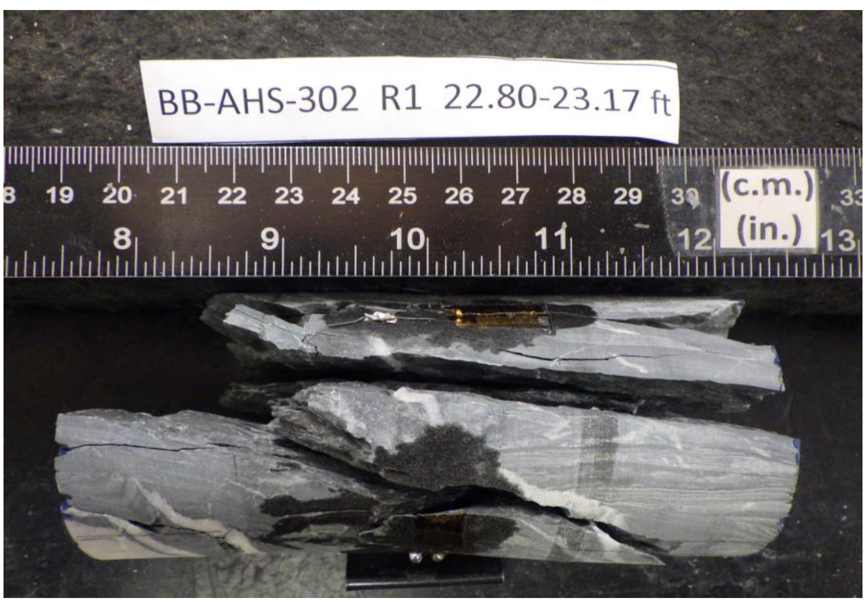
END FLATNESS		
END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	smd
Boring ID:	BB-AHS-302
Sample ID:	R1
Depth, ft:	22.80-23.17



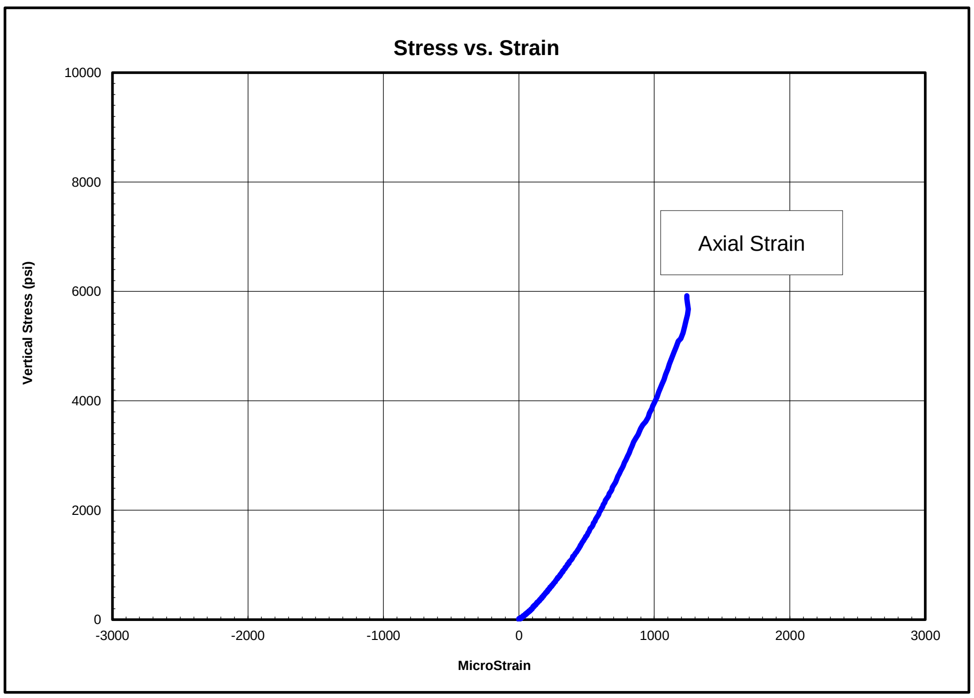
After cutting and grinding



After break

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-AHS-304
Sample ID:	R1
Depth, ft:	22.10-22.48
Sample Type:	rock core
Sample Description:	See photographs Intact material and discontinuity failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 5,920 psi

The lateral strain gauges failed to record meaningful data. Poisson's Ratio could not be determined for this test.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
600-2200	3,490,000	---
2200-3700	4,730,000	---
3700-5300	4,910,000	---

Notes:
Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

GeoTesting EXPRESS

Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-304		
Sample ID:	R1		
Depth (ft):	22.10-22.48		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.49	4.49	4.49		
Specimen Diameter, in:	1.98	1.98	1.98		
Specimen Mass, g:	626.57				
Bulk Density, lb/ft^3	172			**Minimum Diameter Tolerence Met?**	**YES**
Length to Diameter Ratio:	2.3			**Length to Diameter Ratio Tolerance Met?**	**YES**

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? **YES**

END FLATNESS AND PARALLELISM (Procedure FP1)

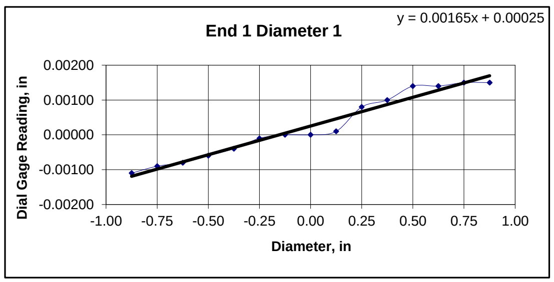
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00110	-0.00090	-0.00080	-0.00060	-0.00040	-0.00010	0.00000	0.00000	0.00010	0.00080	0.00100	0.00140	0.00140	0.00150	0.00150
Diameter 2, in (rotated 90°)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

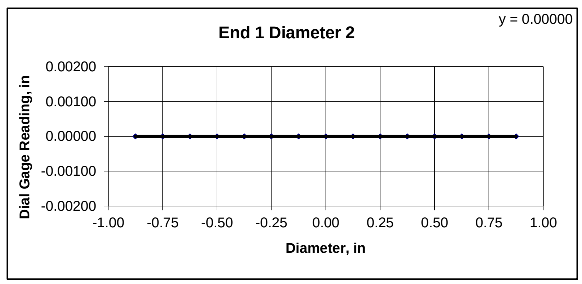
Difference between max and min readings, in:
0° = 0.00260 90° = 0.00000

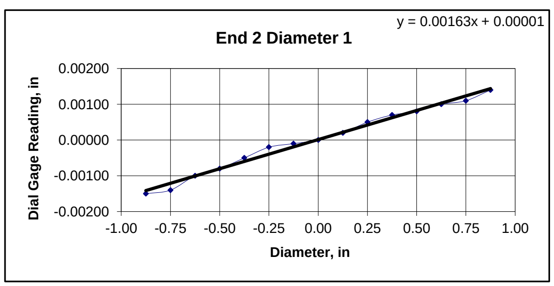
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00150	-0.00140	-0.00100	-0.00080	-0.00050	-0.00020	-0.00010	0.00000	0.00020	0.00050	0.00070	0.00080	0.00100	0.00110	0.00140
Diameter 2, in (rotated 90°)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

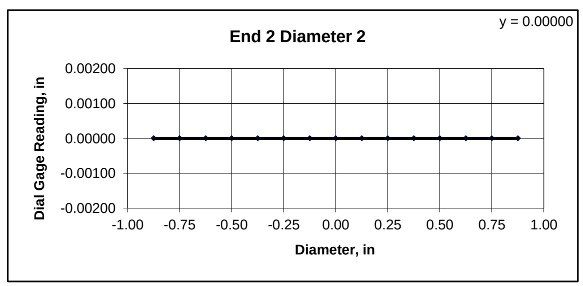
Difference between max and min readings, in:
0° = 0.0029 90° = 0

Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00145
Flatness Tolerance Met? **NO**









DIAMETER 1

End 1:
Slope of Best Fit Line 0.00165
Angle of Best Fit Line: 0.09446

End 2:
Slope of Best Fit Line 0.00163
Angle of Best Fit Line: 0.09331

Maximum Angular Difference: 0.00115

Parallelism Tolerance Met? **YES**
Spherically Seated

DIAMETER 2

End 1:
Slope of Best Fit Line 0.00000
Angle of Best Fit Line: 0.00000

End 2:
Slope of Best Fit Line 0.00000
Angle of Best Fit Line: 0.00000

Maximum Angular Difference: 0.00000

Parallelism Tolerance Met? **YES**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00260	1.980	0.00131	0.075	YES
Diameter 2, in (rotated 90°)	0.00000	1.980	0.00000	0.000	YES
END 2					
Diameter 1, in	0.00290	1.980	0.00146	0.084	YES
Diameter 2, in (rotated 90°)	0.00000	1.980	0.00000	0.000	YES

Maximum angle of departure must be $\leq$ 0.25°
Perpendicularity Tolerance Met? **YES**

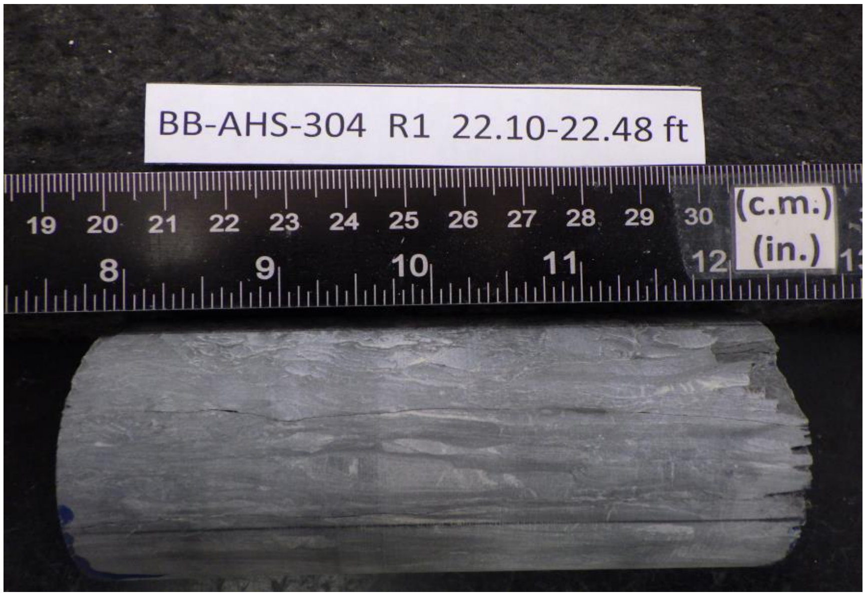
Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-304	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	22.10-22.48		
Visual Description:	See photographs		

BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS		
END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	smd
Boring ID:	BB-AHS-304
Sample ID:	R1
Depth, ft:	22.10-22.48



After cutting and grinding

After break

Appendix D

Calculations

Earth Pressure

Earth Pressure:

Backfill engineering strength parameters

Soil Type 4 Properties from MaineDOT Bridge Design Guide (BDG)

Unit weight $\gamma_1 := 125 \cdot pcf$

Internal friction angle $\phi' := 32 \cdot deg$

Cohesion $c_1 := 0 \cdot psf$

Abutment Backfill Angles

α = Angle of fill slope to the horizontal

Angles computed based on roadway elevation change 25 feet behind the centerline of the abutments

$Rise_{ABT1} := -0.1ft$ $Rise_{ABT2} := 0.1ft$ $Run := 25ft$

$$\alpha_{ABT1} := atan\left(\frac{Rise_{ABT1}}{Run}\right) = -0.23 \cdot deg$$ Abutment No. 1

$$\alpha_{ABT2} := atan\left(\frac{Rise_{ABT2}}{Run}\right) = 0.23 \cdot deg$$ Abutment No. 2

Backfill slope is negligible at both abutments. Treat as level backfill. $\alpha := 0 \cdot deg$

Integral Abutment - Passive Earth Pressure - Coulomb Theory

α = Angle of fill slope to the horizontal $\alpha := 0 \cdot deg$

ϕ_1 = Angle of internal friction $\phi' = 32 \cdot deg$

β = Angle of back face of wall to the horizontal $\beta := 90 \cdot deg$

Use Coulomb for cases where interface friction is considered; typically gravity shaped structures, and integral abutments where the ratio of wall height to wall movement is .020 or greater. Coulomb should also be used when the fill slope is greater than horizontal.

For formed concrete IAB abutment against clean sand, silty sand-gravel mixture use δ = 17 - 22, per LRFD Table 3.11.5.3-1

δ = friction angle between fill and wall taken as specified in LRFD Table 3.11.5.3-1 (degrees)

$\delta' := 17 \cdot deg$

$$K_{p\_coulomb} := \frac{\sin(\beta - \phi')^2}{\sin(\beta)^2 \cdot \sin(\beta + \delta') \cdot \left(1 - \sqrt{\frac{\sin(\phi' + \delta') \cdot \sin(\phi' + \alpha)}{\sin(\beta + \delta') \cdot \sin(\beta + \alpha)}}\right)^2}$$

Das, Principles of Foundation Engineering 7th Ed. p. 366 Eq. 7.71

$K_{p\_coulomb} = 6.02$

Integral Abutment and Wingwall - Passive Earth Pressure - Rankine Theory

Per the BDG, use Rankine only if the ratio of wall height to wall movement is 0.005 or less and the fill slope is horizontal to the top of the wall. Bowles does not recommend use of Rankine method for K_p when $\alpha > 0$.

α = Angle of fill slope to the horizontal $\qquad \alpha := 0 \cdot deg$

$$K_{p\_rank} := \cos(\alpha) \cdot \frac{\cos(\alpha) + \sqrt{\cos(\alpha)^2 - \cos(\phi')^2}}{\cos(\alpha) - \sqrt{\cos(\alpha)^2 - \cos(\phi')^2}}$$

Das, Principles of Foundation Engineering 7th Ed. p. 363 Eq. 7.67

$\boxed{K_{p\_rank} = 3.25}$ $\qquad$ P_p is oriented at an angle of α to the vertical plane

Integral Abutment - Passive Pressure Coefficient per MassDOT LRFD Bridge Manual Part 1

$$K = 0.43 + 5.7[1 - e^{-190(\delta_T/H)}]$$

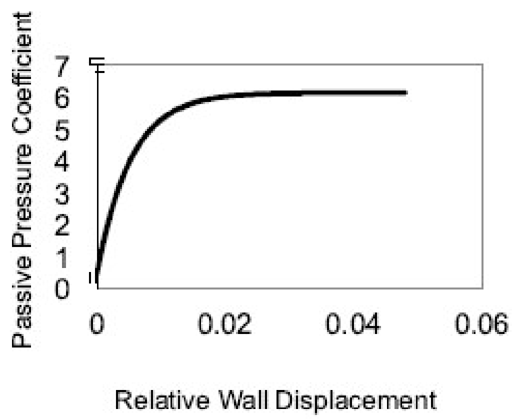


Figure 3.10.8-1: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

Compute Relative Wall Displacement

$\delta := 0.301in$ $\qquad$ Provided by MaineDOT Bridge Designer

Abutment height: $\quad h := 10.5ft \quad h = 126 \cdot in$

Relative wall displacement: $\quad x := \frac{\delta}{h} \qquad x = 0.0024$

Calculate MassDOT Passive Pressure Coefficient

$$K := 0.43 + 5.7\cdot[1 - \exp[-190(x)]]$$

$K = 2.51$ **< K_{p_rank} of 3.25, therefore recommend K=3.25 for both Abutments**

Return Wingwalls - Active Earth Pressure - Rankine Theory

For cantilever walls with horizontal backslope:

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

BDG Section 3.6.5.2

$K_a = 0.31$

Table 3.11.5.3-1—Friction Angle for Dissimilar Materials (U.S. Department of the Navy, 1982a)

Interface Materials	Friction Angle, δ (degrees)	Coefficient of Friction, tan δ (dim.)
Mass concrete on the following foundation materials:		
• Clean sound rock	35	0.70
• Clean gravel, gravel-sand mixtures, coarse sand	29 to 31	0.55 to 0.60
• Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	24 to 29	0.45 to 0.55
• Clean fine sand, silty or clayey fine to medium sand	19 to 24	0.34 to 0.45
• Fine sandy silt, nonplastic silt	17 to 19	0.31 to 0.34
• Very stiff and hard residual or preconsolidated clay	22 to 26	0.40 to 0.49
• Medium stiff and stiff clay and silty clay	17 to 19	0.31 to 0.34
Masonry on foundation materials has same friction factors.		
Steel sheet piles against the following soils:		
• Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls	22	0.40
• Clean sand, silty sand-gravel mixture, single-size hard rock fill	17	0.31
• Silty sand, gravel or sand mixed with silt or clay	14	0.25
• Fine sandy silt, nonplastic silt	11	0.19
Formed or precast concrete or concrete sheet piling against the following soils:		
• Clean gravel, gravel-sand mixture, well-graded rock fill with spalls	22 to 26	0.40 to 0.49
• Clean sand, silty sand-gravel mixture, single-size hard rock fill	17 to 22	0.31 to 0.40
• Silty sand, gravel or sand mixed with silt or clay	17	0.31
• Fine sandy silt, nonplastic silt	14	0.25
Various structural materials:		
• Masonry on masonry, igneous and metamorphic rocks:		
○ dressed soft rock on dressed soft rock	35	0.70
○ dressed hard rock on dressed soft rock	33	0.65
○ dressed hard rock on dressed hard rock	29	0.55
• Masonry on wood in direction of cross grain	26	0.49
• Steel on steel at sheet pile interlocks	17	0.31

3.11.5.4—Passive Lateral Earth Pressure Coefficient, k_p

For noncohesive soils, values of the coefficient of passive lateral earth pressure may be taken from Figure 3.11.5.4-1 for the case of a sloping or vertical wall with a horizontal backfill or from Figure 3.11.5.4-2 for the case of a vertical wall and sloping backfill. For conditions that deviate from those described in Figures 3.11.5.4-1 and 3.11.5.4-2, the passive pressure may be calculated by using a trial procedure based on wedge theory, e.g., see Terzaghi et al. (1996). When wedge theory is used, the limiting value of the wall friction angle should not be taken larger than one-half the angle of internal friction, ϕ_f.

For cohesive soils, passive pressures may be estimated by:

C3.11.5.4

The movement required to mobilize passive pressure is approximately 10.0 times as large as the movement needed to induce earth pressure to the active values. The movement required to mobilize full passive pressure in loose sand is approximately five percent of the height of the face on which the passive pressure acts. For dense sand, the movement required to mobilize full passive pressure is smaller than five percent of the height of the face on which the passive pressure acts, and five percent represents a conservative estimate of the movement required to mobilize the full passive pressure. For poorly compacted cohesive soils, the movement required to mobilize full passive pressure is larger than five percent of the height of the face on which the pressure acts.

Table 7.9 (*Continued*)

		$c'/\gamma z$			
ϕ' (deg)	α (deg)	0.025	0.050	0.100	0.500
30	0	3.087	3.173	3.346	4.732
	5	3.042	3.129	3.303	4.674
	10	2.907	2.996	3.174	4.579
	15	2.684	2.777	2.961	4.394

7.12 Coulomb's Passive Earth Pressure

Coulomb (1776) also presented an analysis for determining the passive earth pressure (i.e., when the wall moves *into* the soil mass) for walls possessing friction (δ' = angle of wall friction) and retaining a granular backfill material similar to that discussed in Section 7.5.

To understand the determination of Coulomb's passive force, P_p, consider the wall shown in Figure 7.25a. As in the case of active pressure, Coulomb assumed that the potential failure surface in soil is a plane. For a trial failure wedge of soil, such as ABC_1, the forces per unit length of the wall acting on the wedge are

1. The weight of the wedge, W
2. The resultant, R, of the normal and shear forces on the plane BC_1, and
3. The passive force, P_p

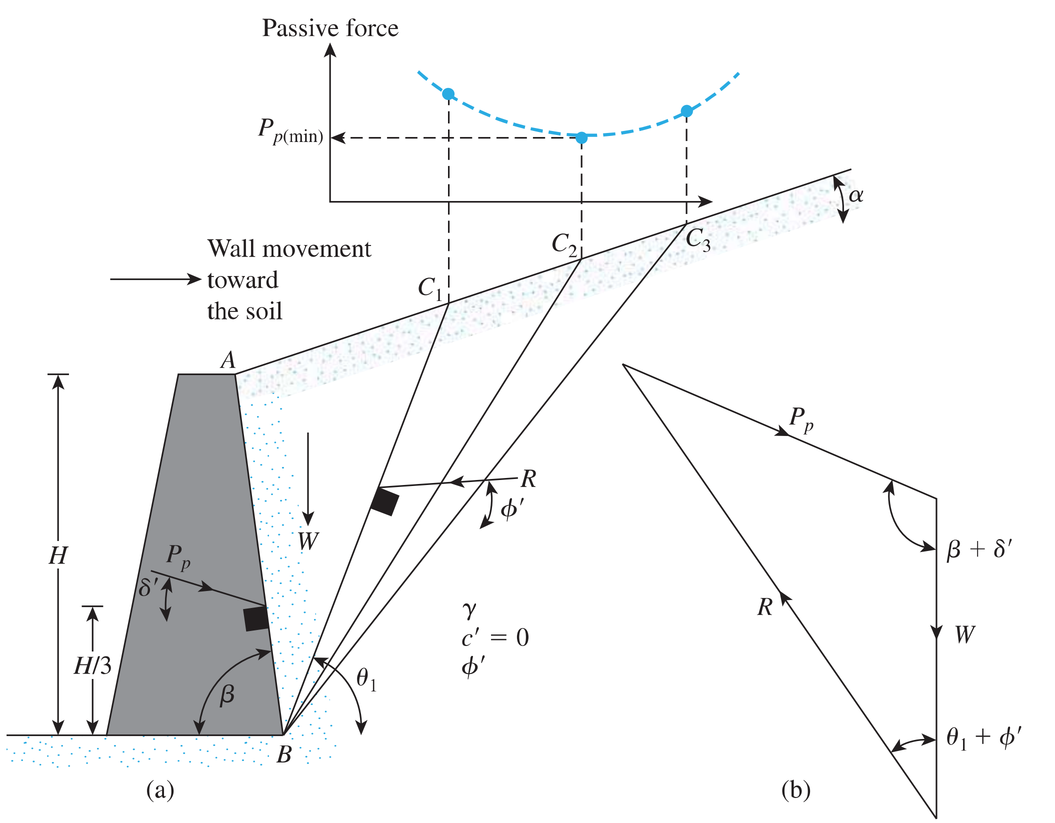


Figure 7.25 Coulomb's passive pressure

Table 7.10 Values of K_p [from Eq. (7.71)] for $\beta = 90°$ and $\alpha = 0°$

	δ' (deg)				
ϕ' (deg)	0	5	10	15	20
15	1.698	1.900	2.130	2.405	2.735
20	2.040	2.313	2.636	3.030	3.525
25	2.464	2.830	3.286	3.855	4.597
30	3.000	3.506	4.143	4.977	6.105
35	3.690	4.390	5.310	6.854	8.324
40	4.600	5.590	6.946	8.870	11.772

Figure 7.25b shows the force triangle at equilibrium for the trial wedge ABC_1. From this force triangle, the value of P_p can be determined, because the direction of all three forces and the magnitude of one force are known.

Similar force triangles for several trial wedges, such as ABC_1, ABC_2, ABC_3, . . . , can be constructed, and the corresponding values of P_p can be determined. The top part of Figure 7.25a shows the nature of variation of the P_p values for different wedges. The *minimum value of* P_p in this diagram is *Coulomb's passive force,* mathematically expressed as

$$P_p = \tfrac{1}{2}\gamma H^2 K_p \tag{7.70}$$

where

$$K_p = \text{Coulomb's passive pressure coefficient}$$
$$= \frac{\sin^2(\beta - \phi')}{\sin^2\beta \sin(\beta + \delta')\left[1 - \sqrt{\dfrac{\sin(\phi' + \delta')\sin(\phi' + \alpha)}{\sin(\beta + \delta')\sin(\beta + \alpha)}}\right]^2} \tag{7.71}$$

The values of the passive pressure coefficient, K_p, for various values of ϕ' and δ' are given in Table 7.10 $(\beta = 90°, \alpha = 0°)$.

Note that the resultant passive force, P_p, will act at a distance $H/3$ from the bottom of the wall and will be inclined at an angle δ' to the normal drawn to the back face of the wall.

7.13 Comments on the Failure Surface Assumption for Coulomb's Pressure Calculations

Coulomb's pressure calculation methods for active and passive pressure have been discussed in Sections 7.5 and 7.12. The fundamental assumption in these analyses is the acceptance of *plane failure surface*. However, for walls with friction, this assumption does not hold in practice. The nature of *actual* failure surface in the soil mass for active and passive pressure is shown in Figure 7.26a and b, respectively (for a vertical wall with a horizontal backfill). Note that the failure surface BC is curved and that the failure surface CD is a plane.

Although the actual failure surface in soil for the case of active pressure is somewhat different from that assumed in the calculation of the Coulomb pressure, the results are not greatly different. However, in the case of passive pressure, as the value of δ' increases, Coulomb's

At this depth, that is $z = 2$ m, for the bottom soil layer

$$\sigma'_p = \sigma'_o K_{p(2)} + 2c'_2\sqrt{K_{p(2)}} = 31.44(2.56) + 2(10)\sqrt{2.56}$$
$$= 80.49 + 32 = 112.49 \text{ kN/m}^2$$

Again, at $z = 3$ m,

$$\sigma'_o = (15.72)(2) + (\gamma_{sat} - \gamma_w)(1)$$
$$= 31.44 + (18.86 - 9.81)(1) = 40.49 \text{ kN/m}^2$$

Hence,

$$\sigma'_p = \sigma'_o K_{p(2)} + 2c'_2\sqrt{K_{p(2)}} = 40.49(2.56) + (2)(10)(1.6)$$
$$= \mathbf{135.65\ kN/m^2}$$

Note that, because a water table is present, the hydrostatic stress, u, also has to be taken into consideration. For $z = 0$ to 2 m, $u = 0$; $z = 3$ m, $u = (1)(\gamma_w) = 9.81$ kN/m^2.

The passive pressure diagram is plotted in Figure 6.24b. The passive force per unit length of the wall can be determined from the area of the pressure diagram as follows:

Area no.	Area	
1	$(\frac{1}{2})$ (2)(94.32)	= 94.32
2	(112.49)(1)	= 112.49
3	$(\frac{1}{2})$ (1)(135.65 − 112.49)	= 11.58
4	$(\frac{1}{2})$ (9.81)(1)	= 4.905
		$P_P \approx 223.3$ **kN/m**

7.11 Rankine Passive Earth Pressure: Vertical Backface and Inclined Backfill

Granular Soil

For a frictionless vertical retaining wall (Figure 7.10) with a *granular backfill* ($c' = 0$), the Rankine passive pressure at any depth can be determined in a manner similar to that done in the case of active pressure in Section 7.4. The pressure is

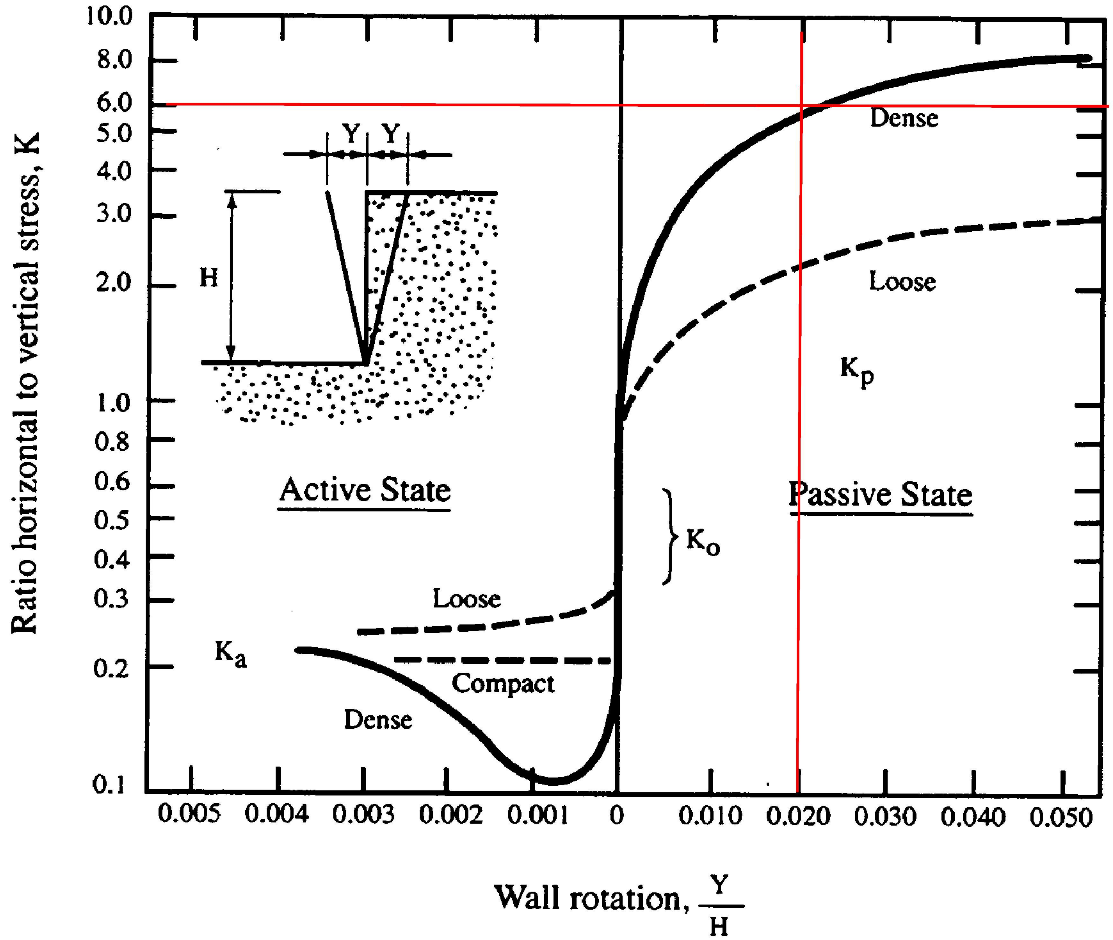
$$\sigma'_p = \gamma z K_p \tag{7.65}$$

and the passive force is

$$P_p = \tfrac{1}{2}\gamma H^2 K_p \tag{7.66}$$

where

$$K_p = \cos\alpha \frac{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}} \tag{7.67}$$



Magnitude of Wall Rotation to Reach Failure

Soil type and condition	Rotation, Y/H	
	Active	Passive
Dense cohesionless	0.001	0.02
Loose cohesionless	0.004	0.06
Stiff cohesive	0.010	0.02
Soft cohesive	0.020	0.04

Figure 10-4. Effect of wall movement on wall pressures (after Canadian Geotechnical Society, 1992).

Frost Depth

Method 1 - MaineDOT Design Freezing Index (DFI) Map and Depth of Frost Penetration Table, BDG Section 5.2.1.

From Design Freezing Index Map: Argyle Township, Maine
DFI = 1825 degree-days.
Coarse-Grained Fill w=10% (BB-AHS-101 2D, BB-AHS-103 2D)

Coarse-Grained Fill

For DFI = 1800 Coarse-Grained Soil, w=10%

$DFI_1 := 1800 \quad d_1 := 90.1\text{in}$

d=Depth of Frost Penetration

For DFI = 1900 Coarse-Grained Soil, w=10%

$DFI_2 := 1900 \quad d_2 := 92.6\text{in}$

Interpolate for DFI = 1825, Coarse-Grained Soil, w=10%

$DFI_3 := 1825$

$$d_{coarse} := d_1 + \left(DFI_3 - DFI_1\right)\cdot\frac{\left(d_2 - d_1\right)}{\left(DFI_2 - DFI_1\right)}$$

$\boxed{d_{coarse} = 90.7\cdot\text{in}}$ $\boxed{d_{coarse} = 7.6\cdot\text{ft}}$

Recommend any foundation bearing on soil be embedded **7.6 feet** for frost protection.

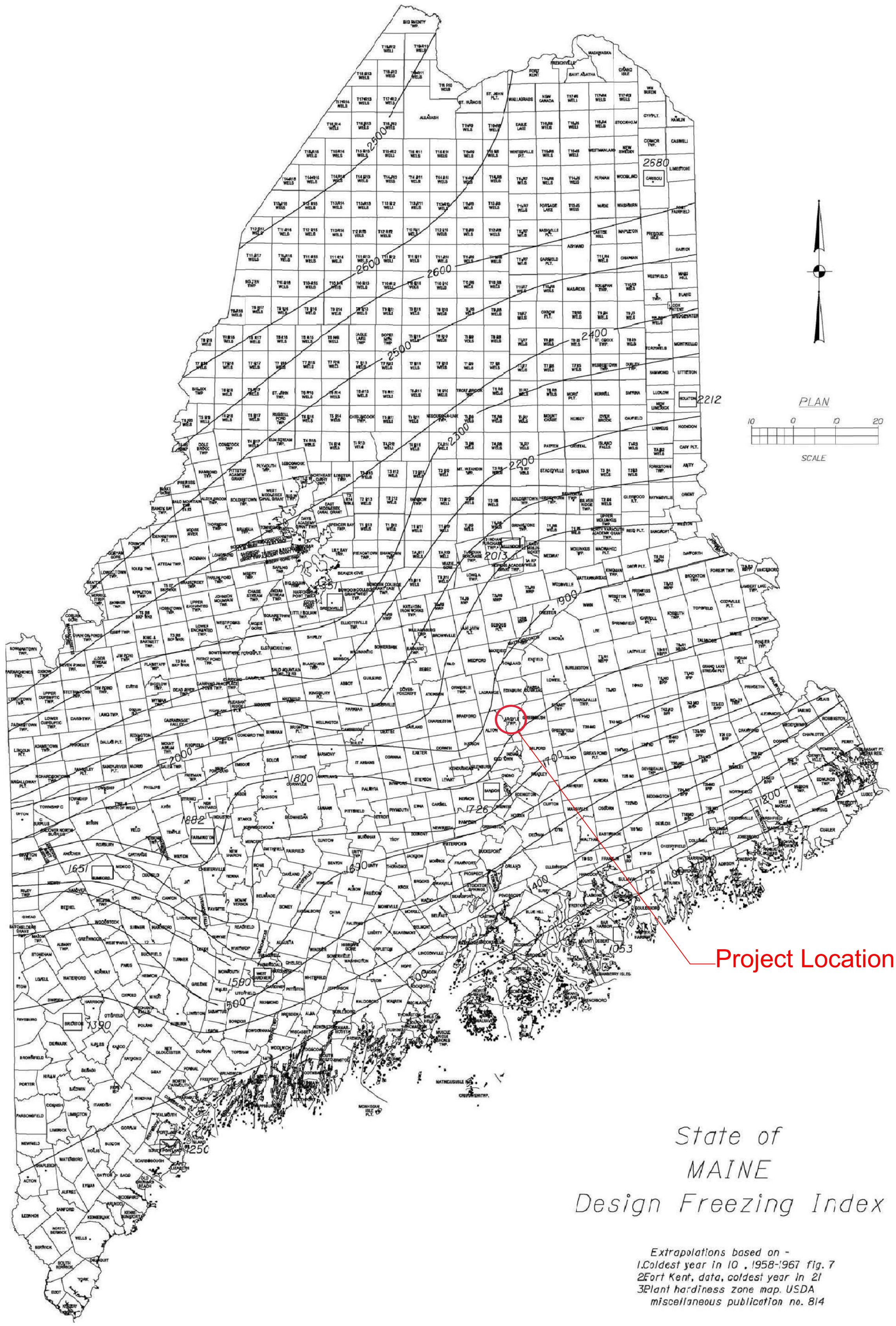


Figure 5-1 Maine Design Freezing Index Map

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

Seismic Parameters

BB-AHS-101			
Depth	**N_{60}**	**di**	**di/N**
5	9	11	1.22
10	11	1	0.09
12	4	3	0.75
15	3	2	0.67
20	50	5	0.10
22	100	78	0.78
SUM		**100**	**3.61**
		di/di/N	**27.70**

BB-AHS-102			
Depth	**N_{60}**	**di**	**di/N**
5	5	10	2.00
10	5	5	1.00
15	56	2	0.04
17	100	83	0.83
SUM		**100**	**3.87**
		di/di/N	**25.87**

BB-AHS-103			
Depth	**N_{60}**	**di**	**di/N**
5	12	10	0.83
10	15	5	0.33
15	33	2	0.06
17	100	81	0.81
SUM		**98**	**2.04**
		di/di/N	**48.10**

BB-AHS-104			
Depth	**N_{60}**	**di**	**di/N**
5	9	10	1.11
10	5	4	0.80
15	67	4	0.06
18	100	82	0.82
SUM		**100**	**2.79**
		di/di/N	**35.83**

BB-AHS-201			
Depth	**N_{60}**	**di**	**di/N**
5	12	10	0.83
10	11	4	0.36
14	52	2	0.04
16	100	84	0.84
SUM		**100**	**2.08**
		di/di/N	**48.18**

BB-AHS-202			
Depth	**N_{60}**	**di**	**di/N**
5	12	10	0.83
10	12	3	0.25
13	26	2	0.08
15	50	2	0.04
17	100	83	0.83
SUM		**100**	**2.03**
		di/di/N	**49.25**

SUM	**Nav.**	**45.34**

15 < Nav. < 50 bpf

Conclusion: Site Class D

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

Argyle, Hemlock Steam Bridge #3735
WIN 21687.00
July 25, 2024

Abutment No. 1 and 2 Seismic Parameters

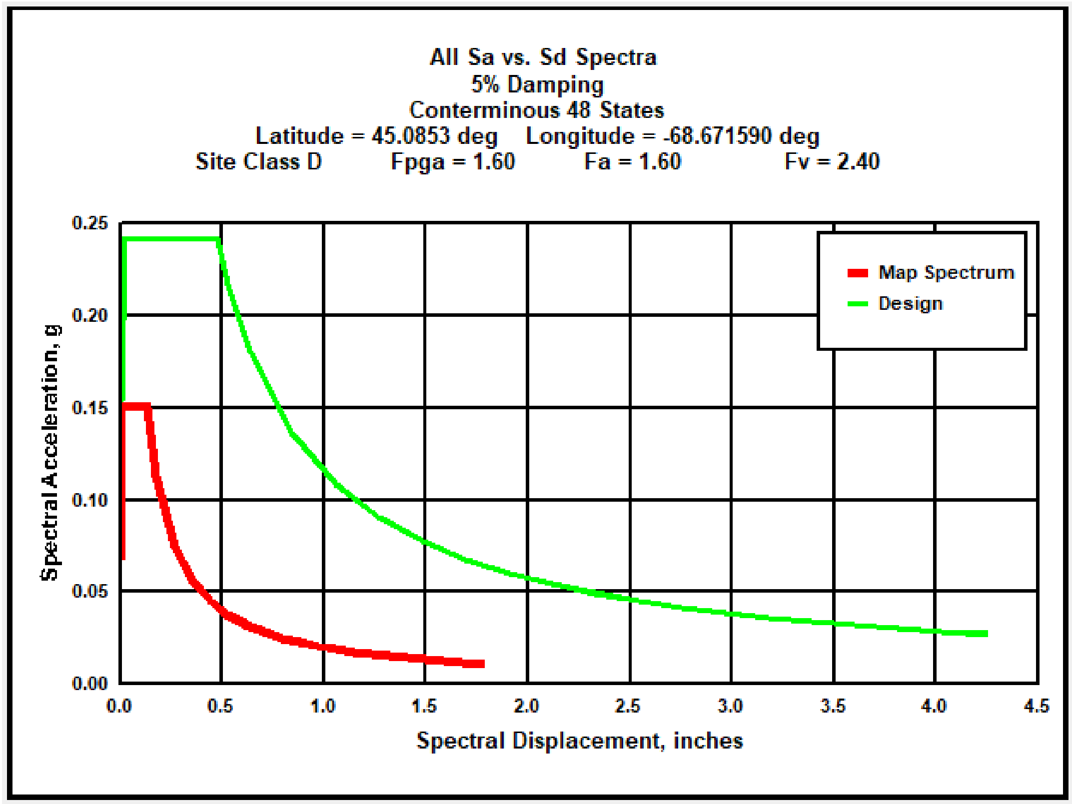
Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 45.085306
Longitude = -068.671583
Site Class B
Data are based on a 0.05 deg grid spacing.

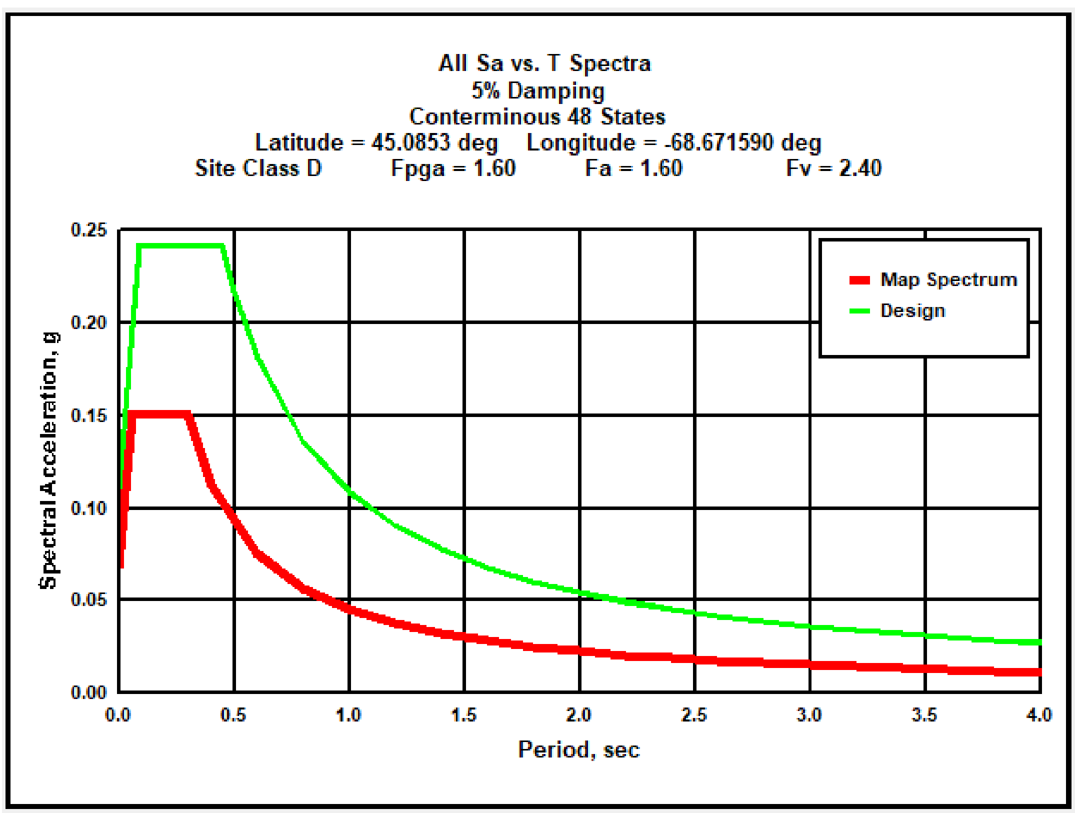
Period (sec)	Sa (g)	
0.0	0.070	PGA - Site Class B
0.2	0.151	Ss - Site Class B
1.0	0.045	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 45.085306
Longitude = -068.671583
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	0.112	As - Site Class D
0.2	0.241	SDs - Site Class D
1.0	0.109	SD1 - Site Class D

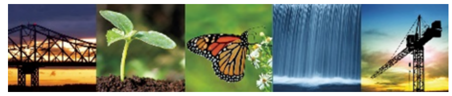
Argyle, Hemlock Steam Bridge #3735
WIN 21687.00
July 25, 2024





Appendix E

Rock-Socketed H-Pile Design Memorandum (GZA GeoEnvironmental)



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MEMORANDUM

To: Laura Krusinski, Maine Department of Transportation
Nathan Pukay, Maine Department of Transportation

From: Nicholas Williams, P.E.

Andrew Blaisdell, P.E.
Christopher Snow, P.E.

STATE OF MAINE
Andrew
R.
Blaisdell
10957
LICENSED
PROFESSIONAL ENGINEER
07/01/2025

Date: July 1, 2025

File No.: 09.0026255.00

Re: Geotechnical Design Memorandum
Design-Phase Abutment Pile Evaluations
Hemlock Bridge over Hemlock Stream, Bridge No. 3735
Maine Department of Transportation WIN 21687.00
Argyle Township, Maine

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707 Sable Oaks Drive
Suite 150
South Portland, ME 04106
T: 207.879.9190
F: 207.536.1173
www.gza.com

GZA GeoEnvironmental, Inc. (GZA) has prepared this memorandum summarizing the requested geotechnical evaluations and recommendations for the proposed abutment pile design for the subject project. Our services were completed in accordance with Bridge Program Assignment Letter #18 (dated August 14, 2024) associated with Multi-PIN Project Contract Number 20200603000000000709 between Maine Department of Transportation (MaineDOT) and GZA dated August 19, 2020. This memorandum is subject to the *Limitations* included in **Appendix A**. We understand MaineDOT will prepare a geotechnical design report for this project.

BACKGROUND

The project consists of replacing the Hemlock Bridge over Hemlock Stream in Argyle Township, Maine. The project includes a 75-foot-long, single span integral abutment bridge carrying Edinburg Road (Route 116) over Hemlock Stream.

Subsurface explorations, laboratory tests, rock core photograph logs, and geotechnical plan sheets (Boring Location Plan & Interpretive Subsurface Profile) were completed for the bridge replacement and provided to GZA from MaineDOT on August 30, 2024.

In response to discussions between GZA and MaineDOT, GZA completed geotechnical engineering services for the Hemlock Bridge abutment foundations, including engineering analyses and preparing recommendations for axial and lateral pile resistance for the proposed substructures.

This memorandum is limited to geotechnical evaluations and recommendations for the socketed H-Pile foundations that will support the abutments.

OBJECTIVES AND SCOPE OF SERVICES

The objectives of our work were to provide geotechnical engineering evaluations and recommendations for select geotechnical aspects of the proposed bridge abutment foundations. To meet these objectives, GZA completed the following Scope of Services:

- Completed geotechnical engineering analyses for soil and bedrock properties; AASHTO load and resistance factors associated with geotechnical design elements; rock-socketed pile design parameters including axial resistance; and made lateral pile evaluations;
- Developed geotechnical engineering recommendations including foundation design recommendations for rock-socketed H-Piles; and
- Prepared this memorandum summarizing our findings and design recommendations.

GZA did not review soil or rock samples as part of our scope of work; we used the data developed by others and provided by MaineDOT as a basis for our evaluations.

SUBSURFACE EXPLORATIONS AND SUBSURFACE CONDITIONS

MaineDOT and S.W. Cole (for MaineDOT) conducted subsurface exploration and laboratory test programs to explore the subsurface conditions for the bridge. The boring location plan and interpretive subsurface profile were provided by MaineDOT and are presented as **Figure 1**. Elevations referenced in this report are in feet and refer to the North American Vertical Datum of 1988 (NAVD88).

Ten total borings were conducted (BB-AHS-100 through -300 series) to depths ranging from 19 to 30 feet for this project, which are broken down as follows:

- BB-AHS-100-series borings (4 total) conducted and logged by S.W. Cole Explorations between February 14, 2017 and February 20, 2017;
- BB-AHS-200-series borings (2 total) conducted by S.W. Cole Explorations and logged by MaineDOT on April 6, 2022; and
- BB-AHS-300-series borings (4 total) conducted and logged by MaineDOT on May 6, 2024. Borings BB-AHS-301 and -303 were advanced with a solid stem auger without sampling.

Three soil units were interpreted by MaineDOT in the test borings above bedrock: Fill, Alluvium, and Glacial Till. Detailed descriptions of the materials encountered at specific locations are provided in the boring logs provided by MaineDOT in **Appendix B**. An interpretive subsurface profile provided by MaineDOT based on the test boring results is presented as **Figure 1**, **Boring Location Plan & Interpretive Subsurface Profile**.

BEDROCK DESCRIPTION

Encountered bedrock elevations ranged from approximately El. 109.0 to 111.4 at Abutment 1 (borings BB-AHS-301 and -302) and from approximately El. 109.4 to 109.9 at Abutment 2 (BB-AHS-303 and -304). Bedrock elevations varied from El. 109.0 to 114.3 at the remaining borings, but these are considered less relevant to anticipated elevations at abutment pile locations since they were drilled on the water side of the proposed abutment footprints.

Bedrock was cored in all borings except for BB-AHS-301 and -303, in which no sampling was conducted. The upper approximately 0.5 to 1.1 feet of rock was noted as fractured in borings BB-AHS-102, -103, and -202. Bedrock was logged and classified by S.W. Cole or MaineDOT as fine-grained moderately hard to hard, and slightly weathered to fresh Graywacke. Based on GZA's review of the core logs, photographs and mapped geology, the site is mapped within the Waterville Formation, and the bedrock may consist of slate. The bedrock is steeply bedded with significant deformation and calcite intrusions. Joints are low angle to vertical, spaced very close to moderately close. The Rock Quality Designation (RQD) ranged from 0 to 100 percent (average 62 percent), corresponding to a Rock Quality of Very Poor to Excellent. Photographs of the collected rock core are presented in **Appendix C**. Rock core data are summarized in **Table 1**.

Two unconfined compressive strength and Young's modulus tests were conducted. Unconfined compressive strength ranged from 5,920 to 6,091 psi, and the minimum Young's modulus values ranged from 2,050 to 3,490 kips per square inch (ksi). Laboratory test results are included in **Appendix D**.

ENGINEERING EVALUATIONS AND RECOMMENDATIONS

GZA conducted geotechnical engineering evaluations in accordance with *2024 AASHTO LRFD Bridge Design Specifications, 10th Edition* (herein designated as AASHTO LRFD) and the *MaineDOT Bridge Design Guide, 2003 Edition*, with updates through 2018 (MaineDOT BDG). The sections that follow describe the evaluations and the geotechnical basis for each element. Supporting calculations are attached in **Appendix E**.

Pile Type and Loading

Based on the PDR and discussions with MaineDOT, both abutments are planned to be supported by four ASTM A572, Grade 50 (f_y=50 ksi) rock-socketed HP14 section steel H-piles.

Pile Design Consideration and Axial Pile Resistance – Strength Limit State

A grouted rock socket detail is proposed that includes a steel plate welded to the tip of the pile and detailed such that grout can be reliably placed below and around the pile tip and promote full, uniform load transfer to end bearing in bedrock. For this condition, the end bearing resistance may be calculated using the AASHTO methodology for a drilled shaft bearing in bedrock. The AASHTO methodology develops two values; an intact rock value, and a jointed rock mass value. In our experience, the moderate to near vertical dip of the foliation often results in significand fracturing and mechanical breaking during coring. Consequently we recommend using a nominal bearing resistance equal to two times the jointed rock mass value (AASHTO LRFD equation 10.8.3.5.4C-2). A pile bearing area of 225 square inches (15-inch square plate) provides a nominal geotechnical axial compression resistance of 2,016 kips, resulting in a factored geotechnical resistance of 1,008 kips.

We also checked the tip resistance of 5,000 psi grout, using the same methodology but assuming an unjointed condition, which is consistent with a uniform grout material. The nominal bearing resistance for sound 5,000-psi grout is 2,813 kips, which is greater than the value calculated above for tip resistance on rock. Therefore, 5,000 psi grout is suitable.

A summary of the calculated factored axial compressive structural and geotechnical resistances of the H-pile sections at strength limit state is provided in the table below:

Factored Axial Compressive Resistances for Strength Limit State – H-Piles with Steel End Plates Installed in Bedrock Sockets

Strength Limit State Factored Axial Pile Resistance			
Pile Section	**Structural Resistance ϕ_c=0.60 (kips)[1]**	**Static Geotechnical Resistance ϕ_{static}=0.50 (kips)[2]**	**Governing Axial Pile Resistance (kips)**
HP 14 x 89	783	1,002	783
HP 14 x 117	1,032	1,002	1,002

Notes:
1. *Considers axial loading in compression only; resistance factor per AASHTO LRFD 6.5.4.2*
2. *Static geotechnical resistance is based on drilled shaft tip resistance in rock; resistance factor per AASHTO LRFD Table 10.5.5.2.4-1.*

Factored Axial Pile Resistance – Service and Extreme Limit States

A summary of the calculated service and extreme limit state axial compressive structural and geotechnical resistances of the H-pile sections is provided in the table below:

Factored Axial Compressive Resistances for Service and Extreme Limit State – H-Piles with Steel End Plates Installed in Bedrock Sockets

Service and Extreme Limit State Factored Axial Pile Resistance			
Pile Section	**Structural Resistance ϕ=1.0 (kips)**	**Static Geotechnical Resistance ϕ =1.0 (kips)**	**Governing Axial Pile Resistance (kips)**
HP 14 x 89	1,131	2,004	1,131
HP 14 x 117	1,498	2,004	1,498

Lateral Pile Evaluation

Based on the axial pile resistance evaluation provided above, MaineDOT designed the abutments to be supported by four, HP14x89 ASTM A572 Grade 50 steel (50-ksi yield stress) H-piles per abutment, oriented for weak-axis bending relative to the alignment of the bridge beams. MaineDOT provided a maximum factored axial compressive load of 376 kips per pile, and deflections of 0.542 and 0.301 inches at the pile head for contraction and expansion conditions, respectively.

GZA developed a single subsurface profile for lateral pile evaluations based on conditions at Abutment 1. A single profile is judged to be appropriate for both abutments since the boring results at both abutments are similar and both locations will have sufficient embedment into rock to restrain the pile tip. The base of the approach slab and the base of the abutment were modelled as the ground surface for the expansion and contraction cases, respectively. A pile length of 17 feet below the bottom of abutment was modeled, assuming the bottom 3 feet of the pile will be grouted in the socket, and granular socket/temporary casing infill material will be placed above the grout.

Since the unconfined compressive strength of the grout will be specified similar to the unconfined compressive strength of the bedrock, the model assumes the bottom 3 feet of the pile is embedded directly in rock with an unconfined compressive strength of 2,000 psi, selected as the highest value appropriate for the Weak Rock lateral pile model, and the shallower portion of the socket and temporary casing is backfilled with granular fill. Input parameters for the design profiles are presented in the following tables.

L-PILE INPUT PARAMETERS – EXPANSION, PILE LENGTH = 17’						
Stratum	**Soil Model**	**Top of Layer Elevation (ft-NAVD 88)**	**Layer Thickness (ft)**	**k (pci) / krm**	**ϕ' (deg)/ UCS (psi)**	**γ_e (pcf)**
New Fill Above Pile	Reese Sand	127	6	k = 83	32	125
New Fill	Reese Sand	121	14	k = 83	32	125
Grout in Rock Socket	Weak Rock	107	3	krm = 0.0005	UCS = 2000	169

L-PILE INPUT PARAMETERS – CONTRACTION, PILE LENGTH = 17’						
Stratum	**Soil Model**	**Top of Layer Elevation (ft-NAVD 88)**	**Layer Thickness (ft)**	**k (pci) / krm**	**ϕ' (deg)/ UCS (psi)**	**γ_e (pcf)**
New Fill	Reese Sand	121	14	k = 83	32	125
Grout in Rock Socket	Weak Rock	107	3	krm = 0.0005	UCS = 2000	169

GZA’s lateral pile analysis for the integral abutments was conducted in accordance with Section 5.4.2.4 of the MaineDOT BDG and the recommendations included in the “Integral Abutment Bridge Design Guidelines” by the Vermont Department of Transportation (VTrans). Lateral pile analysis used the Ensoft, Inc. LPile version 2022.12.11 software.

For initial analysis, the structural resistance was checked to determine if the moment calculated in LPile for a fixed-head condition exceeds the plastic moment, resulting in a plastic hinge, for the specified displacement and factored axial load. The pile head boundary conditions and results of the initial analysis are summarized in the table below.

LATERAL PILE RESULTS – INITIAL					
Condition	**Axial Load (kips)**	**Lateral Thermal Deflection (in)**	**LPile Moment at Pile Head (ft-kips)**	**Total Stress at Pile Head (ksi)**	**Interaction Equation Ratio**
Expansion	376	0.301	-179.8	63.3	1.04
Contraction	376	0.542	-172.5	61.3	1.02

The results indicate that a plastic hinge will form at the base of pile cap for the proposed configuration. The hinge is assumed to transform the pile head to a pinned condition and allow the pile head to rotate and maintain a maximum moment equal to the plastic moment. In the VTrans design methodology, this transformation results in a reduction of the axial buckling resistance of the upper segment of the pile (Segment 1) where the plastic hinge forms and a check is required on the structural demand ratio of Segments 1 and 2 located hinge. The results of the analysis are summarized below.

LATERAL PILE RESULTS – PLASTIC HINGE					
Condition	**Axial Load (kips)**	**Lateral Thermal Deflection (in)**	**Plastic Hinge Moment at Pile Head (ft-kips)**	**Axial Resistance Ratio, Segment 1**	**Combined Bending Demand Ratio, Segment 2**
Expansion	376	0.301	-168.5	0.43	0.62
Contraction	376	0.542	-166.8	0.45	0.66

The results indicate that the axial resistance and combined bending demand ratios are less than 1, indicating the proposed socketed pile detail is acceptable.

<u>RECOMMENDATIONS FOR FOUNDATIONS</u>

- The proposed abutments may be supported on ASTM A572, Grade 50 steel (50 ksi yield stress) HP14x89 H-piles socketed into the bedrock.
- Piles should have a 14-foot minimum length above the grouted portion of the socket. The grouted portion of the socket should extend at least 3 feet above the base plate.
- Rock socket holes should be drilled through the overburden using 3-foot minimum inside-diameter temporary casing that is seated into the top of rock prior to drilling the socket.
- Rock sockets should be at least 36 inches in diameter and should be cleaned of all loose material using an airlift or vacuum truck, and the socket base should be inspected using sounding techniques prior to pile placement.
- The piles should be equipped with centralizers, 15-inch by 15-inch base plates and a 2-inch-outside-diameter tremie tube through a 3-inch diameter hole in the base plate prior to installation.
- The piles should be supported above the bottom of the socket using a central shoe plate or chairs to provide a minimum clearance of 3 inches above the base, then tremie grouted up to 3 feet above the base plate using 5,000 psi minimum unconfined compressive strength cement grout.
- Granular infill consisting of MaineDOT 703.22 Underdrain Backfill Material, Type C should be used to backfill the remainder of the socket and the drill hole. Care should be taken to maintain at least 4 feet of granular infill above the bottom of the temporary casing as it is withdrawn.
- Rock-socketed pile construction shall be conducted in accordance with Special Provision Section 501, Foundation Piles (Rock-Socketed Pile Foundations).

CLOSURE

We trust this information meets current project needs. Please feel free to call Nicholas Williams at (207) 245-8444 if additional information is required.

NVW/ARB/CLS:cc
J:\09 Jobs\0026200s\09.0026255.00 - MEDOT - Hemlock Str. Br., Argyle TWP\Report\FINAL 26255.00 HemlockStrBridge_Design Memo_07.1.2025.docx

Attachments: Table 1 – Rock Core Summary Table
Figure 1 – Boring Location Plan & Interpretive Subsurface Profile
Appendix A - Geotechnical Limitations
Appendix B – Exploration Logs
Appendix C – Rock Core Photo Log
Appendix D – Elastic Moduli of Rock in Uniaxial Compression Laboratory Test Results
Appendix E – Supporting Calculations

TABLES

TABLE 1
Summary of Rock Core
Hemlock Stream Bridge over Hemlock Stream
Argyle, ME
WIN 21687.00

Boring ID	Core Run	Ground Surface El. (ft)	Depth of Core Run below GS (ft)			Depth to Rock (ft)	Depth Below Top of Rock (ft)				Length of Core Run (in)	Rec (in)	Rec (%)	RQD (in)	RQD %	Elev. (ft)		LAB						Rock Type
			Top		Bottom		Top		Bottom	Midpoint Depth						Top	Bottom	Depth to Top of Sample (ft)	Elev Top of Sample (ft)	UCS (psi)	Poissons Ratio	Young's Modulus (ksi)	Unit Wt (pcf)	
BB-AHS-101	R1	130.5	22.5	-	25.2	21.5	1.0	-	3.7	2.4	32	8	25%	6	19%	108.0	105.3							GRAYWACKE
BB-AHS-101	R2	130.5	25.2	-	26.6	21.5	3.7	-	5.1	4.4	17	17	100%	11	67%	105.3	103.9							GRAYWACKE
BB-AHS-101	R3	130.5	26.7	-	28.5	21.5	5.2	-	7.0	6.1	22	20	91%	20	91%	103.8	102.0							GRAYWACKE
BB-AHS-102	R1	130.6	18.0	-	22.0	16.9	1.1	-	5.1	3.1	48	48	100%	39	81%	112.6	108.6							GRAYWACKE
BB-AHS-102	R2	130.6	22.0	-	26.0	16.9	5.1	-	9.1	7.1	48	48	100%	48	100%	108.6	104.6							GRAYWACKE
BB-AHS-102	R3	130.6	26.0	-	28.0	16.9	9.1	-	11.1	10.1	24	23	96%	16	66%	104.6	102.6							GRAYWACKE
BB-AHS-103	R1	130.5	17.8	-	22.8	17.0	0.8	-	5.8	3.3	60	48	80%	41	68%	112.7	107.7							GRAYWACKE
BB-AHS-104	R1	130.7	19.0	-	21.0	18.3	0.7	-	2.7	1.7	24	24	100%	18	75%	111.7	109.7							GRAYWACKE
BB-AHS-104	R2	130.7	21.0	-	24.8	18.3	2.7	-	6.5	4.6	46	45	98%	9	20%	109.7	105.9							GRAYWACKE
BB-AHS-104	R3	130.7	24.8	-	29.2	18.3	6.5	-	10.9	8.7	53	50	94%	40	75%	105.9	101.5							GRAYWACKE
BB-AHS-201	R1	130.7	16.9	-	22.2	16.6	0.3	-	5.6	3.0	64	64	100%	30	47%	113.8	108.5							GRAYWACKE
BB-AHS-201	R2	130.7	22.2	-	26.9	16.6	5.6	-	10.3	8.0	56	56	100%	50	89%	108.5	103.8							GRAYWACKE
BB-AHS-202	R1	130.8	17.0	-	18.1	16.5	0.5	-	1.6	1.1	13	13	100%	0	0%	113.8	112.7							GRAYWACKE
BB-AHS-202	R2	130.8	18.1		19.7	16.5	1.6	-	3.2	2.4	19	19	100%	0	0%	112.7	111.1							GRAYWACKE
BB-AHS-202	R3	130.8	19.7		24.7	16.5	3.2	-	8.2	5.7	60	60	100%	22	37%	111.1	106.1							GRAYWACKE
BB-AHS-202	R4	130.8	24.7	-	27.0	16.5	8.2	-	10.5	9.4	28	28	100%	18	65%	106.1	103.8							GRAYWACKE
BP-AHS-302	R1	130.6	21.6	-	26.6	21.6	0.0	-	5.0	2.5	60	60	100%	40	66%	109.0	104.0	22.8	107.8	6,091	0.41	2,050	173	GRAYWACKE
BP-AHS-304	R1	130.7	21.3	-	26.3	21.3	0.0	-	5.0	2.5	60	60	100%	48	80%	109.4	104.4	22.1	108.6	5,920	--	3,490	172	GRAYWACKE

Notes:

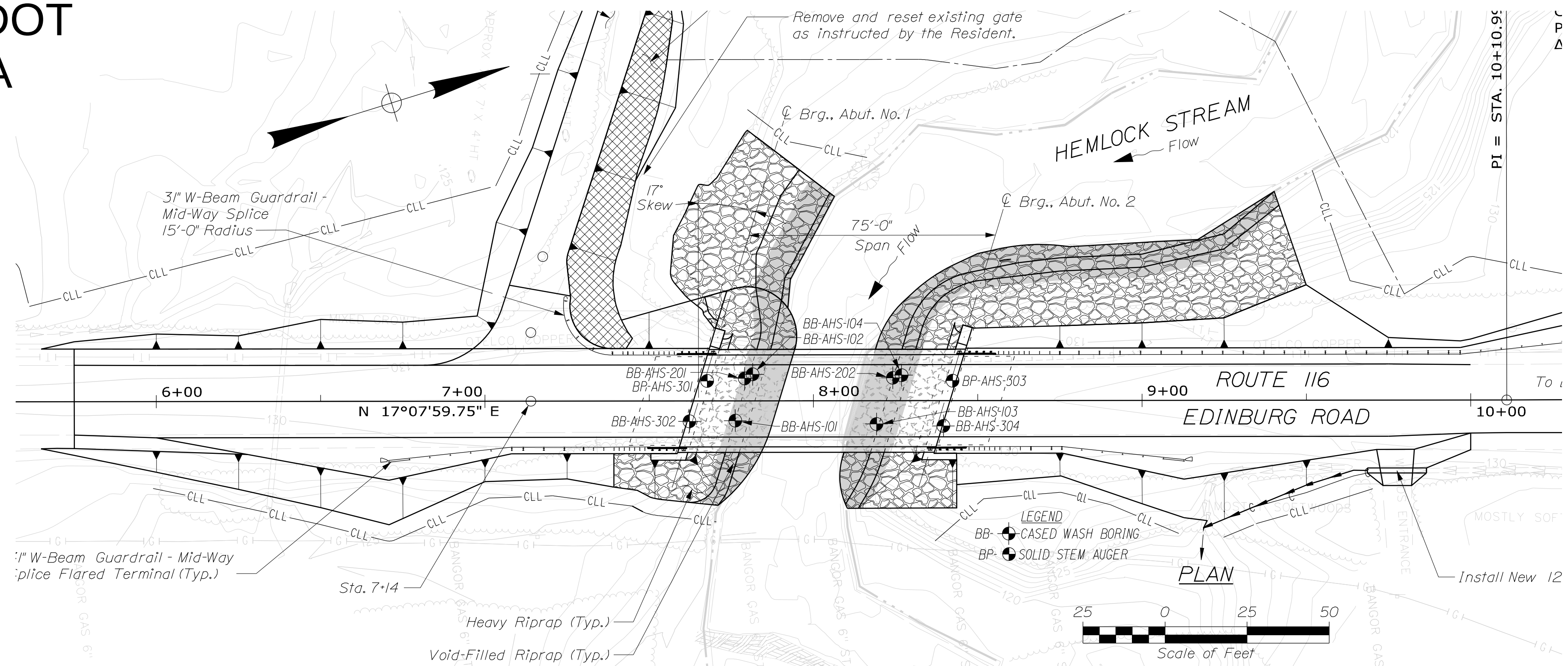
1) Depth below Top of Rock includes Fractured Rock noted on the boring logs.

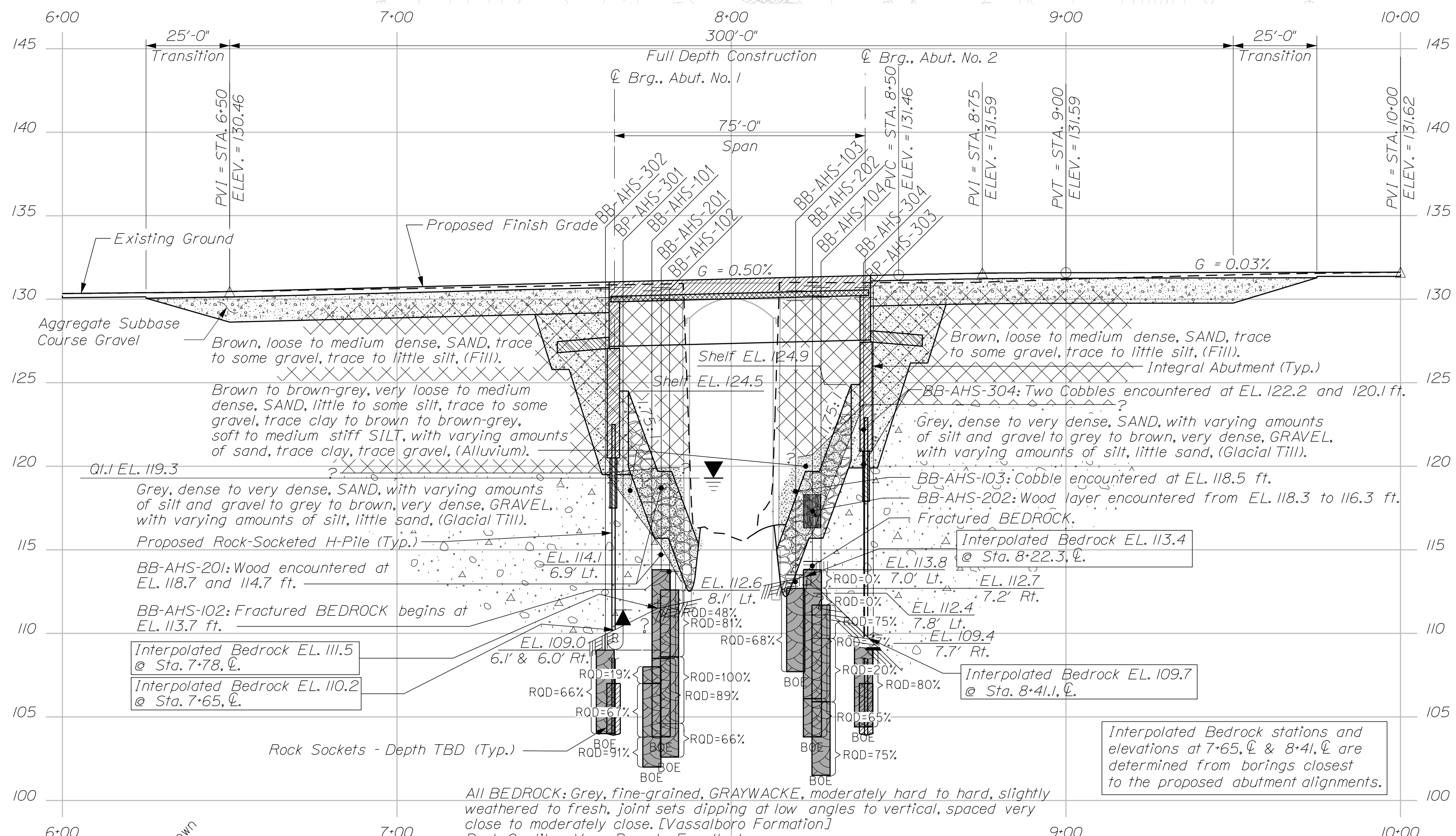
2) UCS = Unconfined Compressive Strength

3) Laboratory test results included Young's Modulus values at three different stress ranges. The Young's Modulus values included in the table are the minimum values from the lab results.

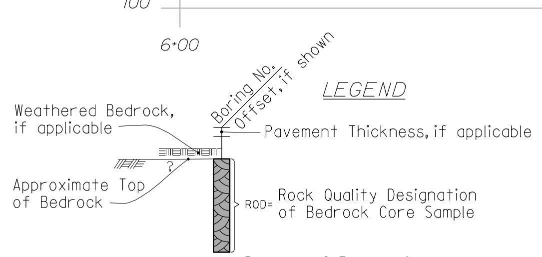
FIGURES

Prepared By MaineDOT
and Provided to GZA





PROFILE



HORIZ 25 0 25 50
VERT 5 0 5 10
SCALE

Notes: 1. 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 and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

2. "Varying Amounts" term = Portion is 0 to 50 percent of Total.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-2168(700)

WIN 21687.00

BRIDGE PLANS

BRIDGE NO. 3735

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED		
CHECKED-REVIEWED	T. WHITE	
DESIGN2-DETAILED2	N. PUKAY	MAR 2022
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

HEMLOCK STREAM BRIDGE
HEMLOCK STREAM
ARGYLE TOWNSHIP PENOBSCOT COUNTY

BORING LOCATION PLAN &
INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
2
OF 3

Filename: ...\GEOTECH\MSTA\006_BLP&ISP1.dgn   Division: GEOTECH   Username: Nathan.P.Pukay   Date: 2/24/2025

APPENDIX A - GEOTECHNICAL LIMITATIONS

GEOTECHNICAL LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions .

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

Subsurface Conditions

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

6. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal

recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

8. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

9. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

Compliance with Codes and Regulations

10. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

Cost Estimates

11. Unless otherwise stated, our cost estimates are only for comparative and general planning purposes. These estimates may involve approximate quantity evaluations. Note that these quantity estimates are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over either when the work will take place or the labor and material costs required to plan and execute the anticipated work, our cost estimates were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

12. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

APPENDIX B – EXPLORATION LOGS

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-101
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/14/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+76.2, 6.0 ft. Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	5.8' (after drilling)
Hammer Efficiency Factor: 0.60		**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	129.9		7" of Pavement 0.6	
	1D	2/2	1.00 - 1.17	100-2"	- -					Brown, frozen, SAND, little gravel, little silt, (Fill).	
5	2D	24/10	5.00 - 7.00	4/4/5/5	9	9	16			Brown, moist, loose, SAND, some gravel, trace silt, (Fill).	G#271096 A-1-b, SW-SM WC=7.9%
							28				
							38				
							30				
							23				
10	MD	24/0	10.00 - 12.00	10/7/4/2	11	11	5	120.0		10.5	
							15				
	3D	24/8	12.00 - 14.00	2/2/2/2	4	4	7			Brown-grey, wet, very loose, fine to medium SAND, little silt, trace clay, trace gravel, (Alluvium).	G#271097 A-2-4, SC-SM WC=26.4%
							7				
							9				
15	4D	24/7	15.00 - 17.00	3/2/1/2	3	3	5			Brown-grey, wet, soft, fine Sandy SILT, trace gravel, (Alluvium).	
							6				
							30	113.2		17.3	
							60				
							49				
20	5D	17/12	20.00 - 21.42	13/26/100-5"	- -		40			5D(A) Grey, wet, very dense, SAND, some silt, trace gravel, (Glacial Till). 5D(B) Bedrock Chips.	
							a135	109.0		a135 blows for 0.5 ft. 21.5	
	R1	32/8	22.50 - 25.17	RQD = 19%			NQ-2			Top of Bedrock at EL. 109.0 ft. Roller coned ahead to 22.5 ft bgs R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, preserved distorted bedding, joints dip at low angles, closely spaced, tight, rough, undulating, with calcite and quartz infilling. [Vassalboro Formation]	
25											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-101
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/14/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+76.2, 6.0 ft. Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	5.8' (after drilling)
Hammer Efficiency Factor: 0.60		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
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V = Field Vane Shear Test, PP = Pocket Penetrometer
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	R2	17/17	25.20 - 26.62	RQD = 67%						Rock Quality = Very Poor. R1 Core Times (min:sec): 22.5-23.5 ft (2:21) 23.5-24.5 ft (3:33) 24.5-25.2 ft (3:45) 25% Recovery	
	R3	22/20	26.70 - 28.53	RQD = 91%				102.0		R2:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, breaks along foliation and low angle orthogonal joints, healed to tight, with calcite and quartz infilling, occasional nonsystematic undulating breaks along calcite and quartz veins. [Vassalboro Formation] Rock Quality = Fair. R2 Core Times (min:sec): 25.2-25.5 ft (2:32) 25.5-26.5 ft (9:49) 26.5-26.7 ft (2:28) 100% Recovery R3:Bedrock: Similar to R2. [Vassalboro Formation] Rock Quality = Excellent. R3 Core Times (min:sec): 26.7-27.5 ft (4:19) 27.5-28.5 ft (6:04) 91% Recovery 28.5 **Bottom of Exploration at 28.5 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-102
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.6	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017 - 2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+81.5, 8.1 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.6' (after drilling)
Hammer Efficiency Factor:	0.60	**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
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MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
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WOH = Weight of 140lb. Hammer
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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
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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.
0							SSA	130.0		7" of Pavement — 0.6	
	1D	5/4	2.00 - 2.42	100-5"	- -					Brown, frozen, SAND, some gravel, trace silt (Fill).	
5	2D	24/13	5.00 - 7.00	8/3/2/2	5	5	9			Brown, moist, loose, SAND, some gravel, trace silt, (Fill).	
							18				
							24				
							27				
							21				
10	3D	24/14	10.00 - 12.00	4/3/2/3	5	5	12	120.6		10.0 — Brown, wet, medium stiff, SILT, some fine to medium sand, trace clay, trace gravel, (Alluvium).	G#271098 A-4, CL WC=26.2%
							20				
							26				
							22				
							50				
15	4D	23/4	15.00 - 16.92	15/28/28/100-5"	56	56	62	115.6		15.0 — Grey, wet, very dense, GRAVEL, little sand, little silt, (Glacial Till).	
							a170			a170 blows for 0.9 ft	
								113.7		16.9 — Fractured Bedrock. Roller coned ahead to 18.0 ft bgs.	
	R1	48/48	18.00 - 22.00	RQD = 81%			NQ-2	112.6		18.0 — Top of Bedrock at El. 112.6. R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, sheared, steep foliation, preserved distorted bedding, joints are steeply dipping, undulating, closely spaced, tight, rough, with calcite and quartz veins. Upper 10" is moderately fractured, then competent and massive rock. [Vassalboro Formation] Rock Quality = Good. R1 Core Times (min:sec): 18.0-19.0 ft (6:05) 19.0-20.0 ft (8:12) 20.0-21.0 ft (5:44) 21.0-22.0 ft (5:11) 100% Recovery	
20											
	R2	48/48	22.00 - 26.00	RQD = 100%							
25											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-102
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.6	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017 - 2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	7+81.5, 8.1 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.6' (after drilling)
Hammer Efficiency Factor:	0.60	**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										R2:Bedrock: Similar to R1 except massive throughout entirety of run. [Vassalboro Formation] Rock Quality = Excellent. R2 Core Times (min:sec): 22.0-23.0 ft (4:14) 23.0-24.0 ft (4:35) 24.0-25.0 ft (4:55) 25.0-26.0 ft (4:05) 100% Recovery	
	R3	24/23	26.00 - 28.00	RQD = 66%				102.6		R3:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, with a single steeply dipping joint, undulating, tight, rough, with calcite and quartz veins. [Vassalboro Formation] Rock Quality = Fair. R3 Core Times (min:sec): 26.0-27.0 ft (6:58) 27.0-28.0 ft (5:25) 96% Recovery	
										28.0 **Bottom of Exploration at 28.0 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-103
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Robert Chaput	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+19.2, 7.2 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	Caved at 11.5', Dry
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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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	129.9		7" of Pavement (0.6)	
	1D	12/9	2.00 - 3.00	86/100	- -					Brown, frozen, SAND, some gravel, trace silt, (Fill).	
5	2D	24/9	5.00 - 7.00	7/8/4/4	12	12	10			Brown, wet, medium dense, SAND, some gravel, little silt, (Fill).	G#271099 A-1-b, SW-SM WC=4.9%
							27				
							26				
							32				
							40				
10	3D	24/1	10.00 - 12.00	8/8/7/8	15	15	17	120.5		(10.0) Rock in tip of spoon.	
							44				
							a155			a155 blows for 0.9 ft Roller cone through cobble to 13.0'.	
							110				
							117				
15	4D	24/10	15.00 - 17.00	29/16/17/33	33	33	85	115.5		(15.0) Grey, wet, dense, Gravelly SAND, little silt, (Glacial Till).	G#271100 A-1-b, SM WC=12.4%
							273				
	R1	60/48	17.80 - 22.80	RQD = 68%			NQ-2	113.5		(17.0) Fractured Bedrock. Roller cone to 17.8 ft bgs.	
								112.7		(17.8) Top of Bedrock at EL. 112.7 ft. R1 Bedrock: Grey, GRAYWACKE, hard, fresh, laminated, steep foliation, joints dip at steep angles, closely spaced, tight, calcite and quartz veins. Upper 18" is minimally fractured, then competent and massive rock. [Vassalboro Formation] Rock Quality = Fair. R1 Core Times (min:sec): 17.8-18.8 ft (4:45) 18.8-19.8 ft (5:12) 19.8-20.8 ft (6:46) 20.8-21.8 ft (5:22) 21.8-22.8 ft (5:16) 80% Recovery	
20											
								107.7		(22.8)	
25											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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Boring No.: BB-AHS-103

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-103
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.5	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Robert Chaput	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/20/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+19.2, 7.2 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	Caved at 11.5', Dry
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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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.
25										**Bottom of Exploration at 22.8 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-104
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+26.8, 7.8 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.7' (after drilling)
Hammer Efficiency Factor:	0.60	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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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	130.1		7" of Pavement 0.6	
	1D	3/2	1.00 - 1.25	100-3"	- -					Brown, frozen, SAND, little gravel, trace silt, (Fill).	
5	2D	24/9	5.00 - 7.00	5/4/5/4	9	9	9			Similar to 1D, except moist and loose.	
							20				
							18				
							18				
							28	120.7		10.0	
10	3D	24/14	10.00 - 12.00	5/3/2/3	5	5	5			Brown, wet, medium stiff, fine to medium, Sandy SILT, trace gravel, (Alluvium).	G#304299 A-4, CL WC=23.0%
							6				
							26				
							21				
							60	116.7		14.0	
15	4D	24/15	15.00 - 17.00	16/36/31/22	67	67	35			Brown, wet, very dense, GRAVEL, little sand, little silt, (Glacial Till).	
							81				
							95				
							71/4"	112.4		18.3 Top of Bedrock at EL. 112.4 ft. Roller cone through Bedrock to 19.0 ft bgs.	
	R1	24/24	19.00 - 21.00	RQD = 75%			NQ-2			R1:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, moderate to steep foliation, breaks along foliation and low angle conjugate joints, spaced moderately close, healed to tight, calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Fair. R1 Core Times (min:sec): 19.0-20.0 ft (5:30) 20.0-21.0 ft (5:52) 100% Recovery	
20											
	R2	46/45	21.00 - 24.83	RQD = 20%							
25	R3	53/50	24.80 - 29.22	RQD = 75%							

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-104
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	SSA 2.25" OD
Operator:	Kevin Hanscom	**Datum:**	NAVD 88	**Sampler:**	Split-Spoon
Logged By:	Nathan Strout	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/17/2017	**Drilling Method:**	Cased-Wash	**Core Barrel:**	NQ 2"
Boring Location:	8+26.8, 7.8 ft Lt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	8.7' (after drilling)
Hammer Efficiency Factor:	0.60	**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
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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										R2:Bedrock: Similar to R1, except more fractured. [Vassalboro Formation] Rock Quality = Very Poor. R2 Core Times (min:sec): 21.0-22.0 ft (4:31) 22.0-23.0 ft (4:16) 23.0-24.0 ft (4:51) 24.0-24.8 ft (4:48) 98% Recovery	
								101.5			
30										R3:Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, moderate to steep foliation, joints dip at low angles, closely spaced, healed to tight, significant calcite and quartz infilling. [Vassalboro Formation] Rock Quality = Fair. R3 Core Times (min:sec): 24.8-25.0 ft (0:27) 25.0-26.0 ft (6:36) 26.0-27.0 ft (7:06) 27.0-28.0 ft (7:05) 28.0-29.0 ft (5:44) 29.0-29.2 ft (0:39) 94% Recovery	
35										29.2 **Bottom of Exploration at 29.2 feet below ground surface.**	
40											
45											
50											

Remarks:

Casing driven using rope and cathead with 140# safety hammer

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-AHS-104

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-201
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 11:30-13:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+79, 6.9 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
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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	130.0		8" HMA. (0.7)	
5	1D	24/12	5.00 - 7.00	4/4/4/7	8	12				Brown, damp, medium dense, SAND, trace gravel, trace silt, (Fill).	
10	2D/A	24/13	10.00 - 12.00	2/3/4/2	7	11	HP			2D (10.0-11.5 ft bgs.) Brown, wet, medium dense, SAND, trace gravel, trace silt, (Fill).	
							HP	119.2		(11.5) 2D/A (11.5-12.0 ft bgs.) Grey-brown, wet, fine to medium, Sandy SILT, trace clay, trace gravel, (Alluvium).	G#241517 A-4, CL WC=24.2%
							102			Wood observed in wash water.	
							21				
	3D	24/13	14.00 - 16.00	20/17/17/11	34	52	32	116.7		(14.0) Grey, wet, very dense, Silty SAND, trace gravel, (Glacial Till).	
15							45				
	4D/A	9/9	16.00 - 16.75	16/54(3")	---		a53	114.1		a53 blows for 0.6 ft. 4D (16.0-16.6) Similar to above, except very dense, with wood chips. 4D/A (16.6-16.75) Bedrock Chips.	
	R1	63.6/63.6	16.90 - 22.20	RQD = 47%			NQ-2			(16.6) Top of Bedrock at Elev. 114.1 ft. Roller Coned ahead to 16.9 ft bgs. R1: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, steep foliation paralleling thin bedding, joints are low angle to vertical and are not parallel to bedding or foliation, joint spacing is close, fresh to slightly weathered, tight to open, some rock flour. [Vassalboro Formation] Rock Quality = Poor. R1: Core Times (min:sec) 16.9-17.9 ft (3:54) 17.9-18.9 ft (3:21) 18.9-19.9 ft (2:52) 19.9-20.9 ft (2:45) 20.9-21.9 ft (3:02) 21.9-22.2 ft (1:01)	
20											
	R2	56.4/56.4	22.20 - 26.90	RQD = 89%							
25											

Remarks:

Hammer # 367
HP = Hydraulic Push

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-201
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 11:30-13:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+79, 6.9 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.91	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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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.
25										100% Recovery	
								103.8		R2: Bedrock: Similar to R1, except less fractured, more competent. [Vassalboro Formation] Rock Quality = Good. R2: Core Times (min:sec) 22.2-23.2 ft (2:53) 23.2-24.2 ft (2:33) 24.3-25.2 ft (3:01) 25.2-26.2 ft (2:54) 26.2-26.9 ft (1:40) 100% Recovery	
										26.9	
										Bottom of Exploration at 26.9 feet below ground surface.	
30											
35											
40											
45											
50											

Remarks:

Hammer # 367
HP = Hydraulic Push

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-202
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 08:30-11:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+24.2, 7.0 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor: 0.91		**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
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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	130.2		7" HMA. —0.6	
5	1D	24/14	5.00 - 7.00	4/4/4/3	8	12				Brown, dry, medium dense, SAND, little gravel, trace silt, (Fill).	
	2D	28.8/10	9.90 - 12.30	4/4/4/2	8	12	aHP			—9.9	
10							HP	120.9		aHP for 0.1 ft. Brown, moist, medium dense, SAND, some gravel, some silt, trace clay, (Alluvium).	G#241516 A-1-b, SC-SM WC=16.4%
							HP				
	3D	24/5	12.50 - 14.50	1/1/16/7	17	26	HP			WOOD, trace sand. aHP for 0.8 ft.	
							aHP a23			Wood 13.8-15.0 ft bgs. a23 blows for 0.2 ft.	
							54				
15	4D	6/5	15.00 - 15.50	17(6")	---		88	115.8		—15.0 Grey, wet, Silty GRAVEL, little sand, (Glacial Till). a40 blows for 0.5 ft.	
	~~MD~~	~~6/0~~	~~15.50 - 16.00~~	~~16(6")~~	~~---~~		~~a40~~				
	5D	12/8	16.00 - 17.00	18/50(5.5")	---			114.3		—16.5 Grey, wet, very dense, rock fragments, trace silt, trace fine to coarse sand, (Fractured Rock).	
	R1	13.2/13.2	17.00 - 18.10	RQD = 0%			NQ-2	113.8		—17.0 Top of Bedrock at Elev. 113.8 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, very fractured, steep to vertical joints broken along bedding planes, joints very close and tight with no infilling. [VASSALBORO FORMATION] Rock Quality = Very Poor. R1: Core Times (min:sec) 17.0-18.0 ft (3:16) 18.0-18.1 ft (0:40) Core Blocked 100% Recovery	
	R2	19.2/19.2	18.10 - 19.70	RQD = 0%						R2: Bedrock: Similar to R1. [Vassalboro Formation] Rock Quality = Very Poor. R2: Core Times (min:sec)	
	R3	60/60	19.70 - 24.70	RQD = 37%							
20											
	R4	27.6/27.6	24.70 - 27.00	RQD = 65%							
25											

Remarks:

Hammer # 367
HP = Hydraulic Push

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-202
WIN: 21687.00

Driller:	S.W. Cole Explorations, LLC	**Elevation (ft.)**	130.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Kevin/Brian	**Datum:**	NAVD 88	**Sampler:**	Standard Split Spoon
Logged By:	Nathan Pukay	**Rig Type:**	Diedrich D-50	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	4/6/2022; 08:30-11:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+24.2, 7.0 ft Lt.	**Casing ID/OD:**	NW-3"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.91	**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
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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										18.1-19.1 ft (3:20) 19.1-19.7 ft (3:18) Core Blocked 100% Recovery	
								103.8		R3: Bedrock: Grey, fine-grained, GRAYWACKE, moderately hard, fresh, steep to vertical joints, closely spaced with infrequent quartz infilling. Quartz discontinuity from 20.7' to 21.8' with open, moderately weathered fractures at each end. Upper 2' moderately fractured, then more competent and massive. [Vassalboro Formation] Rock Quality = Poor. R3: Core Times (min:sec) 19.7-20.7 ft (4:32) 20.7-21.7 ft (4:48) 21.7-22.7 ft (4:17) 22.7-23.7 ft (3:50) 23.7-24.7 ft (3:11) 100% Recovery	
30											
										R4: Bedrock: Grey, fine-grained, GRAYWACKE with frequent annealed quartz intrusions, hard, slightly weathered, moderately fractured, joints are steeply dipping to horizontal, closely spaced. [Vassalboro Formation] Rock Quality = Fair. R4: Core Times (min:sec) 24.7-25.7 ft (3:33) 25.7-26.7 ft (3:42) 26.7-27.0 ft (1:04) 100% Recovery	
35											
										27.0	
										Bottom of Exploration at 27.0 feet below ground surface.	
40											
45											
50											

Remarks:

Hammer # 367
HP = Hydraulic Push

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BP-AHS-301
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	5/6/2024; 13:30-14:00	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	7+67.6, 6.1 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
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WOH = Weight of 140lb. Hammer
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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
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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	130.1		7" HMA. 0.6	
										No material descriptions.	
5											
10											
15											
								111.4		19.3	
20										**Bottom of Exploration at 19.3 feet below ground surface.** Auger REFUSAL, presumed Top of Rock Elev. at 111.4 ft. Grey rock dust on tip of auger.	
25											

Remarks:

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

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Boring No.: BP-AHS-301

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream **Location:** Argyle TWP, Maine	**Boring No.:** BB-AHS-302 **WIN:** 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.6	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 08:05-10:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 6.1 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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 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	130.2		5" HMA. 0.4	
5							20			(FILL).	
							13				
							8				
							31				
10							71				
							41	119.6		11.0	
							98				
							138				
							235				
							209				
15							RC			(GLACIAL TILL).	
20											
	R1	60/60	21.60 - 26.60	RQD = 66%			NQ-2	109.0		21.6 Top of Bedrock at Elev. 109.0 ft. R1: Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, joints low angle to moderately dipping, closely spaced, with significant quartz or calcite infilling. [Vassalboro Formation] Rock Quality = Fair R1: Core Times (min:sec)	
25											

Remarks:

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Boring No.: BB-AHS-302

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-302
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.6	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 08:05-10:15	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	7+62.3, 6.1 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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V = Field Vane Shear Test, PP = Pocket Penetrometer
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										21.6-22.6 ft (2:40) 22.6-23.6 ft (3:01) 23.6-24.6 ft (3:36)	
								104.0		24.6-25.6 ft (4:07) 25.6-26.6 ft (4:55) 100% Recovery	
										26.6 **Bottom of Exploration at 26.6 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BP-AHS-303
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.8	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	5/6/2024; 12:55-13:30	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	8+42.4, 6.2 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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
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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			No material descriptions.	
5											
10											
15											
20								109.9		20.9 **Bottom of Exploration at 20.9 feet below ground surface.** Auger REFUSAL, presumed Top of Rock Elev. at 109.9 ft. Grey rock dust on tip of auger.	
25											

Remarks:

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Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream

Location: Argyle TWP, Maine

Boring No.: BB-AHS-304

WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 10:30-12:45	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+39.5, 7.7 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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SSA = Solid Stem Auger
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WOH = Weight of 140lb. Hammer
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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	130.1		7" HMA. 0.6	
										(FILL).	
5							22				
							31	123.7		7.0	
							242				
							RC			Cobble at 8.5 ft bgs.	
10										Cobble at 10.6 ft bgs.	
15										(GLACIAL TILL).	
20								109.4		Top of Bedrock at 109.7 ft. 21.3	
	R1	60/60	21.30 - 26.30	RQD = 80%			NQ-2			R1: Bedrock: Grey, fine-grained, GRAYWACKE, hard, fresh, steep foliation, massive. [Vassalboro Formation] Rock Quality = Good R1: Core Times (min:sec) 21.3-22.3 ft (2:27) 22.3-23.3 ft (2:30)	
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Hemlock Stream Bridge #3735 carries Route 116 over Hemlock Stream
Location: Argyle TWP, Maine

Boring No.: BB-AHS-304
WIN: 21687.00

Driller:	MaineDOT	**Elevation (ft.)**	130.7	**Auger ID/OD:**	5" Solid Stem
Operator:	Daggett/Andrle	**Datum:**	NAVD 88	**Sampler:**	N/A
Logged By:	Nathan Pukay	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	5/6/2024; 10:30-12:45	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	8+39.5, 7.7 ft Rt.	**Casing ID/OD:**	NW 3"/3.5"	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.962	**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								104.4		23.3-24.3 ft (2:27) 24.3-25.3 ft (2:34) 25.3-26.3 ft (3:04) 100% Recovery — 26.3 **Bottom of Exploration at 26.3 feet below ground surface.**	
30											
35											
40											
45											
50											

Remarks:

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

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

APPENDIX C – ROCK CORE PHOTO LOG

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-101	R1	22.5-25.2	32	25%	6	19%	GRAYWACKE	1
BB-AHS-101	R2	25.2-26.7	17	100%	12	70%	GRAYWACKE	1
BB-AHS-101	R3	26.7-28.5	22	91%	20	91%	GRAYWACKE	1
BB-AHS-104	R1	19.0-21.0	24	100%	18	75%	GRAYWACKE	2
BB-AHS-104	R2	21.0-24.8	46	98%	9	20%	GRAYWACKE	2+3
BB-AHS-104	R3	24.8-29.2	53	94%	40	75%	GRAYWACKE	3+4

Notes: 1. “Box row” indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Top of each core run is on the left and increases with depth to the right.
3. Transition between core runs is marked by pink flagging.

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-102	R1	18.0-22.0	48	100%	39	81%	GRAYWACKE	1
BB-AHS-102	R2	22.0-26.0	48	100%	48	100%	GRAYWACKE	2
BB-AHS-102	R3	26.0-28.0	24	95%	16	66%	GRAYWACKE	3
BB-AHS-103	R1	17.8-22.8	60	80%	41	68%	GRAYWACKE	4

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Top of each core run is on the left and increases with depth to the right.

MaineDOT

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-201	R1	16.9-22.2	63	100%	30	48%	GRAYWACKE	1+2
BB-AHS-201	R2	22.2-26.9	56	100%	50	89%	GRAYWACKE	2+3

Notes: 1. “Box row” indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Top of each core run is on the left and increases with depth to the right.

3. Transition between core runs is marked by wooden blocks.

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-202	R1	17.0-18.1	13.2	100%	0	0%	GRAYWACKE	1
BB-AHS-202	R2	18.1-19.7	19.2	100%	0	0%	GRAYWACKE	1
BB-AHS-202	R3	19.7-24.7	60.0	100%	22	37%	GRAYWACKE	1+2
BB-AHS-202	R4	24.7-27.0	27.6	100%	18	65%	GRAYWACKE	2+3

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Top of each core run is on the left and increases with depth to the right.

3. Transition between core runs is marked by wooden blocks.

MaineDOT

MaineDOT

Hemlock Stream Bridge #3735 Carries Route 116 Over Hemlock Stream

Argyle Township, ME

Rock Core Photographs

Boring No.	Run	Depth (ft)	Penetration (in)	Recovery (in)	RQD (in)	RQD (%)	Rock Type	Box Row
BB-AHS-302	R1	21.6-26.6	60	100%	40	66%	GRAYWACKE	1
BB-AHS-304	R1	21.3-26.3	60	100%	48	80%	GRAYWACKE	2

Notes: 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.

2. Top of each core run is on the left and increases with depth to the right.

APPENDIX D – ELASTIC MODULIE OF ROCK IN UNIAXIAL COMPRESSION LABORATORY TEST RESULTS

Boston
New York
Atlanta
Chicago
Los Angeles
Houston
www.geotesting.com

Transmittal

TO:

Nathan Pukay
Maine Department of Transportation
16 State House Station
Augusta, ME 04333-0016

DATE: 8/5/2024	GTX NO: 319158
RE: Hemlock Stream Bridge #3735	

COPIES	DATE	DESCRIPTION
	8/5/2024	**Aug 2024 Laboratory Test Report**

REMARKS:

SIGNED: Sarah Delaney

Sarah Delaney, Assistant Laboratory Manager

APPROVED BY: Jon Campbell

Jon Campbell, Senior Laboratory Manager

Boston
New York
Atlanta
Chicago
Los Angeles
Houston
www.geotesting.com

August 5, 2024

Nathan Pukay
Maine Department of Transportation
16 State House Station
Augusta, ME 04333-0016

RE: Hemlock Stream Bridge #3735, Argyle Township, ME (GTX-319158)

Dear Nathan Pukay:

Enclosed are the test results you requested for the above referenced project. GeoTesting Express, LLC. (GTX) received two samples from you on 5/24/2024. These samples were labeled as follows:

Boring Number	Sample Number	Depth
BB-AHS-302	R1	22.8-23.3'
BB-AHS-304	R1	22.1-22.8'

GTX performed the following tests on these samples:

2 ASTM D7012D- Elastic Moduli of Rock in Uniaxial Compression

A copy of your test request is attached.

The results presented in this report apply only to the items tested. This report shall not be reproduced except in full, without written approval from GeoTesting Express. The remainder of these samples will be retained for a period of sixty (60) days and will then be discarded unless otherwise notified by you. Please call me if you have any questions or require additional information. Thank you for allowing GeoTesting Express the opportunity of providing you with testing services. We look forward to working with you again in the future.

Respectfully yours,

Sarah Delaney

Sarah Delaney
Assistant Laboratory Manager

Boston
New York
Atlanta
Chicago
Los Angeles
Houston
www.geotesting.com

Geotechnical Test Report **8/5/2024**

GTX-319158

Hemlock Stream Bridge #3735

Argyle Township, ME

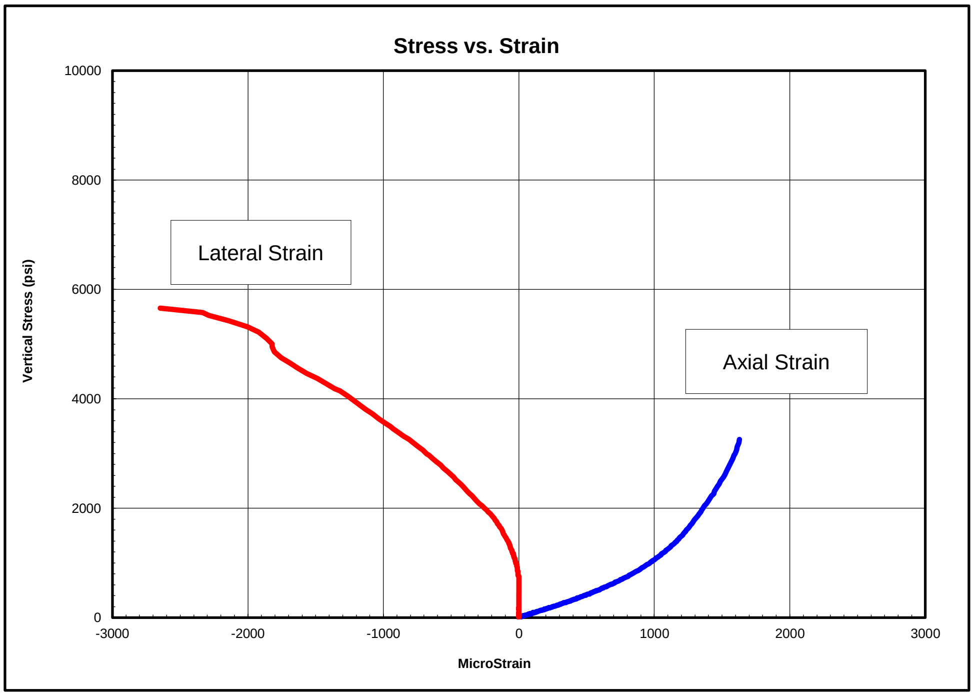
Client Project No.: 21687.00

Prepared for:

Maine Department of Transportation

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-AHS-302
Sample ID:	R1
Depth, ft:	22.80-23.17
Sample Type:	rock core
Sample Description:	See photographs Intact material and discontinuity failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 6,091 psi

The axial strain gauges failed before the peak value was attained. Young's Modulus could not be determined within the third stress range. Poisson's Ratio could not be determined within the second and third stress range.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
600-2200	2,050,000	0.41
2200-3900	5,880,000	---
3900-5500	---	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

GeoTesting EXPRESS

Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-302		
Sample ID:	R1		
Depth (ft):	22.80-23.17		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average	
Specimen Length, in:	4.45	4.45	4.45	
Specimen Diameter, in:	1.97	1.97	1.97	
Specimen Mass, g:	618.82			
Bulk Density, lb/ft^3	173	**Minimum Diameter Tolerence Met?**	YES	
Length to Diameter Ratio:	2.3	**Length to Diameter Ratio Tolerance Met?**	YES	

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap $\leq$ 0.02 in.? NO

Maximum difference must be < 0.020 in.

Straightness Tolerance Met? NO

END FLATNESS AND PARALLELISM (Procedure FP1)

END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00020	-0.00020	-0.00020	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	0.00130	0.00120	0.00090	0.00070	0.00060	0.00050	0.00030	0.00000	-0.00010	-0.00020	-0.00040	-0.00070	-0.00090	-0.00110	-0.00140

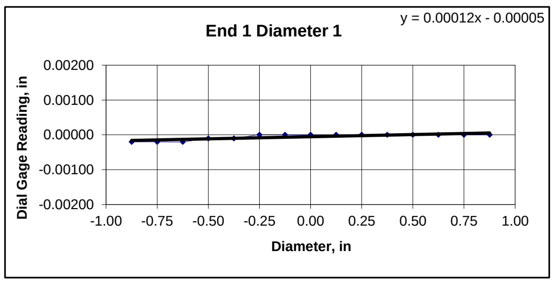
Difference between max and min readings, in:
0° = 0.00020 90° = 0.00270

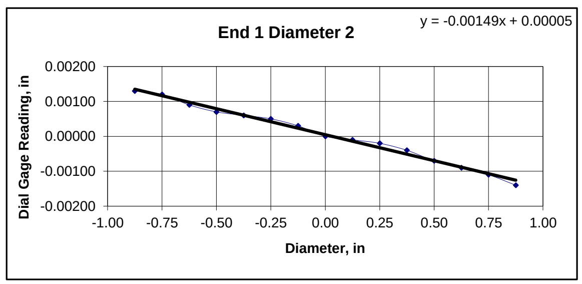
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00020	-0.00010	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	-0.00140	-0.00120	-0.00090	-0.00080	-0.00060	-0.00030	-0.00010	0.00000	0.00010	0.00030	0.00060	0.00080	0.00100	0.00110	0.00160

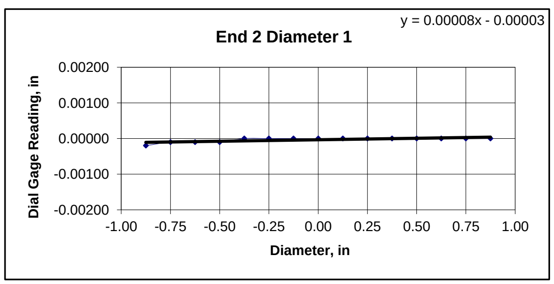
Difference between max and min readings, in:
0° = 0.0002 90° = 0.003

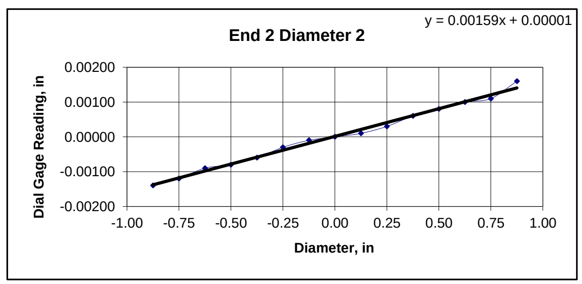
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00150

Flatness Tolerance Met? NO









DIAMETER 1

End 1:
Slope of Best Fit Line 0.00012
Angle of Best Fit Line: 0.00704

End 2:
Slope of Best Fit Line 0.00008
Angle of Best Fit Line: 0.00475

Maximum Angular Difference: 0.00229

Parallelism Tolerance Met? YES
Spherically Seated

DIAMETER 2

End 1:
Slope of Best Fit Line 0.00149
Angle of Best Fit Line: 0.08529

End 2:
Slope of Best Fit Line 0.00159
Angle of Best Fit Line: 0.09118

Maximum Angular Difference: 0.00589

Parallelism Tolerance Met? NO
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00020	1.970	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00270	1.970	0.00137	0.079	YES
END 2					
Diameter 1, in	0.00020	1.970	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00300	1.970	0.00152	0.087	YES

Maximum angle of departure must be $\leq$ 0.25°

Perpendicularity Tolerance Met? YES

GeoTesting EXPRESS
A SERCEL COMPANY

Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-302	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	22.80-23.17		
Visual Description:	See photographs		

BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS

END 1

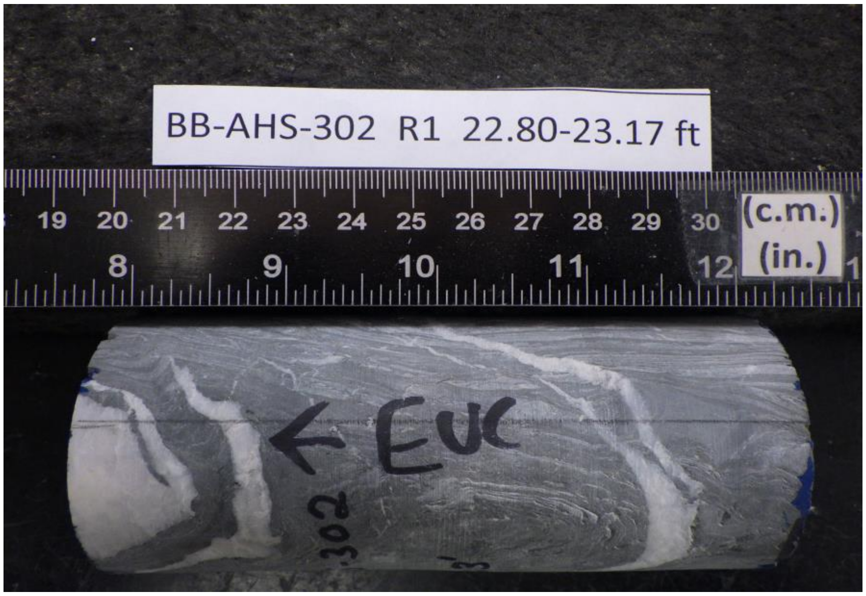
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES

END 2

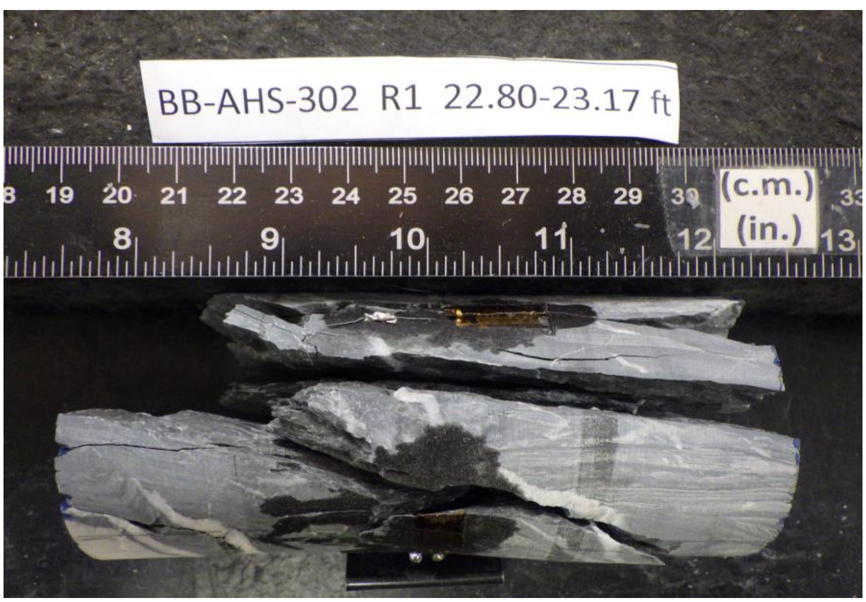
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90°)	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	smd
Boring ID:	BB-AHS-302
Sample ID:	R1
Depth, ft:	22.80-23.17



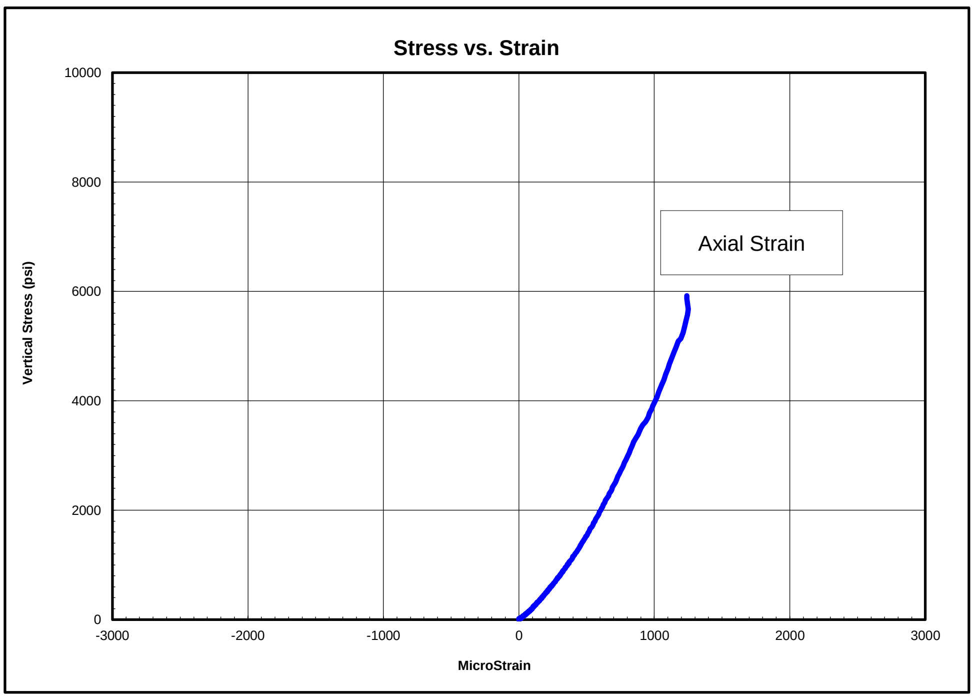
After cutting and grinding



After break

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	jsc
Boring ID:	BB-AHS-304
Sample ID:	R1
Depth, ft:	22.10-22.48
Sample Type:	rock core
Sample Description:	See photographs Intact material and discontinuity failure Best Effort end preparation performed

Compressive Strength and Elastic Moduli of Rock by ASTM D7012 - Method D



Peak Compressive Stress: 5,920 psi

The lateral strain gauges failed to record meaningful data. Poisson's Ratio could not be determined for this test.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
600-2200	3,490,000	---
2200-3700	4,730,000	---
3700-5300	4,910,000	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature.
The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.
Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed.
Calculations assume samples are isotropic, which is not necessarily the case.

GeoTesting EXPRESS

Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-304		
Sample ID:	R1		
Depth (ft):	22.10-22.48		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average		
Specimen Length, in:	4.49	4.49	4.49		
Specimen Diameter, in:	1.98	1.98	1.98		
Specimen Mass, g:	626.57				
Bulk Density, lb/ft^3	172			**Minimum Diameter Tolerence Met?**	**YES**
Length to Diameter Ratio:	2.3			**Length to Diameter Ratio Tolerance Met?**	**YES**

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:

Is the maximum gap $\leq$ 0.02 in.? YES

Maximum difference must be < 0.020 in.

Straightness Tolerance Met? **YES**

END FLATNESS AND PARALLELISM (Procedure FP1)

END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00110	-0.00090	-0.00080	-0.00060	-0.00040	-0.00010	0.00000	0.00000	0.00010	0.00080	0.00100	0.00140	0.00140	0.00150	0.00150
Diameter 2, in (rotated 90°)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

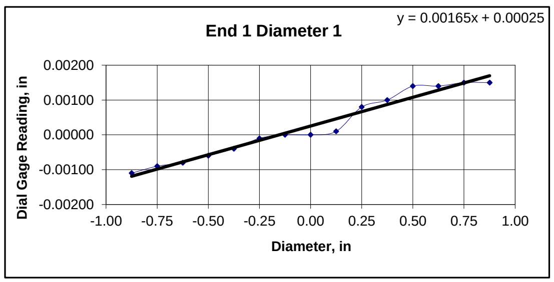
Difference between max and min readings, in:
0° = 0.00260 90° = 0.00000

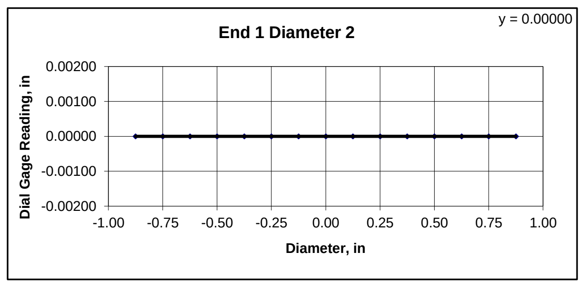
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00150	-0.00140	-0.00100	-0.00080	-0.00050	-0.00020	-0.00010	0.00000	0.00020	0.00050	0.00070	0.00080	0.00100	0.00110	0.00140
Diameter 2, in (rotated 90°)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

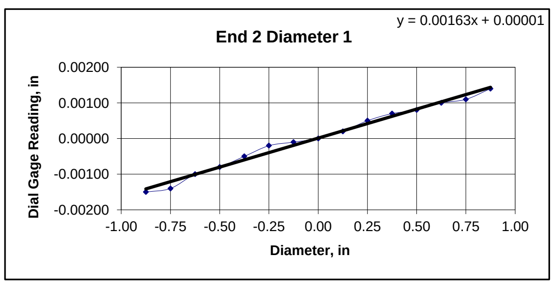
Difference between max and min readings, in:
0° = 0.0029 90° = 0

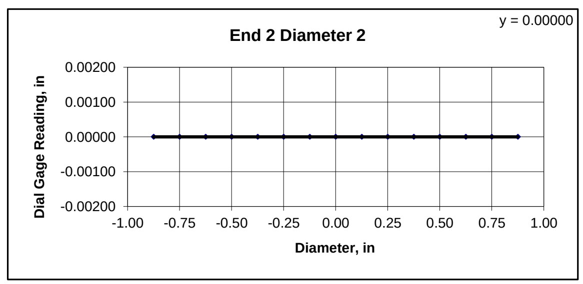
Maximum difference must be < 0.0020 in. Difference = $\pm$ 0.00145

Flatness Tolerance Met? **NO**









DIAMETER 1

End 1:	
Slope of Best Fit Line	0.00165
Angle of Best Fit Line:	0.09446
End 2:	
Slope of Best Fit Line	0.00163
Angle of Best Fit Line:	0.09331
Maximum Angular Difference:	0.00115

Parallelism Tolerance Met? **YES**
Spherically Seated

DIAMETER 2

End 1:	
Slope of Best Fit Line	0.00000
Angle of Best Fit Line:	0.00000
End 2:	
Slope of Best Fit Line	0.00000
Angle of Best Fit Line:	0.00000
Maximum Angular Difference:	0.00000

Parallelism Tolerance Met? **YES**
Spherically Seated

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00260	1.980	0.00131	0.075	YES
Diameter 2, in (rotated 90°)	0.00000	1.980	0.00000	0.000	YES
END 2					
Diameter 1, in	0.00290	1.980	0.00146	0.084	YES
Diameter 2, in (rotated 90°)	0.00000	1.980	0.00000	0.000	YES

Maximum angle of departure must be $\leq$ 0.25°

Perpendicularity Tolerance Met? **YES**

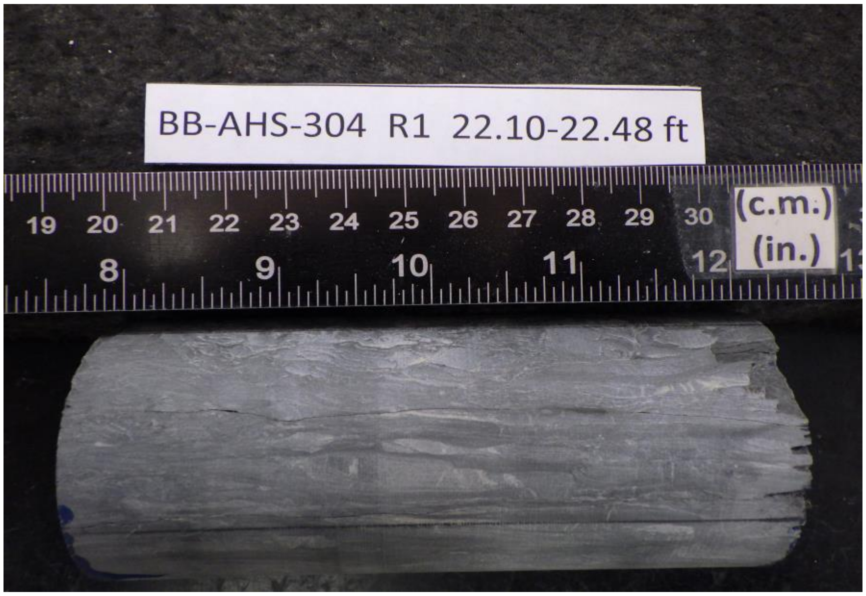
Client:	Maine Department of Transportation	Test Date:	6/12/2024
Project Name:	Hemlock Stream Bridge #3735	Tested By:	gp
Project Location:	Argyle Township, ME	Checked By:	smd
GTX #:	319158		
Boring ID:	BB-AHS-304	Reliable dial gauge measurements could not be performed on this rock type. Tolerance measurements were performed using a machinist straightedge and feeler gauges to ASTM specifications.	
Sample ID:	R1		
Depth (ft):	22.10-22.48		
Visual Description:	See photographs		

BEST EFFORT END FLATNESS TOLERANCES OF ROCK CORE SPECIMENS TO ASTM D4543

END FLATNESS		
END 1		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^o)	Is the maximum gap $\leq \pm 0.001$ in.?	YES
END 2		
Diameter 1	Is the maximum gap $\leq \pm 0.001$ in.?	YES
Diameter 2 (rotated 90^o)	Is the maximum gap $\leq \pm 0.001$ in.?	YES

End Flatness Tolerance Met? YES

Client:	Maine Department of Transportation
Project Name:	Hemlock Stream Bridge #3735
Project Location:	Argyle Township, ME
GTX #:	319158
Test Date:	6/13/2024
Tested By:	gp
Checked By:	smd
Boring ID:	BB-AHS-304
Sample ID:	R1
Depth, ft:	22.10-22.48



After cutting and grinding

After break

GeoTesting EXPRESS

ROCK CHAIN OF CUSTODY & TEST REQUEST

GeoTesting Express, Inc.
125 Nagog Park
Acton, MA 01720
800 434 1062 Toll Free
978 635 0266 Fax

2358 Perimeter Park Drive, Suite 320
Atlanta, GA 30341
770 645 6575 Tel
770 645 6570 Fax

www.geotesting.com

CLIENT	
Company: Maine Department of Transportation	
Address: 16 State House Station	
City, State, Zip: Augusta, Maine 04333-0016	
Contact: Nathan Pukay	Phone:
E-mail: nathan.p.pukay@maine.gov	Cell: 207-991-2854

INVOICE (complete if different from Client)	
Company: Maine Department of Transportation	
Address: 219 Hogan Road	
City, State, Zip: Bangor, ME 04401-5603	
Contact: Ryan Robinson	Phone: 207-624-3482
E-mail: james.r.robinson@maine.gov	Cell: 207-441-2474

PROJECT		
Project Name: Hemlock Stream Bridge #3735	Client Project #: 21687.00	Purchase Order#:
Project Location: Argyle Township, Maine	GTX Sales Order #:	Requested Turnaround: 7/19/24
On-site Contact: Nathan Pukay	E-mail: nathan.p.pukay@maine.gov	Phone: 207-991-2854

ROCK

Boring ID	Sample ID	Depth	CERCHAR Abrasivity (ASTM D 7625) * 55HRC/40HRC	Direct Shear (ASTM D5607)*	Direct Tensile Strength (ASTM D 2936)	Elastic Moduli in Triaxial Compression (ASTM D 7012B)	Elastic Moduli in Uniaxial Compression (ASTM D 7012D)	Unit Weight (ISRM)	Petrographic Analysis (ISRM)	Point Load Index (ASTM D 5731)* Diametral, Axial, Lump/Block	Punch Penetration (Handewith)	Slake Durability (ASTM D 4644)	Splitting (Brazilian) Tensile Strength (ASTM D 3967)	Schmidt Hammer (ASTM D 5873)	Total Hardness (Schmidt Hammer and Taber Abrasion)	Triaxial Compression (ASTM D 7012A)	Unconfined Compression (ASTM D 7012C)	Other:	Other:
BB-AHS-302	R1	22.8-23.3'					x												
BB-AHS-304	R1	22.1-22.8'					x												

*Specify Test Conditions (Undisturbed or Remolded, Density and Moisture, Test Normal Loads, Test Confining Stresses, etc.):

AUTHORIZE BY SIGNING AND DATING:

SIGNATURE: Pukay, Nathan P Digitally signed by Pukay, Nathan P Date: 2024.05.21 08:06:08 -04'00' PRINT NAME: Nathan Pukay DATE: 05/21/24

For GTX Use Only
Incoming Sample Inspection Performed ☐
Adverse conditions:

Relinquished By:	DATE:	Received By:	DATE: 5/29/24
	TIME:		TIME: 10:17 AM
Relinquished By:	DATE:	Received By:	DATE:
	TIME:		TIME:

GeoTesting EXPRESS

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GTX may report engineering parameters that require us to interpret the test data. Such parameters are determined using accepted engineering procedures. However, GTX does not warrant that these parameters accurately reflect the true engineering properties of the *in situ* material. Responsibility for interpretation and use of the test data and these parameters for engineering and/or construction purposes rests solely with the user and not with GTX or any of its employees.

GTX's liability will be limited to correcting or repeating a test which fails our warranty. GTX's liability for damages to the Purchaser of testing services for any cause whatsoever shall be limited to the amount GTX received for the testing services. GTX will not be liable for any damages, or for any lost benefits or other consequential damages resulting from the use of these test results, even if GTX has been advised of the possibility of such damages. GTX will not be responsible for any liability of the Purchaser to any third party.

Commonly Used Symbols

A	pore pressure parameter for $\Delta\sigma_1 - \Delta\sigma_3$
B	pore pressure parameter for $\Delta\sigma_3$
CAI	CERCHAR Abrasiveness Index
CIU	isotropically consolidated undrained triaxial shear test
CR	compression ratio for one dimensional consolidation
CSR	cyclic stress ratio
C_c	coefficient of curvature, $(D_{30})^2 / (D_{10} \text{ x } D_{60})$
C_u	coefficient of uniformity, D_{60}/D_{10}
C_c	compression index for one dimensional consolidation
C_α	coefficient of secondary compression
c_v	coefficient of consolidation
c	cohesion intercept for total stresses
c'	cohesion intercept for effective stresses
D	diameter of specimen
D	damping ratio
D_{10}	diameter at which 10% of soil is finer
D_{15}	diameter at which 15% of soil is finer
D_{30}	diameter at which 30% of soil is finer
D_{50}	diameter at which 50% of soil is finer
D_{60}	diameter at which 60% of soil is finer
D_{85}	diameter at which 85% of soil is finer
d_{50}	displacement for 50% consolidation
d_{90}	displacement for 90% consolidation
d_{100}	displacement for 100% consolidation
E	Young's modulus
e	void ratio
e_c	void ratio after consolidation
e_o	initial void ratio
G	shear modulus
G_s	specific gravity of soil particles
H	height of specimen
H_R	Rebound Hardness number
i	gradient
I_S	Uncorrected point load strength
$I_{S(50)}$	Size corrected point load strength index
H_A	Modified Taber Abrasion
H_T	Total hardness
K_o	lateral stress ratio for one dimensional strain
k	permeability
LI	Liquidity Index
m_v	coefficient of volume change
n	porosity
PI	plasticity index
P_c	preconsolidation pressure
p	$(\sigma_1 + \sigma_3) / 2$, $(\sigma_v + \sigma_h) / 2$
p'	$(\sigma'_1 + \sigma'_3) / 2$, $(\sigma'_v + \sigma'_h) / 2$
p'_c	p' at consolidation
Q	quantity of flow
q	$(\sigma_1 - \sigma_3) / 2$
q_f	q at failure
q_o, q_i	initial q
q_c	q at consolidation

S_r	Post cyclic undrained shear strength
T	temperature
t	time
U, UC	unconfined compression test
UU, Q	unconsolidated undrained triaxial test
u_a	pore gas pressure
u_e	excess pore water pressure
u, u_w	pore water pressure
V	total volume
V_g	volume of gas
V_s	volume of solids
V_s	shear wave velocity
V_v	volume of voids
V_w	volume of water
V_o	initial volume
v	velocity
W	total weight
W_s	weight of solids
W_w	weight of water
w	water content
w_c	water content at consolidation
w_f	final water content
w_l	liquid limit
w_n	natural water content
w_p	plastic limit
w_s	shrinkage limit
w_o, w_i	initial water content
α	slope of q_f versus p_f
α'	slope of q_f versus p_f'
γ_t	total unit weight
γ_d	dry unit weight
γ_s	unit weight of solids
γ_w	unit weight of water
ε	strain
ε_{vol}	volume strain
ε_h, ε_v	horizontal strain, vertical strain
μ	Poisson's ratio, also viscosity
σ	normal stress
σ'	effective normal stress
σ_c, σ'_c	consolidation stress in isotropic stress system
σ_h, σ'_h	horizontal normal stress
σ_v, σ'_v	vertical normal stress
σ'_{vc}	Effective vertical consolidation stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
τ	shear stress
φ	friction angle based on total stresses
φ'	friction angle based on effective stresses
φ'_r	residual friction angle
φ_{ult}	φ for ultimate strength

APPENDIX E - SUPPORTING CALCULATIONS

Socketed Pile Design Parameters in Bedrock

Project:	Hemlock Bridge #3735 over Hemlock Stream	**WIN:**	021687
	Argyle Township, Maine		
	STP-2168(700)		
	WIN 021687.00		
Location:	Argyle TWP, ME		
Calculated By:	E. Tome, N. Williams	**Date:**	2/24/2025
Checked By:	A. Blaisdell	**Date:**	2/25/2025

Objective: Develop foundation design parameters for rock socketed H-piles using AASHTO methodology for support of the Hemlock Stream Bridge. The two foundation types bring considered are 14x89 and 14x117 H-piles.

Inputs: Rock core data from BB-AHS-100, -200, and -300 series test borings, including rock type and RQD, and laboratory test data including unit weight, unconfined compressive strength, Youngs Modulus, and Poisson's ratio for specimens, were assessed as follows:

1. Considering the variation from geologic maps to the actual classified rock type shown on the boings (Greywacke and Slate), the upper bound properties for Slate were selected for design, which are below the lower bound of Sandstone (Greywacke).
2. The design RQD was selected as 62% (Weigted Avg).
3. Design Unconfined Compressive Strength and Youngs Modulus were averaged from laboratory test results.

Approach:

1. Evaluate Geologic Strength Index (GSI) in accordance with AASHTO methodology. See page 5.
2. Calculate unit tip resistance in rock for 14x89 and 14x117 H-piles using AASHTO Eq. 10.8.3.5.4c-1 (intact or tightly jointed rock) and Eq. 10.8.3.5.4c-2 (random joint orientation). Considering generally Fair to Good rock quality and no infilling to minor silt infilling, use 2 times the resistance calculated using 10.8.3.5.4c-2 for the design unit tip resistance, which is still less than half of the intact value from 10.8.3.5.4c-1.
3. Calculate tip resistance using end area of a 15" by 15" plate that will be welded to either pile size. Geotechnical resistance will be the same for both pile types. See page 3.

Conclusions: The nominal tip resistance for both pile types with a 15-inch x 15-inch bearing plate is approximately 2016 kips, resulting in a factored tip resistance of 1008 kips for the assumed bedrock conditions.

Calculation: H-Pile Tip Resistance in Rock

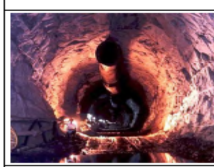
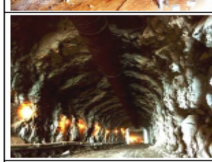
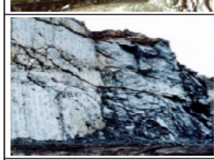
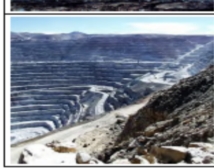
References: 1) AASHTO LRFD Bridge Design Specifications, 10th Ed. (2024)

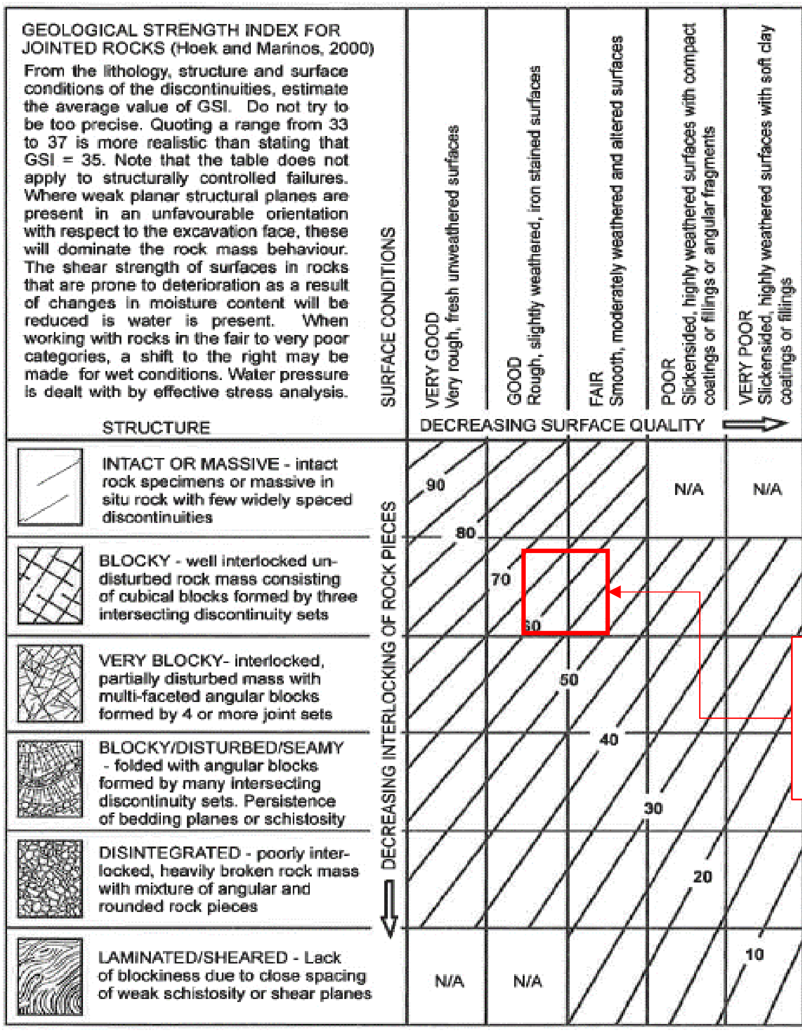
Parameter Description	Parameter Symbol	Bedrock Values	Reference
Pile Tip Area 15"x15"	*At (in^2)*	*225.0*	
Unconfined compressive strength of intact rock	q_u (psi)	6,006	Lab data for rock
Nominal Unit Tip Resistance, Intact Rock	$q_{p\ intact}$ (ksf)	2,161.980	AASHTO Eq. 10.8.3.5.4C-1
Geological Strength Index	GSI	60	AASHTO Fig. 10.4.6.4-1
Hoek - Brown 2002	D	0	Hoek - Brown 2002
Empirically determined rock mass parameter	s	0.01175	AASHTO Eq. 10.4.6.4-2
Empirically determined rock mass parameter	a	0.503	AASHTO Eq. 10.4.6.4-3
Rock group constant	m_i	11	AASHTO Table 10.4.6.4-1
Empirically determined rock mass parameter	m_b	2.6	AASHTO Eq. 10.4.6.4-4
Vertical effective stress at the socket bearing elevation	$\sigma'_{v,b}$ (psf)	2212	Vertical effective stress at bottom of socket
	$\sigma'_{v,b}$ (psi)	15.4	
Fracturing coefficient	A	823	AASHTO Eq. 10.8.3.5.4C-3 (Turner and Ramey, 2010)
Nominal Unit Tip Resistance, Jointed Rock Mass	$q_{p\ jointed}$ (ksf)	645	AASHTO Eq. 10.8.3.5.4C-2
Design Nominal Unit Tip Resistance	*$q_{p\ design}$ (ksf)*	*1,290*	*Use 2*Jointed value (less than 1/2 of intact) for rock based on primarily Fair quality*
Nominal Tip Resistance	***$R_{p,i}$ (kips)***	***2,016***	
Resistance Factor	ϕ_{qp}	0.5	AASHTO TABLE 10.5.5.2.5-1, no load testing
Factored Tip Resistance	***$R_{R,i}$ (kips)***	***1,008***	AASHTO Eq. 10.8.3.5-1

Table 10.5.5.2.4-1—Resistance Factors for Geotechnical Resistance of Drilled Shafts

Method/Soil/Condition			Resistance Factor
Nominal Axial Compressive Resistance of Single-Drilled Shafts, φ_{stat}	Side resistance in clay	α-method (Brown et al., 2010)	0.45
	Tip resistance in clay	Total Stress (Brown et al., 2010)	0.40
	Side resistance in sand	β-method (Brown et al., 2010)	0.55
	Tip resistance in sand	Brown et al. (2010)	0.50
	Side resistance in cohesive IGMs	Brown et al. (2010)	0.60
	Tip resistance in cohesive IGMs	Brown et al. (2010)	0.55
	Side resistance in rock	Kulhawy et al. (2005) Brown et al. (2010)	0.55
	Side resistance in rock	Carter and Kulhawy (1988)	0.50
	Tip resistance in rock	Canadian Geotechnical Society (1985) Pressuremeter Method (Canadian Geotechnical Society, 1985) Brown et al. (2010)	0.50
Block Failure, φ_{b1}	Clay		0.55
Uplift Resistance of Single-Drilled Shafts, φ_{up}	Clay	α-method (Brown et al., 2010)	0.35
	Sand	β-method (Brown et al., 2010)	0.45
	Rock	Kulhawy et al. (2005) Brown et al. (2010)	0.40
Group Uplift Resistance, φ_{ug}	Sand and clay		0.45
Horizontal Geotechnical Resistance of Single Shaft or Shaft Group	All materials		1.0
Static Load Test (compression), φ_{load}	All Materials		0.70
Static Load Test (uplift), φ_{upload}	All Materials		0.60

Table 1: Guidelines for estimating disturbance factor *D* From Hoek et al., 2002

Appearance of rock mass	Description of rock mass	Suggested value of *D*
	Excellent quality controlled blasting or excavation by Tunnel Boring Machine results in minimal disturbance to the confined rock mass surrounding a tunnel. No Blasting, No Disturbance	$D = 0$
	Mechanical or hand excavation in poor quality rock masses (no blasting) results in minimal disturbance to the surrounding rock mass. Where squeezing problems result in significant floor heave, disturbance can be severe unless a temporary invert, as shown in the photograph, is placed.	$\boxed{D = 0}$ $D = 0.5$ No invert
	Very poor quality blasting in a hard rock tunnel results in severe local damage, extending 2 or 3 m, in the surrounding rock mass.	$D = 0.8$
	Small scale blasting in civil engineering slopes results in modest rock mass damage, particularly if controlled blasting is used as shown on the left hand side of the photograph. However, stress relief results in some disturbance.	$D = 0.7$ Good blasting $D = 1.0$ Poor blasting
	Very large open pit mine slopes suffer significant disturbance due to heavy production blasting and also due to stress relief from overburden removal. In some softer rocks excavation can be carried out by ripping and dozing and the degree of damage to the slopes is less.	$D = 1.0$ Production blasting $D = 0.7$ Mechanical excavation



Best Estimate
Structure: Blocky
Surface Conditions: Good/Fair
Select GSI=60

Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

Table 10.4.6.4-1—Values of the Constant m_i by Rock Group (after Marinos and Hoek 2000; with updated values from Rocscience, Inc., 2007)

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
		Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
		Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

Use upper bound of slate considering the variation from geologic maps and the classified rock type (Slate and Greywacke).

Lateral Pile Analysis for Abutments

Project:	Hemlock Stream Bridge No. 3735	GZA File No.:	09.0026255.00
Location:	Argyle, Maine		
Prepared by:	E. Tome	Date:	06/20/2025
Checked by:	A. Blaisdell / N. Williams	Date:	06/20/2025

Objective

The purpose of this calculation package is to evaluate the behavior of the proposed HP14x89 abutment piles under lateral loading conditions provided by MaineDOT.

Steps:
1. Develop soil properties and LPile inputs.
2. Complete initial LPile evaluation.
3. Complete plastic hinge analysis.

References

Documents that were used as a basis of our evaluation include:
1. AASHTO LRFD Bridge Design Specifications, 10^{th} Edition, 2024
2. Maine BDG Chapter 5 – Substructures 2018
3. VTrans Integral Abutment Bridge Design Guidelines 2008

Given

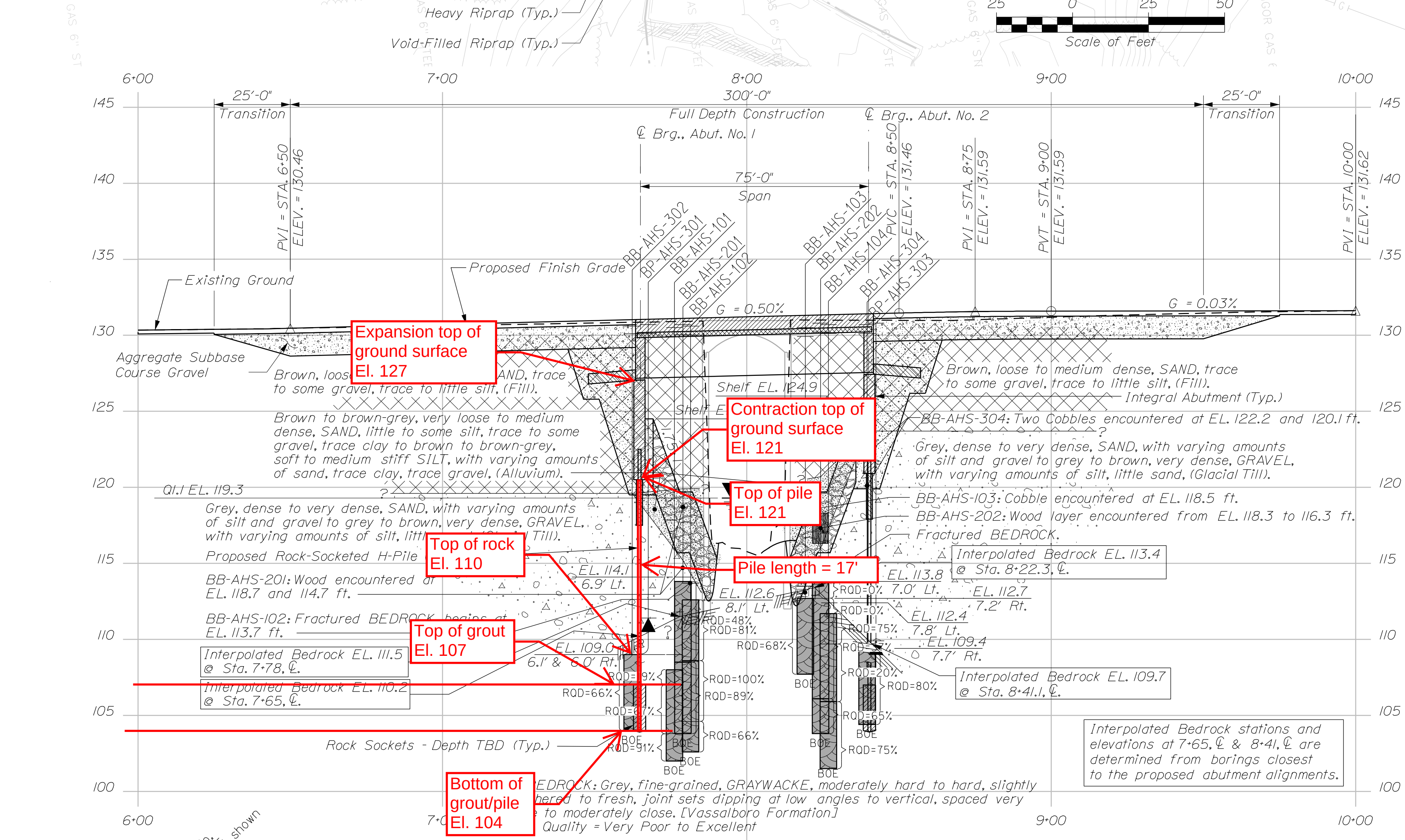
The following information was provided by MaineDOT:
- The maximum factored axial loads were 376 kips at Abutments 1 and 2.
- Lateral deflection for expansion was 0.301 inches and zero rotation at the pile head.
- Lateral deflection for contraction was 0.542 inches and zero rotation at the pile head.

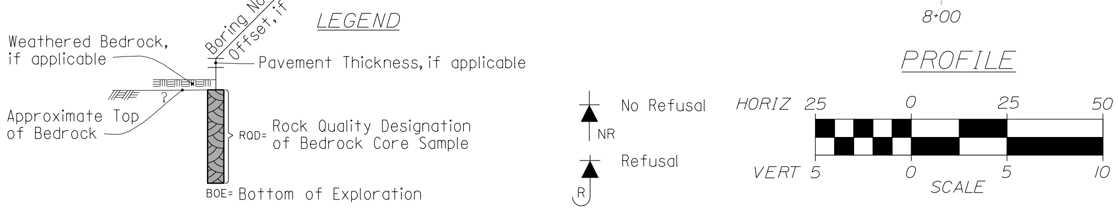
Assumptions

The following assumptions were made for our analyses:
- Abutment 1 was evaluated to be representative of both abutments since the soil profiles at both abutments are similar.

LPile Results

The initial LPile evaluation for the proposed HP14x89 abutment piles shows the pile overstressing at the pile head. A plastic hinge analysis was conducted to check the axial capacity and assess the suitability of the pile section, which shows a plastic hinge does not form in the lower section of the pile and the pile section is suitable to support combined axial load and flexure for the proposed abutments.





PROFILE

Notes: 1. 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 and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

2. "Varying Amounts" term = Portion is 0 to 50 percent of Total.

Table 1 - LPile Input Parameters
MaineDOT - Hemlock Stream Bridge #3735
Argyle, Maine

GZA FILE NO. 09.0026255.00
CALCULATED BY E. Tome 5/30/2025
CHECKED BY A. Blaisdell 6/4/2025

Objective: To estimate the horizontal modulus of subgrade reaction (k) or E50 of subsurface strata for use in lateral analyses. K values are estimated using strata internal friction angles (ϕ') or shear strength.

Methods Correlations between the horizontal modulus of subgrade reaction and the soil internal friction angle of a given stratum are based on Figure 3-34 presented in the 2022 LPile Technical Manual.

Given Information: Subsurface conditions are based on Abutment 1 borings BB-AHS-301 and -302 performed by MaineDOT on May 6, 2024.

Expansion, Pile length = 17' (14' infill, 3' grouted in rock socket)					
Stratum	**Soil Model**	**Top of Layer Elevation (NAVD88 ft)**	**k (pci) / krm**	**ϕ' (deg)/ UCS (psi)**	**γ_e (pcf)**
New Fill Above Pile	Reese Sand	127	83	32	125
Pile Infill	Reese Sand	121	83	32	125
Top of Grout in Rock Socket	Weak Rock	107	krm=0.0005	2000	169

Contraction, Pile length = 17' (14' infill, 3' grouted in rock socket)					
Stratum	**Soil Model**	**Top of Layer Elevation (NAVD88 ft)**	**k (pci) / krm**	**ϕ' (deg)/ UCS (psf)**	**γ_e (pcf)**
Pile Infill	Reese Sand	121	83	32	125
Top of Grout in Rock Socket	Weak Rock	107	krm=0.0005	2000	169

Notes: 1. Pile tip elevation should be assumed to be embedded into rock socket and 3 feet of grout.
2. Additional parameter for Weak Rock include: Modulus of 10,500 psi from rock labortory testing.
3. ** indicates the top of layer is the approximate ground water elevation based on the boring logs.
4. pci = pounds per cubic inch, deg = degrees, psi =pounds per square inch, γe = effective unit weight, pcf = pounds per square foot.
5. Since the pile geometry is similar at both abutments, only Abutment 1 was evaluated.

Table 2 - Initial LPile Output Summary
MaineDOT - Hemlock Stream Bridge #3735
GZA GeoEnvironmental, Inc.

GZA FILE NO. 09.0026255.00
CALCULATED BY E. Tome 5/30/2025
CHECKED BY A. Blaisdell 6/4/2025

Expansion, Pile length = 17' (14' infill, 3' grouted in rock socket)						
Pile Section	**Axial Load (kips)**	**Shear Force for Lateral deflection of 0.301 in. (kips)**	**Moment at Pile Head (in-kip)**	**Depth below Pile Head to Fixity (ft)**	**Total Stress at Pile Head (ksi)**	**Interaction Equation Ratio**
HP 14x89 (Weak axis)	376	68.5	-2158	14.4	63.3	1.04

Contraction, Pile length = 17' (14' infill, 3' grouted in rock socket)						
Pile Section	**Axial Load (kips)**	**Shear Force for Lateral deflection of 0.542 in. (kips)**	**Moment at Pile Head (in-kip)**	**Depth below Pile Head to Fixity (ft)**	**Total Stress at Pile Head (ksi)**	**Interaction Equation Ratio**
HP 14x89 (Weak axis)	376	41.1	-2070	15.6	61.3	1.02

Notes:

1. Soil layering and properties are presented in Table 1.
2. The axial load is the maximum Factored Axial Load.
3. Lpile model included imposed lateral deflection of 0.301 inches for the expansion case and 0.542 inches for the contraction case and zero rotation applied at the pile head.

Table 3 - LPile Output Plastic Hinge Summary
MaineDOT - Hemlock Stream Bridge #3735
Argyle, Maine

GZA FILE NO. 09.0026255.00
CALCULATED BY E. Tome 5/30/2025
CHECKED BY A. Blaisdell 6/4/2025

Expansion, Pile length = 17' (14' infill, 3' grouted in rock socket)									
Pile Section	**Pile Length (ft)**	**Axial Load[2] (kips)**	**Deflection at Pile Head (in)**	**Shear Force at Pile Head (kips)**	**Max Moment in Upper Section (in-kip)**	**Upper Section Length[3] (ft)**	**Lower Section Length[3] (ft)**	**Axial Resistance Ratio, Segment 1**	**Combined Bending Demand Ratio, Segment 2**
HP 14x89 (Weak axis) Plastic Hinge	17	376	0.301	66.1	-2022.0	3.2	9.8	0.43	0.62

Contraction, Pile length = 17' (14' infill, 3' grouted in rock socket)									
Pile Section	**Pile Length (ft)**	**Axial Load[2] (kips)**	**Deflection at Pile Head (in)**	**Shear Force at Pile Head (kips)**	**Max Moment in Upper Section (in-kip)**	**Upper Section Length[3] (ft)**	**Lower Section Length[3] (ft)**	**Axial Resistance Ratio, Segment 1**	**Combined Bending Demand Ratio, Segment 2**
HP 14x89 (Weak axis) Plastic Hinge	17	376	0.542	40.2	-2002.0	4.6	10.3	0.45	0.66

Notes:

1. Soil layering and properties are presented in Table 1.
2. The axial load is the maximum Factored Axial Load provided by MaineDOT.
3. The upper section length is measured from the bottom of abutment backwall to the first moment inflection point. The lower section length is measured between first and second moment inflection points.

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GeoEnvironmental, Inc
707 Sable Oaks Drive, Suite 150
South Portland, Maine 04106
207-879-9190
Fax 207-879-0099
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Engineers and Scientists

JOB: 09.0026255.00
SUBJECT: Pile Evaluation for Integral Abutment
SHEET: 1 OF 9
CALCULATED BY E. Tome 06/04/2025
CHECKED BY N. Williams 06/04/2025

Integral Abutment LRFD Pile Design

Subject: Pile Design for the thermal expansion of the Hemlock Stream Bridge Replacement in Argyle Maine. Abutment 1 parameters and results were used and are considered representative for both abutments.

Reference:

- AASHTO LRFD Bridge Design Specifications, 10th Edition, 2024
- Maine BDG Chapter 5 - Substructures 2014
- VTRANS Integral Abutment Bridge Design Guidelines 2008

Design Steps - Maine BDG

Step 1 - Determine the foundation displacements and the load effects (P_u and M_u) from the superstructure and substructure designs.

$P_u := 376 \cdot kip$ Maximum Factored Axial Load from MaineDOT

The limitations of the software require the plastic hinge evaluations be complete using a single deflection. MaineDOT provided a total deflection of 0.301 inches with zero end rotation for these analyses.

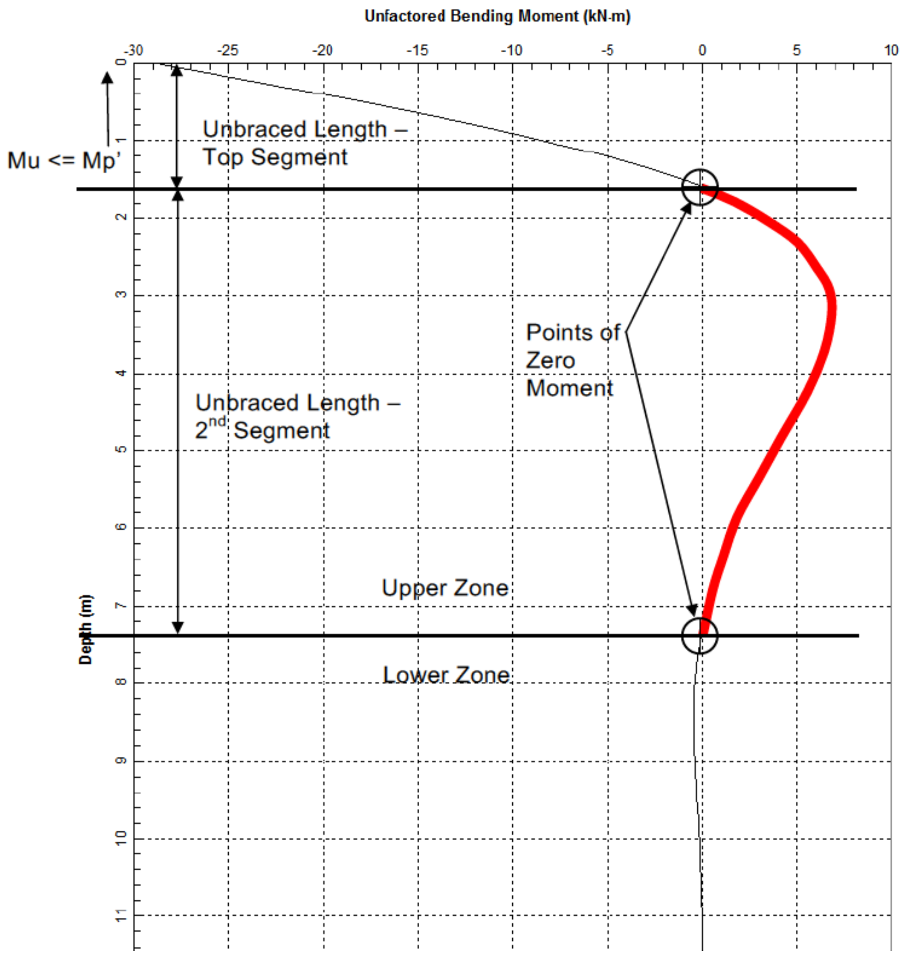
Step 2 - If applicable, determine the magnitude of scour.
Step 3 - Select preliminary pile size.

Analysis by others concludes that with additional detailing, scour is prevented.

HP14 x 89, Weak Axis Properties

Steel yield strength	$F_{y50} := 50ksi$
Modulus of elasticity for steel	$E := 29000ksi$
Cross sectoinal area of pile	$A_g := 26.1in^2$
Radius of gyration	$r_y := 3.53in$
Width of Flange	$b_f := 14.7 \cdot in$
Thickness of Flange	$t_f := 0.615 \cdot in$
Elastic Section Modulus	$S_y := 44.3 \cdot in^3$
Plastic Section Modulus	$Z_y := 67.7 \cdot in^3$

Step 4 - Determine the pile unbraced length and maximum moment at the top of the pile by running LPile software for top translation = 0.301 inches, P_u = 376 kip, and Live Load Rotation = 0 (Fixed against rotation)



EXAMPLE FIGURE: NOT TAKEN FROM THIS ANALYSIS

Maximum moment from LPile output (page 20) $M_u := 2158\text{kip}\cdot\text{in} = 179.83\cdot\text{kip}\cdot\text{ft}$

Unbraced lengths from LPile output (pages 20-21)

Upper segment $L_1 := 3.3\cdot\text{ft}$

Lower segment $L_2 := 9.8\cdot\text{ft}$

Step 5 - Determine if the applied moment on the pile will cause pile head plastic deformation considering the interaction of combined axial and flexural load effects on a single pile (LRFD 6.9.2.2)

a. Obtain the unbraced lengths of the top and lower segments of the pile and calculate the column slenderness factor (λ) for each segment.

See above for unbraced lengths (critical lengths L_1 and L_2).

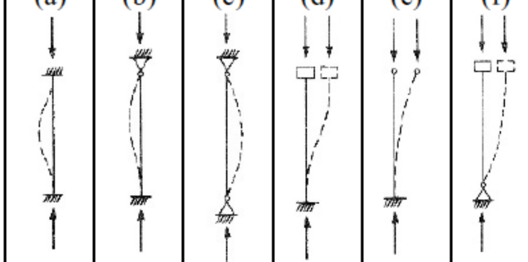
Upper segment slenderness factor

$$\lambda_1 := \frac{(L_1)}{r_y} = 11.2$$

Lower segment slenderness factor

$$\lambda_2 := \frac{(L_2)}{r_y} = 33.3$$

b. Determine K values for top and bottom of the pile per LRFD Table C4.6.2.5-1

	(a)	(b)	(c)	(d)	(e)	(f)
Buckled shape of column is shown by dashed line						
Theoretical *K* value	0.5	0.7	1.0	1.0	2.0	2.0
Design value of *K* when ideal conditions are approximated	0.65	0.80	1.0	1.2	2.1	2.0
End condition code		Rotation fixed Translation fixed Rotation free Translation fixed Rotation fixed Translation free Rotation free Translation free				

Upper segment K value (Type d)

$$K_1 := 1.2$$

Lower segment K value (Type c)

$$K_2 := 1$$

c. Calculate the nominal and factored structural pile resistance P_n, per AASHTO LRFD 6.9.4.1 using the λ values

Elastic critical buckling resistance, P_e, based on flexural buckling (AASHTO LRFD Eq. 6.9.4.1.2-1)

Upper P_e $$P_{e1} := \frac{(\pi^2 \cdot E) \cdot A_g}{(K_1 \cdot \lambda_1)^2} = 41223 \cdot kip$$

Lower P_e $$P_{e2} := \frac{(\pi^2 \cdot E) \cdot A_g}{(K_2 \cdot \lambda_2)^2} = 6731 \cdot kip$$

Nominal yield resistance, P_o $$P_o := F_{y50} \cdot A_g = 1305 \cdot kip$$

Check that the ratio of Pe to Po is > 0.44

If $P_e/P_o > 0.44$ then use AASHTO LRFD Eq. 6.9.4.1.1-1
If $P_e/P_o < 0.44$ then use AASHTO LRFD Eq. 6.9.4.1.1-2

$$P_n = \left[0.658^{\left(\frac{P_o}{P_e}\right)}\right] P_o \qquad (6.9.4.1.1\text{-}1)$$

$$P_n = 0.877 P_e \qquad (6.9.4.1.1\text{-}2)$$

$$\frac{P_{e1}}{P_o} = 31.588 \qquad \frac{P_{e2}}{P_o} = 5.158$$

Both ratios are greater than 0.44, therefore, use AASHTO LRFD Eq. 6.9.4.1.1-1: Nominal structural axial Pile resistance, P_n for both segments

$$P_{n1} := \left[0.658^{\left(\frac{P_o}{P_{e1}}\right)}\right] \cdot P_o = 1288 \cdot kip$$

$$P_{n2} := \left[0.658^{\left(\frac{P_o}{P_{e2}}\right)}\right] \cdot P_o = 1203 \cdot kip$$

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707 Sable Oaks Drive, Suite 150
South Portland, Maine 04106
207-879-9190
Fax 207-879-0099
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Factored structural axial Pile Resistance, $P_r = \phi_c (P_n)$

$\phi_c := 0.7$ for axial resistance according to AASHTO LRFD 6.5.4.2

$$P_{r1} := \phi_c \cdot P_{n1} = 901.5 \cdot kip$$

$$P_{r2} := \phi_c \cdot P_{n2} = 842.3 \cdot kip$$

d. Compare the ratio of P_u, the maximum factored axial load, to P_r, the structural resistance in the specified portion of the pile - the pile size should be such that the ratio is not less than 0.20.

Check for both segments

$\frac{P_u}{P_{r1}} = 0.417$ > 0.20, OK $\qquad$ $\frac{P_u}{P_{r2}} = 0.446$ > 0.20, OK

e. Determine the nominal and factored flexural resistance about H-Pile weak axis, (AASHTO LRFD Eq. 6.12.2.2)

Check slenderness ratio for flange, limiting slenderness ratio for compact flange, and limiting slenderness ratio for a noncompact flange.

$\lambda_f := \frac{b_f}{2 \cdot t_f} = 11.951$ slenderness ratio for flange (AASHTO LRFD Eq. 6.12.2.2.1-3)

$$\lambda_{pf} := 0.38 \cdot \left(\frac{E}{F_{y50}}\right)^{.5} = 9.152$$

$$\lambda_{rf} := 0.83 \cdot \left(\frac{E}{F_{y50}}\right)^{.5} = 19.989$$

If $\lambda_{pf} < \lambda_f < \lambda_{rf}$ Use ASSHTO LRFD Eq. 6.12.2.2.1-2 to find the nominal flexural resistance

$$M_n := \left[1 - \left(1 - \frac{S_y}{Z_y}\right) \cdot \left[\frac{\lambda_f - \lambda_{pf}}{0.45 \cdot \left(\frac{E}{F_{y50}}\right)^{.5}}\right]\right] \cdot F_{y50} \cdot Z_y = 256.9 \cdot ft \cdot kip$$

$\phi_f := 1.0$ for flexural resistance according to AASHTO LRFD 6.5.4.2

$M_r := M_n \cdot \phi_f = 256.9 \cdot ft \cdot kip$

$M_u = 179.8 \cdot ft \cdot kip$

$\frac{P_u}{P_{r1}} + \frac{8}{9} \cdot \frac{M_u}{M_r} = 1.04$ If less than 1, remains in elastic zone. Since it exceeds 1, yielding is expected at the base of the pile cap.

f. Calculate the moment that will cause a plastic hinge at the top of the pile, M_p',
Note: M_p' will be lower than M_n due to the inclusion of the axial load in the interaction equation for pile overstresses

$$\frac{P_u}{P_r} + \frac{8.0}{9.0}\left(\frac{M_{ux}}{M_{rx}} + \frac{M_{uy}}{M_{ry}}\right) \leq 1.0$$

AASHTO LRFD Eq. 6.9.2.2 Interaction equation

Use the interaction equation to find the moment that will cause a plastic hinge at the top of the pile. Assume M_{ux} and M_{rx} = 0 (out-of-plane), $M_{ry} = M_r$ and $M_u = M_p$', solve for Mp'

$M_p := \left(\frac{9}{8}\right) \cdot \left[1 - \left(\frac{P_u}{P_{r1}}\right)\right] \cdot M_r = 168.5 \cdot ft \cdot kip$ $\quad M_p = 2021577.6 \cdot in \cdot lbf$

g. The calculated moment from LPile Run 1 (shown in step 4) exceeds the moment that would cause a plastic hinge (above), therefore a plastic hinge forms, and the moment (M_p') represents the limiting moment reaction at the pile top for the subsequent analysis.

Step 6 - For fixed head piles, run a second LPILE analysis with end conditions 1) Top moment = M_p', top translation = 0.301 in; and axial load equal to P_u. Recalculate unbraced lengths from the moment vs. depth curve.

New unbraced lengths were determined from the second LPile analysis

Upper segment $L_{1p} := 3.2 \cdot ft$

Lower segment $L_{2p} := 9.8 \cdot ft$

6a. Repeat steps 5a through 5d above.

6b - If the pile size is such that the ratio of Pu to structural resistance exceeds 0.2, check the upper segment of the pile with the interaction equation of AASHTO LRFD Eq. 6.9.2.2. If a plastic hinge forms at the top of the pile, the K value of the upper segment changes from 1.2, for a rotation fixed head condition, to 2.1, for a rotation free head condition. With the new K value and lengths repeat step 5.

5a.

Upper segment slenderness factor $\lambda_{1p} := \frac{(L_{1p})}{r_y} = 10.878$

Lower segment slenderness factor $\lambda_{2p} := \frac{(L_{2p})}{r_y} = 33.314$

5b.

Upper segment K value (Type e) $K_{1p} := 2.1$

Lower segment K value (Type c) $K_{2p} := 1$

5c.

Elastic critical buckling resistance, P_e, based on flexural buckling

Upper P_e $$P_{ep1} := \frac{(\pi^2 \cdot E) \cdot A_g}{(K_{1p} \cdot \lambda_{1p})^2} = 14315 \cdot kip$$

Lower P_e $$P_{ep2} := \frac{(\pi^2 \cdot E) \cdot A_g}{(K_{2p} \cdot \lambda_{2p})^2} = 6731 \cdot kip$$

Nominal yield resistance, P_o $P_o := F_{y50} \cdot A_g = 1305 \cdot kip$

Check that the ratio of Pe to Po is > 0.44

If $P_e/P_o > 0.44$ then use equation 6.9.4.1.1-1
If $P_e/P_o < 0.44$ then use equation 6.9.4.1.1-2

$$\frac{P_{ep1}}{P_o} = 10.969 \qquad \frac{P_{ep2}}{P_o} = 5.158$$

Both ratios are greater than 0.44, therefore, use eq. 6.9.4.1.1-1: Nominal structural Pile resistance, P_n for both segments

$$P_{np1} := \left[0.658^{\left(\frac{P_o}{P_{ep1}}\right)}\right] \cdot P_o = 1256 \cdot \text{kip}$$

$$P_{np2} := \left[0.658^{\left(\frac{P_o}{P_{ep2}}\right)}\right] \cdot P_o = 1203 \cdot \text{kip}$$

Factored structural Pile Resistance, $P_r = \phi_c (P_n)$

$$P_{rp1} := \phi_c \cdot P_{np1} = 879.3 \cdot \text{kip}$$

$$P_{rp2} := \phi_c \cdot P_{np2} = 842.3 \cdot \text{kip}$$

5d. Compare the ratio of P_u to the structural resistance in the upper portion of the pile - the pile size should be such that the ratio is not less than 0.20.

Check for both segments

$$\frac{P_u}{P_{rp1}} = 0.428$$ > 0.20, OK

$$\frac{P_u}{P_{rp2}} = 0.446$$ > 0.20, OK

From VTrans Integral Abutment Design Section 4.5.2 - Check the axial capacity of the upper segment and the interaction equation for the second segment to assess suitability of pile section.

Upper Segment

Check that P_u/P_{rp1} is < 1

$$\frac{P_u}{P_{rp1}} = 0.428$$ < 1, OK

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707 Sable Oaks Drive, Suite 150
South Portland, Maine 04106
207-879-9190
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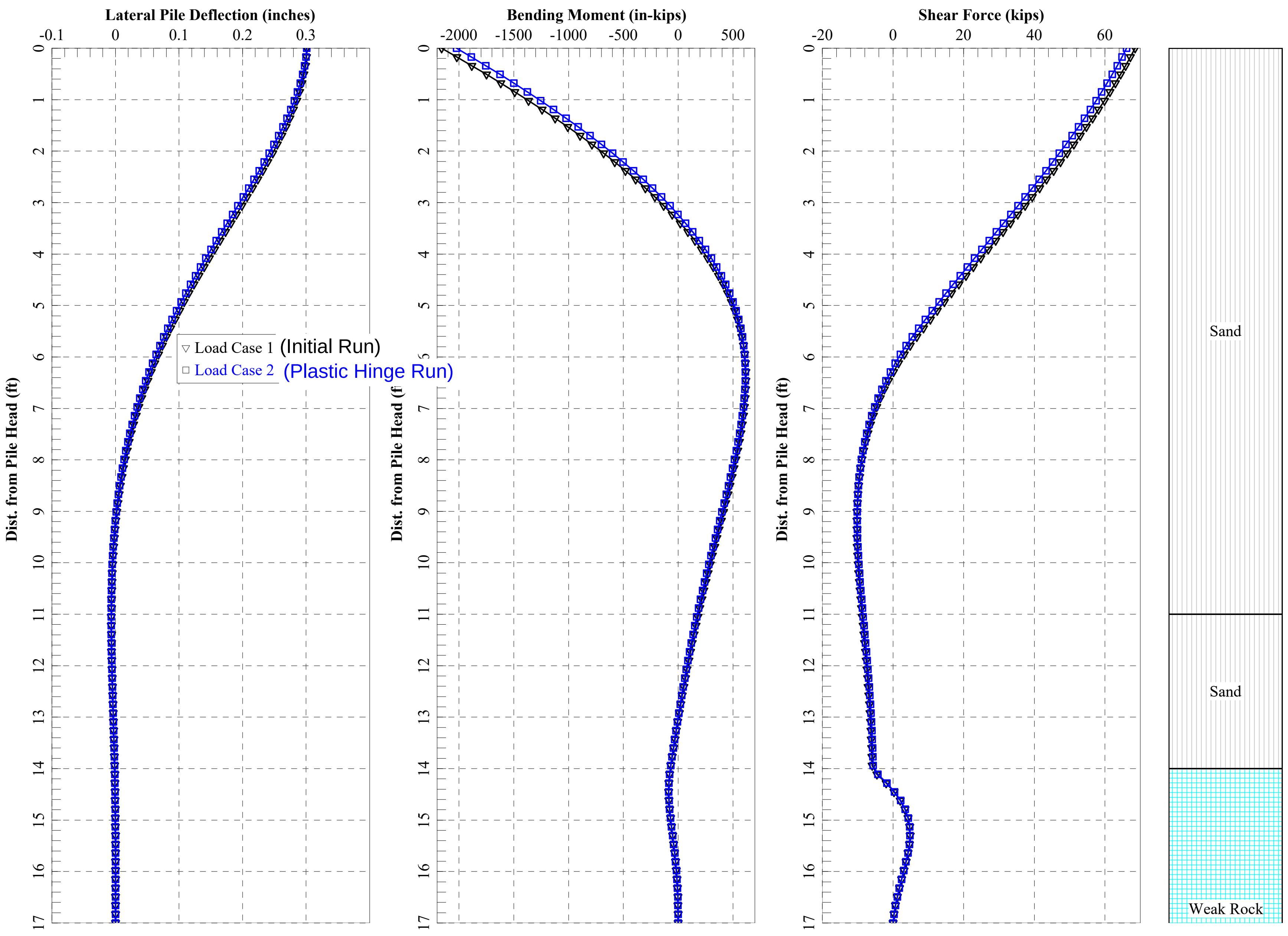
Lower Segment

Ultimate moment along the lower segment from LPile output

$$M_{maxp2} := 613379 \cdot in \cdot lbf$$

$$\frac{P_u}{P_{rp2}} + \frac{8}{9} \cdot \frac{M_{maxp2}}{M_r} = 0.623$$ < 1, OK

Expansion


Lateral Pile Deflection (inches)
-0.1
0
0.1
0.2
0.3
Bending Moment (in-kips)
-2000
-1500
-1000
-500
0
500
Shear Force (kips)
-20
0
20
40
60
Dist. from Pile Head (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Load Case 1 (Initial Run)
Load Case 2 (Plastic Hinge Run)
Sand
Sand
Weak Rock

```
===============================================================================

                    LPile for Windows, Version 2022-12.011

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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===============================================================================

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-------------------------------------------------------------------------------
                            Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\09 Jobs\0026200s\09.0026255.00 - MEDOT - Hemlock Str. Br., Argyle TWP\Work\Lpile\

Name of input data file:
14x89_Expansion.lp12d

Name of output report file:
14x89_Expansion.lp12o

Name of plot output file:
14x89_Expansion.lp12p
```

```
Name of runtime message file:
14x89_Expansion.lp12r


-------------------------------------------------------------------------------
                           Date and Time of Analysis
-------------------------------------------------------------------------------

              Date:  June 10, 2025              Time:   9:07:14


-------------------------------------------------------------------------------
                                 Problem Title
-------------------------------------------------------------------------------

Project Name: Hemlock Stream Bridge #3735


Job Number: 09.0026255.00


Client: MEDOT


Engineer: E. Tome


Description:




-------------------------------------------------------------------------------
                         Program Options and Settings
-------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)
```

```
Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
 - Number of pile increments                          =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                       =            1
Total length of pile                                  =       17.000 ft
Depth of ground surface below top of pile             =      -6.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.
```

```
            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.7000
  2           17.000           14.7000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H weak axis steel pile
   Length of section                                  =    17.000000 ft
   Pile width                                         =    13.800000 in


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =     -6.00000 ft
   Distance from top of pile to bottom of layer       =    11.000000 ft
   Effective unit weight at top of layer              =   125.000000 pcf
   Effective unit weight at bottom of layer           =   125.000000 pcf
   Friction angle at top of layer                     =    32.000000 deg.
   Friction angle at bottom of layer                  =    32.000000 deg.
   Subgrade k at top of layer                         =    83.000000 pci
   Subgrade k at bottom of layer                      =    83.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    11.000000 ft
   Distance from top of pile to bottom of layer       =    14.000000 ft
   Effective unit weight at top of layer              =   125.000000 pcf
```

```
   Effective unit weight at bottom of layer           =   125.000000 pcf
   Friction angle at top of layer                     =    32.000000 deg.
   Friction angle at bottom of layer                  =    32.000000 deg.
   Subgrade k at top of layer                         =    83.000000 pci
   Subgrade k at bottom of layer                      =    83.000000 pci


Layer 3 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer          =    14.000000 ft
   Distance from top of pile to bottom of layer       =    25.000000 ft
   Effective unit weight at top of layer              =   169.000000 pcf
   Effective unit weight at bottom of layer           =   169.000000 pcf
   Uniaxial compressive strength at top of layer      =        2000. psi
   Uniaxial compressive strength at bottom of layer   =        2000. psi
   Initial modulus of rock at top of layer            =       10500. psi
   Initial modulus of rock at bottom of layer         =       10500. psi
   RQD of rock at top of layer                        =    62.000000 %
   RQD of rock at bottom of layer                     =    62.000000 %
   k rm of rock at top of layer                       =    0.0005000
   k rm of rock at bottom of layer                    =    0.0005000


 (Depth of the lowest soil layer extends 8.000 ft below the pile tip)


**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer   1, for effective unit weight = 169.00 pcf

This data may be erroneous. Please check your data.



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective     Angle of     Uniaxial                     E50
 Rock Mass
```

```
 Num.           Name             Depth      Unit Wt.     Friction       qu         RQD %        or          kpy
  Modulus
        (p-y Curve Type)          ft          pcf          deg.         psi                     krm         pci
   psi
-----  -------------------  ----------  ----------  ----------  ----------  ----------  ----------  ----------
----------
  1          Sand                -6.000    125.0000     32.0000      --          --          --         83.0000
   --
        (Reese, et al.)         11.0000    125.0000     32.0000      --          --          --         83.0000
   --
  2          Sand               11.0000    125.0000     32.0000      --          --          --         83.0000
   --
        (Reese, et al.)         14.0000    125.0000     32.0000      --          --          --         83.0000
   --
  3          Weak               14.0000    169.0000      --          2000.     62.0000     5.00E-04      --
   10500.
             Rock               25.0000    169.0000      --          2000.     62.0000     5.00E-04      --
   10500.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 2

Load   Load         Condition               Condition             Axial Thrust     Compute Top y     Run Analysis
 No.   Type             1                       2                  Force, lbs     vs. Pile Length
-----  ----   --------------------   -----------------------   ----------------   ---------------   ------------
  1     5     y =     0.301000 in    S =        0.0000 in/in          376000.           N.A.              Yes
  2     4     y =     0.301000 in    M =     -2021578. in-lbs         376000.           N.A.              Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
```

(Initial Run)
(Plastic Hinge Run)

S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel H Weak Axis:

Length of Section	=	17.000000 ft
Flange Width	=	14.700000 in
Section Depth	=	13.800000 in
Flange Thickness	=	0.615000 in
Web Thickness	=	0.615000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	25.811550 sq. in.
Moment of Inertia	=	325.837265 in^4
Elastic Bending Stiffness	=	9449281. kip-in^2
Plastic Modulus, Z	=	67.636247in^3
Plastic Moment Capacity = Fy Z	=	3382.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1290.578 kips
Nominal Axial Tensile Capacity	=	-1290.578 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	376.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 376.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000440	41.5715426	9448389.	121.5161626	15.4955729	
0.00000880	83.1430852	9448389.	64.4330813	16.4240237	
0.00001320	124.7146278	9448389.	45.4053875	17.3524747	
0.00001760	166.2861703	9448389.	35.8915406	18.2809255	
0.00002200	207.8577129	9448389.	30.1832325	19.2093760	
0.00002640	249.4292555	9448389.	26.3776938	20.1378269	
0.00003080	291.0007981	9448389.	23.6594518	21.0662777	
0.00003520	332.5723407	9448389.	21.6207703	21.9947285	
0.00003960	374.1438833	9448389.	20.0351292	22.9231793	
0.00004400	415.7154258	9448389.	18.7666163	23.8516300	
0.00004840	457.2869684	9448389.	17.7287421	24.7800809	
0.00005280	498.8585110	9448389.	16.8638469	25.7085317	
0.00005720	540.4300536	9448389.	16.1320125	26.6369824	
0.00006160	582.0015962	9448389.	15.5047259	27.5654333	
0.00006600	623.5731388	9448389.	14.9610775	28.4938841	
0.00007040	665.1446813	9448389.	14.4853852	29.4223349	
0.00007480	706.7162239	9448389.	14.0656566	30.3507857	
0.00007920	748.2877665	9448389.	13.6925646	31.2792365	
0.00008360	789.8593091	9448389.	13.3587454	32.2076873	
0.00008800	831.4308517	9448389.	13.0583081	33.1361381	
0.00009240	873.0023943	9448389.	12.7864839	34.0645889	
0.00009680	914.5739368	9448389.	12.5393710	34.9930397	
0.0001012	956.1454794	9448389.	12.3137462	35.9214905	
0.0001056	997.7170220	9448389.	12.1069234	36.8499413	

0.0001100	1039.	9448389.	11.9166465	37.7783921	
0.0001144	1081.	9448389.	11.7410063	38.7068429	
0.0001188	1122.	9448389.	11.5783764	39.6352937	
0.0001232	1164.	9448389.	11.4273629	40.5637445	
0.0001276	1206.	9448389.	11.2867642	41.4921953	
0.0001320	1247.	9448389.	11.1555388	42.4206461	
0.0001364	1289.	9448389.	11.0327794	43.3490969	
0.0001408	1330.	9448389.	10.9176926	44.2775477	
0.0001452	1372.	9448389.	10.8095807	45.2059985	
0.0001496	1413.	9448389.	10.7078283	46.1344493	
0.0001540	1455.	9448389.	10.6118904	47.0629002	
0.0001584	1497.	9448389.	10.5212823	47.9913509	
0.0001628	1538.	9448389.	10.4355720	48.9198018	
0.0001672	1580.	9448389.	10.3543727	49.8482526	
0.0001716	1620.	9442006.	10.2785109	50.0000000	Y
0.0001804	1697.	9404746.	10.1426965	50.0000000	Y
0.0001892	1768.	9344087.	10.0248119	50.0000000	Y
0.0001980	1835.	9266049.	9.9221100	50.0000000	Y
0.0002068	1897.	9175503.	9.8322907	50.0000000	Y
0.0002156	1957.	9076399.	9.7534083	50.0000000	Y
0.0002244	2013.	8971948.	9.6838001	50.0000000	Y
0.0002332	2067.	8863225.	9.6224238	50.0000000	Y
0.0002420	2118.	8753077.	9.5678906	50.0000000	Y
0.0002508	2167.	8641592.	9.5195811	50.0000000	Y
0.0002596	2215.	8530771.	9.4764371	50.0000000	Y
0.0002684	2260.	8421006.	9.4378806	50.0000000	Y
0.0002772	2304.	8312038.	9.4035813	50.0000000	Y
0.0002860	2347.	8205023.	9.3728357	50.0000000	Y
0.0002948	2388.	8100163.	9.3452502	50.0000000	Y
0.0003036	2428.	7997626.	9.3204741	50.0000000	Y
0.0003124	2467.	7897548.	9.2981940	50.0000000	Y
0.0003212	2505.	7800038.	9.2781279	50.0000000	Y
0.0003300	2541.	7700496.	9.2588509	50.0000000	Y
0.0003388	2574.	7598194.	9.2400184	50.0000000	Y
0.0003476	2605.	7494632.	9.2215001	50.0000000	Y
0.0003564	2634.	7390641.	9.2032503	50.0000000	Y
0.0003652	2661.	7286269.	9.1853257	50.0000000	Y
0.0003740	2686.	7181958.	9.1678573	50.0000000	Y
0.0003828	2710.	7078834.	9.1505323	50.0000000	Y
0.0003916	2732.	6976422.	9.1337616	50.0000000	Y
0.0004004	2753.	6875661.	9.1172593	50.0000000	Y
0.0004092	2773.	6776194.	9.1010914	50.0000000	Y
0.0004180	2791.	6677848.	9.0850292	50.0000000	Y

0.0004268	2809.	6581450.	9.0694012	50.0000000	Y
0.0004356	2826.	6487230.	9.0541304	50.0000000	Y
0.0004444	2841.	6393828.	9.0389426	50.0000000	Y
0.0004532	2856.	6303153.	9.0239710	50.0000000	Y
0.0004620	2871.	6213715.	9.0096017	50.0000000	Y
0.0004708	2884.	6126267.	8.9951500	50.0000000	Y
0.0004796	2897.	6041126.	8.9811796	50.0000000	Y
0.0004884	2909.	5956972.	8.9672822	50.0000000	Y
0.0004972	2921.	5875626.	8.9537945	50.0000000	Y
0.0005060	2932.	5795193.	8.9401850	50.0000000	Y
0.0005148	2943.	5717148.	8.9273281	50.0000000	Y
0.0005236	2953.	5640282.	8.9141441	50.0000000	Y
0.0005588	2990.	5350984.	8.8644637	50.0000000	Y
0.0005940	3021.	5086449.	8.8178341	50.0000000	Y
0.0006292	3048.	4844558.	8.7740532	50.0000000	Y
0.0006644	3071.	4622815.	8.7325815	50.0000000	Y
0.0006996	3092.	4419336.	8.6935213	50.0000000	Y
0.0007348	3110.	4231926.	8.6568133	50.0000000	Y
0.0007700	3125.	4059160.	8.6217515	50.0000000	Y
0.0008052	3140.	3899184.	8.5888249	50.0000000	Y
0.0008404	3152.	3751012.	8.5574130	50.0000000	Y
0.0008756	3164.	3613451.	8.5276286	50.0000000	Y
0.0009108	3174.	3485012.	8.4993032	50.0000000	Y
0.0009460	3183.	3365204.	8.4720851	50.0000000	Y
0.0009812	3192.	3253455.	8.4462397	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	376.0000000000	3192.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	-6.000	0.00	N.A.	No	0.00	473059.
2	11.0000	17.0000	Yes	No	473059.	272251.
3	14.0000	20.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Initial LPile Run (Expansion)

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.301000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 376000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3010	-2158238.	68488.	0.00	63251.	8.66E+09	-618.812	2097.	0.00
0.1700	0.3005	-2019685.	67163.	-4.92E-04	60126.	8.66E+09	-646.613	4390.	0.00
0.3400	0.2990	-1883458.	65813.	-9.39E-04	57053.	9.20E+09	-676.793	4618.	0.00
0.5100	0.2967	-1749727.	64402.	-0.00134	54036.	9.36E+09	-706.215	4856.	0.00
0.6800	0.2935	-1618643.	62933.	-0.00170	51079.	9.44E+09	-734.803	5107.	0.00
0.8500	0.2897	-1490348.	61405.	-0.00204	48185.	9.45E+09	-762.478	5369.	0.00
1.0200	0.2852	-1364979.	59823.	-0.00235	45357.	9.45E+09	-789.159	5645.	0.00
1.1900	0.2801	-1242669.	58187.	-0.00263	42598.	9.45E+09	-814.775	5934.	0.00
1.3600	0.2745	-1123543.	56500.	-0.00289	39911.	9.45E+09	-839.260	6238.	0.00
1.5300	0.2683	-1007724.	54764.	-0.00312	37299.	9.45E+09	-862.560	6557.	0.00
1.7000	0.2618	-895328.	52982.	-0.00332	34763.	9.45E+09	-884.627	6894.	0.00
1.8700	0.2548	-786465.	51156.	-0.00350	32308.	9.45E+09	-905.425	7249.	0.00
2.0400	0.2475	-681240.	49289.	-0.00366	29934.	9.45E+09	-924.926	7624.	0.00
2.2100	0.2399	-579751.	47383.	-0.00380	27645.	9.45E+09	-943.060	8021.	0.00
2.3800	0.2320	-482091.	45443.	-0.00391	25442.	9.45E+09	-959.628	8438.	0.00
2.5500	0.2239	-388345.	43470.	-0.00401	23327.	9.45E+09	-974.555	8879.	0.00
2.7200	0.2156	-298589.	41468.	-0.00408	21302.	9.45E+09	-987.784	9344.	0.00
2.8900	0.2073	-212896.	39441.	-0.00413	19369.	9.45E+09	-999.263	9835.	0.00
3.0600	0.1988	-131325.	37393.	-0.00417	17529.	9.45E+09	-1009.	10354.	0.00
3.2300	0.1902	-53932.	35327.	-0.00419	15784.	9.45E+09	-1017.	10903.	0.00
3.4000	0.1817	19239.	33247.	-0.00420	15001.	9.45E+09	-1023.	11484.	0.00
3.5700	0.1731	88151.	31156.	-0.00418	16556.	9.45E+09	-1027.	12100.	0.00
3.7400	0.1646	152774.	29059.	-0.00416	18013.	9.45E+09	-1029.	12752.	0.00
3.9100	0.1562	213091.	26960.	-0.00412	19374.	9.45E+09	-1029.	13444.	0.00
4.0800	0.1478	269089.	24862.	-0.00407	20637.	9.45E+09	-1027.	14179.	0.00
4.2500	0.1396	320768.	22771.	-0.00400	21803.	9.45E+09	-1024.	14961.	0.00
4.4200	0.1315	368133.	20688.	-0.00393	22871.	9.45E+09	-1018.	15793.	0.00
4.5900	0.1235	411203.	18620.	-0.00384	23843.	9.45E+09	-1010.	16680.	0.00
4.7600	0.1158	450000.	16569.	-0.00375	24718.	9.45E+09	-1000.	17627.	0.00
4.9300	0.1082	484559.	14540.	-0.00365	25497.	9.45E+09	-988.876	18639.	0.00
5.1000	0.1009	514922.	12536.	-0.00354	26182.	9.45E+09	-975.353	19721.	0.00
5.2700	0.09378	541142.	10562.	-0.00343	26774.	9.45E+09	-959.932	20882.	0.00
5.4400	0.08690	563276.	8622.	-0.00331	27273.	9.45E+09	-942.639	22128.	0.00
5.6100	0.08028	581395.	6718.	-0.00319	27682.	9.45E+09	-923.508	23468.	0.00
5.7800	0.07391	595574.	4892.	-0.00306	28002.	9.45E+09	-867.131	23935.	0.00
5.9500	0.06780	606046.	3184.	-0.00293	28238.	9.45E+09	-806.940	24280.	0.00
6.1200	0.06196	613059.	1598.	-0.00280	28396.	9.45E+09	-747.904	24626.	0.00
6.2900	0.05638	616858.	131.4482	-0.00266	28482.	9.45E+09	-690.194	24971.	0.00
6.4600	0.05108	617683.	-1219.	-0.00253	28500.	9.45E+09	-633.969	25317.	0.00
6.6300	0.04606	615767.	-2457.	-0.00240	28457.	9.45E+09	-579.373	25662.	0.00

L1=3.3 ft

6.8000	0.04130	611338.	-3585.	-0.00227	28357.	9.45E+09	-526.531	26008.	0.00
6.9700	0.03681	604616.	-4607.	-0.00213	28206.	9.45E+09	-475.557	26353.	0.00
7.1400	0.03259	595816.	-5527.	-0.00200	28007.	9.45E+09	-426.549	26698.	0.00
7.3100	0.02863	585141.	-6349.	-0.00188	27766.	9.45E+09	-379.590	27044.	0.00
7.4800	0.02493	572790.	-7078.	-0.00175	27488.	9.45E+09	-334.751	27389.	0.00
7.6500	0.02148	558951.	-7717.	-0.00163	27176.	9.45E+09	-292.089	27735.	0.00
7.8200	0.01828	543804.	-8272.	-0.00151	26834.	9.45E+09	-251.647	28080.	0.00
7.9900	0.01532	527520.	-8746.	-0.00140	26467.	9.45E+09	-213.459	28425.	0.00
8.1600	0.01259	510259.	-9145.	-0.00128	26077.	9.45E+09	-177.545	28771.	0.00
8.3300	0.01008	492176.	-9473.	-0.00118	25669.	9.45E+09	-143.913	29116.	0.00
8.5000	0.00779	473412.	-9735.	-0.00107	25246.	9.45E+09	-112.564	29462.	0.00
8.6700	0.00571	454101.	-9935.	-9.71E-04	24810.	9.45E+09	-83.486	29807.	0.00
8.8400	0.00383	434368.	-10078.	-8.75E-04	24365.	9.45E+09	-56.660	30153.	0.00
9.0100	0.00214	414327.	-10168.	-7.83E-04	23913.	9.45E+09	-32.058	30498.	0.00
9.1800	6.38E-04	394083.	-10211.	-6.96E-04	23457.	9.45E+09	-9.643	30843.	0.00
9.3500	-6.95E-04	373735.	-10210.	-6.13E-04	22998.	9.45E+09	10.6289	31189.	0.00
9.5200	-0.00186	353368.	-10169.	-5.35E-04	22538.	9.45E+09	28.8074	31534.	0.00
9.6900	-0.00288	333064.	-10094.	-4.60E-04	22080.	9.45E+09	44.9493	31880.	0.00
9.8600	-0.00374	312891.	-9988.	-3.91E-04	21625.	9.45E+09	59.1167	32225.	0.00
10.0300	-0.00447	292912.	-9855.	-3.25E-04	21174.	9.45E+09	71.3772	32570.	0.00
10.2000	-0.00507	273182.	-9699.	-2.64E-04	20729.	9.45E+09	81.8026	32916.	0.00
10.3700	-0.00555	253746.	-9523.	-2.07E-04	20291.	9.45E+09	90.4690	33261.	0.00
10.5400	-0.00592	234646.	-9331.	-1.55E-04	19860.	9.45E+09	97.4564	33607.	0.00
10.7100	-0.00618	215912.	-9127.	-1.06E-04	19438.	9.45E+09	102.8481	33952.	0.00
10.8800	-0.00635	197570.	-8913.	-6.14E-05	19024.	9.45E+09	106.7302	34297.	0.00
11.0500	-0.00643	179640.	-8693.	-2.06E-05	18619.	9.45E+09	109.1917	34643.	0.00
11.2200	-0.00643	162135.	-8469.	1.63E-05	18224.	9.45E+09	110.3238	34988.	0.00
11.3900	-0.00636	145061.	-8244.	4.94E-05	17839.	9.45E+09	110.2198	35334.	0.00
11.5600	-0.00623	128423.	-8021.	7.90E-05	17464.	9.45E+09	108.9750	35679.	0.00
11.7300	-0.00604	112216.	-7801.	1.05E-04	17098.	9.45E+09	106.6864	36025.	0.00
11.9000	-0.00580	96436.	-7586.	1.27E-04	16742.	9.45E+09	103.4524	36370.	0.00
12.0700	-0.00552	81069.	-7379.	1.47E-04	16396.	9.45E+09	99.3732	36715.	0.00
12.2400	-0.00520	66103.	-7182.	1.63E-04	16058.	9.45E+09	94.5500	37061.	0.00
12.4100	-0.00486	51519.	-6994.	1.75E-04	15729.	9.45E+09	89.0856	37406.	0.00
12.5800	-0.00449	37298.	-6819.	1.85E-04	15408.	9.45E+09	83.0840	37752.	0.00
12.7500	-0.00410	23416.	-6656.	1.91E-04	15095.	9.45E+09	76.6509	38097.	0.00
12.9200	-0.00371	9849.	-6506.	1.95E-04	14789.	9.45E+09	69.8929	38442.	0.00
13.0900	-0.00331	-3429.	-6371.	1.96E-04	14644.	9.45E+09	62.9185	38788.	0.00
13.2600	-0.00291	-16444.	-6250.	1.93E-04	14938.	9.45E+09	55.8376	39133.	0.00
13.4300	-0.00252	-29224.	-6143.	1.89E-04	15226.	9.45E+09	48.7621	39479.	0.00
13.6000	-0.00214	-41796.	-6051.	1.81E-04	15510.	9.45E+09	41.8053	39824.	0.00
13.7700	-0.00178	-54188.	-5972.	1.71E-04	15789.	9.45E+09	35.0830	40169.	0.00
13.9400	-0.00145	-66424.	-5907.	1.58E-04	16065.	9.45E+09	28.7129	40515.	0.00

L2=13.1-3.3= 9.8 ft

14.1100	-0.00114	-78530.	-4512.	1.42E-04	16339.	9.45E+09	1339.	2398457.	0.00
14.2800	-8.67E-04	-85050.	-1934.	1.24E-04	16486.	9.45E+09	1188.	2794800.	0.00
14.4500	-6.32E-04	-86612.	286.2174	1.06E-04	16521.	9.45E+09	989.1668	3191143.	0.00
14.6200	-4.36E-04	-84044.	2077.	8.72E-05	16463.	9.45E+09	766.4937	3587486.	0.00
14.7900	-2.76E-04	-78272.	3409.	6.97E-05	16333.	9.45E+09	539.7634	3983829.	0.00
14.9600	-1.51E-04	-70241.	4292.	5.37E-05	16152.	9.45E+09	325.0933	4380171.	0.00
15.1300	-5.74E-05	-60845.	4760.	3.95E-05	15940.	9.45E+09	134.2948	4776514.	0.00
15.3000	9.90E-06	-50880.	4871.	2.75E-05	15715.	9.45E+09	-25.093	5172857.	0.00
15.4700	5.47E-05	-41011.	4693.	1.76E-05	15492.	9.45E+09	-149.433	5569200.	0.00
15.6400	8.15E-05	-31758.	4298.	9.70E-06	15283.	9.45E+09	-238.374	5965543.	0.00
15.8100	9.43E-05	-23491.	3755.	3.73E-06	15097.	9.45E+09	-294.097	6361886.	0.00
15.9800	9.67E-05	-16444.	3128.	-5.78E-07	14938.	9.45E+09	-320.513	6758229.	0.00
16.1500	9.19E-05	-10728.	2472.	-3.51E-06	14809.	9.45E+09	-322.477	7154571.	0.00
16.3200	8.24E-05	-6353.	1832.	-5.35E-06	14710.	9.45E+09	-305.086	7550914.	0.00
16.4900	7.01E-05	-3246.	1242.	-6.39E-06	14640.	9.45E+09	-273.093	7947257.	0.00
16.6600	5.63E-05	-1275.	728.5507	-6.88E-06	14596.	9.45E+09	-230.464	8343600.	0.00
16.8300	4.20E-05	-262.672	309.7891	-7.05E-06	14573.	9.45E+09	-180.086	8739943.	0.00
17.0000	2.76E-05	0.00	0.00	-7.07E-06	14567.	9.45E+09	-123.628	4568143.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.30100000 inches
Computed slope at pile head     =       0.000000 radians
Maximum bending moment          =      -2158238. inch-lbs
Maximum shear force             =         68488. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              7
Number of zero deflection points =             2
```

Plastic Hinge LPile Run

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = 0.301000 inches
Moment at pile head = -2021577.6 in-lbs
Axial load at pile head = 376000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3010	-2021578.	66094.	-4.13E-04	60168.	8.96E+09	-618.812	2097.	0.00
0.1700	0.2997	-1887540.	64805.	-8.58E-04	57145.	8.96E+09	-645.495	4394.	0.00
0.3400	0.2975	-1755859.	63458.	-0.00126	54175.	9.35E+09	-674.584	4626.	0.00
0.5100	0.2945	-1626691.	62053.	-0.00163	51261.	9.44E+09	-702.922	4869.	0.00
0.6800	0.2908	-1500179.	60591.	-0.00197	48407.	9.45E+09	-730.430	5123.	0.00
0.8500	0.2865	-1376459.	59074.	-0.00228	45616.	9.45E+09	-757.025	5390.	0.00
1.0200	0.2815	-1255661.	57503.	-0.00256	42891.	9.45E+09	-782.632	5671.	0.00
1.1900	0.2760	-1137911.	55882.	-0.00282	40235.	9.45E+09	-807.183	5965.	0.00
1.3600	0.2700	-1023333.	54211.	-0.00306	37651.	9.45E+09	-830.620	6275.	0.00
1.5300	0.2636	-912042.	52494.	-0.00326	35140.	9.45E+09	-852.893	6601.	0.00
1.7000	0.2567	-804149.	50733.	-0.00345	32707.	9.45E+09	-873.959	6945.	0.00
1.8700	0.2495	-699760.	48930.	-0.00361	30352.	9.45E+09	-893.788	7308.	0.00
2.0400	0.2420	-598975.	47087.	-0.00375	28078.	9.45E+09	-912.338	7692.	0.00
2.2100	0.2342	-501887.	45209.	-0.00387	25888.	9.45E+09	-929.419	8096.	0.00
2.3800	0.2262	-408585.	43297.	-0.00397	23784.	9.45E+09	-944.932	8523.	0.00
2.5500	0.2180	-319146.	41355.	-0.00405	21766.	9.45E+09	-958.815	8973.	0.00
2.7200	0.2097	-233646.	39387.	-0.00411	19838.	9.45E+09	-971.014	9448.	0.00
2.8900	0.2012	-152147.	37395.	-0.00415	17999.	9.45E+09	-981.478	9950.	0.00
3.0600	0.1927	-74708.	35384.	-0.00417	16252.	9.45E+09	-990.164	10481.	0.00
3.2300	0.1842	-1377.	33357.	-0.00418	14598.	9.45E+09	-997.030	11042.	0.00
3.4000	0.1757	67805.	31318.	-0.00417	16097.	9.45E+09	-1002.	11637.	0.00
3.5700	0.1672	132805.	29271.	-0.00415	17563.	9.45E+09	-1005.	12267.	0.00
3.7400	0.1587	193600.	27219.	-0.00412	18934.	9.45E+09	-1006.	12935.	0.00
3.9100	0.1504	250175.	25166.	-0.00407	20210.	9.45E+09	-1006.	13645.	0.00
4.0800	0.1421	302524.	23117.	-0.00401	21391.	9.45E+09	-1003.	14399.	0.00
4.2500	0.1340	350647.	21076.	-0.00394	22477.	9.45E+09	-998.550	15202.	0.00
4.4200	0.1260	394557.	19045.	-0.00386	23467.	9.45E+09	-992.060	16057.	0.00
4.5900	0.1183	434273.	17030.	-0.00377	24363.	9.45E+09	-983.641	16969.	0.00
4.7600	0.1107	469824.	15034.	-0.00367	25165.	9.45E+09	-973.303	17943.	0.00
4.9300	0.1033	501246.	13061.	-0.00357	25874.	9.45E+09	-961.062	18985.	0.00
5.1000	0.09610	528586.	11115.	-0.00346	26491.	9.45E+09	-946.938	20101.	0.00
5.2700	0.08917	551897.	9199.	-0.00334	27016.	9.45E+09	-930.957	21299.	0.00
5.4400	0.08248	571243.	7318.	-0.00322	27453.	9.45E+09	-913.146	22586.	0.00
5.6100	0.07604	586694.	5490.	[illegible]	27801.	9.45E+09	-879.242	23590.	0.00
5.7800	0.06985	598388.	3757.	[illegible]	28065.	9.45E+09	-819.588	23935.	0.00
5.9500	0.06394	606573.	2145.	-0.00284	28250.	9.45E+09	-760.978	24280.	0.00
6.1200	0.05829	611491.	651.3422	-0.00270	28361.	9.45E+09	-703.589	24626.	0.00
6.2900	0.05290	613379.	-726.853	-0.00257	28403.	9.45E+09	-647.583	24971.	0.00
6.4600	0.04779	612470.	-1992.	-0.00244	28383.	9.45E+09	-593.107	25317.	0.00
6.6300	0.04295	608992.	-3148.	-0.00231	28304.	9.45E+09	-540.294	25662.	0.00
6.8000	0.03838	603165.	-4199.	-0.00218	28173.	9.45E+09	-489.262	26008.	0.00
6.9700	0.03407	595201.	-5147.	-0.00205	27993.	9.45E+09	-440.112	26353.	0.00
7.1400	0.03002	585308.	-5996.	-0.00192	27770.	9.45E+09	-392.935	26698.	0.00
7.3100	0.02624	573682.	-6752.	-0.00179	27508.	9.45E+09	-347.805	27044.	0.00
7.4800	0.02270	560514.	-7417.	-0.00167	27211.	9.45E+09	-304.785	27389.	0.00
7.6500	0.01941	545985.	-7998.	-0.00155	26883.	9.45E+09	-263.924	27735.	0.00
7.8200	0.01637	530266.	-8496.	-0.00144	26528.	9.45E+09	-225.260	28080.	0.00
7.9900	0.01355	513523.	-8919.	-0.00132	26151.	9.45E+09	-188.819	28425.	0.00
8.1600	0.01096	495909.	-9269.	-0.00122	25753.	9.45E+09	-154.614	28771.	0.00
8.3300	0.00859	477569.	-9552.	-0.00111	25340.	9.45E+09	-122.651	29116.	0.00
8.5000	0.00643	458639.	-9772.	-0.00101	24913.	9.45E+09	-92.923	29462.	0.00
8.6700	0.00448	439247.	-9933.	-9.12E-04	24475.	9.45E+09	-65.415	29807.	0.00
8.8400	0.00271	419510.	-10041.	-8.19E-04	24030.	9.45E+09	-40.104	30153.	0.00
9.0100	0.00113	399537.	-10099.	-7.31E-04	23580.	9.45E+09	-16.959	30498.	0.00
9.1800	-2.69E-04	379427.	-10112.	-6.47E-04	23126.	9.45E+09	4.0610	30843.	0.00
9.3500	-0.00150	359271.	-10085.	-5.67E-04	22671.	9.45E+09	23.0008	31189.	0.00
9.5200	-0.00258	339151.	-10021.	-4.92E-04	22217.	9.45E+09	39.9129	31534.	0.00
9.6900	-0.00351	319141.	-9924.	-4.21E-04	21766.	9.45E+09	54.8555	31880.	0.00
9.8600	-0.00430	299307.	-9799.	-3.54E-04	21319.	9.45E+09	67.8920	32225.	0.00
10.0300	-0.00495	279705.	-9649.	-2.91E-04	20877.	9.45E+09	79.0904	32570.	0.00
10.2000	-0.00549	260387.	-9478.	-2.33E-04	20441.	9.45E+09	88.5230	32916.	0.00
10.3700	-0.00590	241393.	-9289.	-1.79E-04	20012.	9.45E+09	96.2661	33261.	0.00
10.5400	-0.00622	222760.	-9087.	-1.29E-04	19592.	9.45E+09	102.3992	33607.	0.00
10.7100	-0.00643	204517.	-8873.	-8.26E-05	19180.	9.45E+09	107.0048	33952.	0.00
10.8800	-0.00655	186685.	-8652.	-4.03E-05	18778.	9.45E+09	110.1682	34297.	0.00
11.0500	-0.00659	169280.	-8425.	-1.91E-06	18386.	9.45E+09	111.9771	34643.	0.00
11.2200	-0.00656	152314.	-8196.	3.28E-05	18003.	9.45E+09	112.5211	34988.	0.00
11.3900	-0.00646	135790.	-7967.	6.39E-05	17630.	9.45E+09	111.8918	35334.	0.00
11.5600	-0.00630	119710.	-7741.	9.15E-05	17267.	9.45E+09	110.1825	35679.	0.00
11.7300	-0.00609	104068.	-7519.	1.16E-04	16915.	9.45E+09	107.4878	36025.	0.00
11.9000	-0.00583	88857.	-7303.	1.36E-04	16571.	9.45E+09	103.9037	36370.	0.00
12.0700	-0.00553	74063.	-7095.	1.54E-04	16238.	9.45E+09	99.5276	36715.	0.00
12.2400	-0.00520	59671.	-6898.	1.69E-04	15913.	9.45E+09	94.4579	37061.	0.00
12.4100	-0.00484	45662.	-6711.	1.80E-04	15597.	9.45E+09	88.7944	37406.	0.00
12.5800	-0.00447	32016.	-6536.	1.88E-04	15289.	9.45E+09	82.6378	37752.	0.00

Lp1=3.2 ft

Mmaxp2

Lp2=13.0-3.2= 9.8 ft

12.7500	-0.00407	18708.	-6374.	1.94E-04	14989.	9.45E+09	76.0902	38097.	0.00
12.9200	-0.00368	5713.	-6226.	1.96E-04	14696.	9.45E+09	69.2549	38442.	0.00
13.0900	-0.00327	-6994.	-6092.	1.96E-04	14725.	9.45E+09	62.2365	38788.	0.00
13.2600	-0.00287	-19441.	-5972.	1.93E-04	15006.	9.45E+09	55.1411	39133.	0.00
13.4300	-0.00248	-31656.	-5867.	1.88E-04	15281.	9.45E+09	48.0764	39479.	0.00
13.6000	-0.00211	-43665.	-5776.	1.80E-04	15552.	9.45E+09	41.1518	39824.	0.00
13.7700	-0.00175	-55496.	-5698.	1.69E-04	15819.	9.45E+09	34.4784	40169.	0.00
13.9400	-0.00142	-67174.	-5634.	1.56E-04	16082.	9.45E+09	28.1696	40515.	0.00
14.1100	-0.00112	-78723.	-4268.	1.40E-04	16343.	9.45E+09	1311.	2398457.	0.00
14.2800	-8.47E-04	-84802.	-1747.	1.22E-04	16480.	9.45E+09	1160.	2794800.	0.00
14.4500	-6.16E-04	-86038.	419.8741	1.04E-04	16508.	9.45E+09	963.7374	3191143.	0.00
14.6200	-4.23E-04	-83249.	2162.	8.57E-05	16445.	9.45E+09	743.8902	3587486.	0.00
14.7900	-2.67E-04	-77350.	3451.	6.83E-05	16312.	9.45E+09	520.6241	3983829.	0.00
14.9600	-1.44E-04	-69272.	4298.	5.25E-05	16130.	9.45E+09	309.7322	4380171.	0.00
15.1300	-5.24E-05	-59893.	4740.	3.85E-05	15918.	9.45E+09	122.7409	4776514.	0.00
15.3000	1.30E-05	-49993.	4831.	2.67E-05	15695.	9.45E+09	-33.041	5172857.	0.00
15.4700	5.65E-05	-40223.	4640.	1.69E-05	15474.	9.45E+09	-154.141	5569200.	0.00
15.6400	8.22E-05	-31088.	4238.	9.25E-06	15268.	9.45E+09	-240.310	5965543.	0.00
15.8100	9.42E-05	-22947.	3693.	3.42E-06	15085.	9.45E+09	-293.768	6361886.	0.00
15.9800	9.61E-05	-16026.	3069.	-7.91E-07	14929.	9.45E+09	-318.414	6758229.	0.00
16.1500	9.10E-05	-10426.	2418.	-3.65E-06	14802.	9.45E+09	-319.050	7154571.	0.00
16.3200	8.12E-05	-6153.	1786.	-5.44E-06	14706.	9.45E+09	-300.688	7550914.	0.00
16.4900	6.88E-05	-3130.	1206.	-6.44E-06	14638.	9.45E+09	-267.986	7947257.	0.00
16.6600	5.50E-05	-1222.	703.5423	-6.91E-06	14595.	9.45E+09	-224.809	8343600.	0.00
16.8300	4.06E-05	-248.955	296.8031	-7.07E-06	14573.	9.45E+09	-173.955	8739943.	0.00
17.0000	2.61E-05	0.00	0.00	-7.09E-06	14567.	9.45E+09	-117.029	4568143.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection             =     0.30100000 inches
Computed slope at pile head      =    -0.0004126 radians
Maximum bending moment           =     -2021578. inch-lbs
Maximum shear force              =        66094. lbs
Depth of maximum bending moment  =      0.000000 feet below pile head
Depth of maximum shear force     =      0.000000 feet below pile head
```

```
Number of iterations             =              6
Number of zero deflection points =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.3010	S, rad	0.00	376000.	0.3010	0.00	68488.	-2158238.
2	y, in	0.3010	M, in-lb	-2021578.	376000.	0.3010	-4.13E-04	66094.	-2021578.

Maximum pile-head deflection = 0.3010000000 inches
Maximum pile-head rotation = -0.0004125651 radians = -0.023638 deg.

Summary of Warning Messages

The following warning was reported 126 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.

GZA
GeoEnvironmental, Inc
707 Sable Oaks Drive, Suite 150
South Portland, Maine 04106
207-879-9190
Fax 207-879-0099
http://www.gza.com

Engineers and Scientists

JOB: 09.0026255.00
SUBJECT: Pile Evaluation for Integral Abutment

CALCULATED BY E. Tome 06/04/2025
CHECKED BY N. Williams 06/04/2025

Integral Abutment LRFD Pile Design

Subject: Pile Design for the thermal contraction of the Hemlock Stream Bridge Replacement in Argyle Maine. Abutment 1 parameters and results were used and are considered representative for both abutments.

Reference:

- AASHTO LRFD Bridge Design Specifications, 10th Edition, 2024
- Maine BDG Chapter 5 - Substructures 2014
- VTRANS Integral Abutment Bridge Design Guidelines 2008

Design Steps - Maine BDG

Step 1 - Determine the foundation displacements and the load effects (P_u and M_u) from the superstructure and substructure designs.

$P_u := 376 \cdot kip$ Maximum Factored Axial Load from MaineDOT

The limitations of the software require the plastic hinge evaluations be complete using a single deflection. MaineDOT provided a total deflection of 0.542 inches with zero end rotation for these analyses.

Step 2 - If applicable, determine the magnitude of scour.

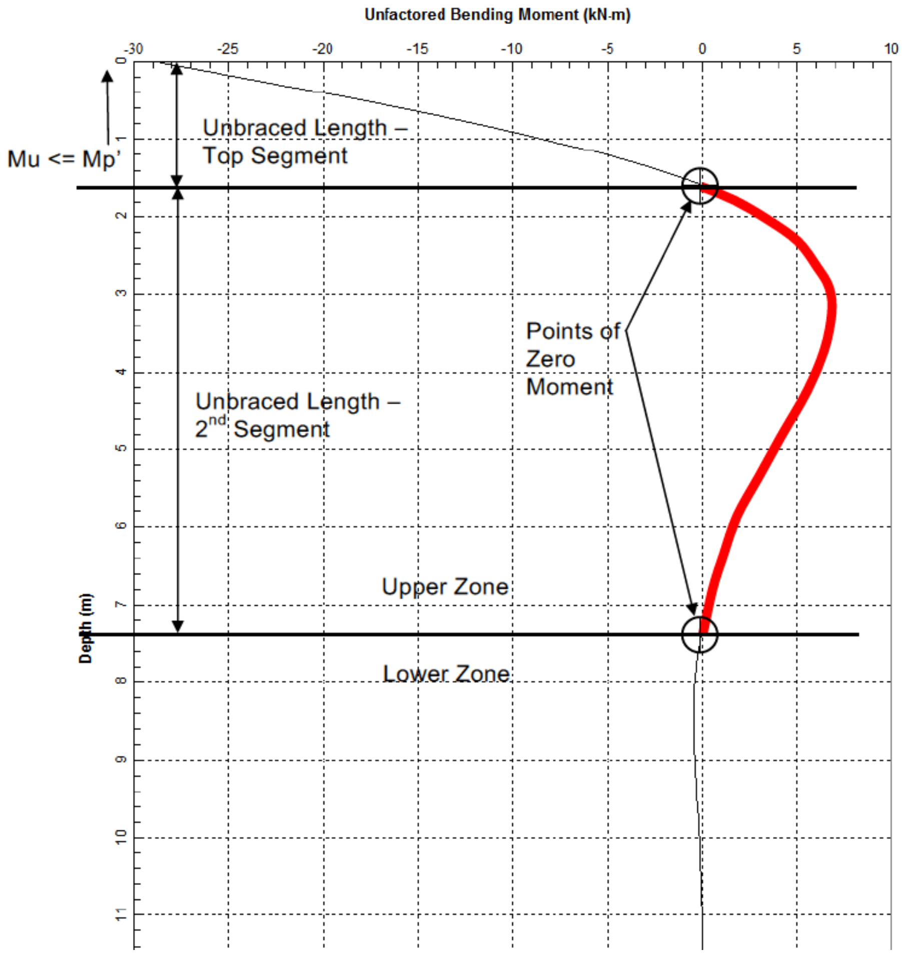
Analysis by others concludes that with additional detailing, scour is prevented.

Step 3 - Select preliminary pile size.

HP14 x 89, Weak Axis Properties

Steel yield strength	$F_{y50} := 50ksi$
Modulus of elasticity for steel	$E := 29000ksi$
Cross sectoinal area of pile	$A_g := 26.1in^2$
Radius of gyration	$r_y := 3.53in$
Width of Flange	$b_f := 14.7 \cdot in$
Thickness of Flange	$t_f := 0.615 \cdot in$
Elastic Section Modulus	$S_y := 44.3 \cdot in^3$
Plastic Section Modulus	$Z_y := 67.7 \cdot in^3$

Step 4 - Determine the pile unbraced length and maximum moment at the top of the pile by running LPile software for top translation = 0.542 inches, P_u = 376 kip, and Live Load Rotation = 0 (Fixed against rotation)



EXAMPLE FIGURE: NOT TAKEN FROM THIS ANALYSIS

Maximum moment from LPile output (page 40) $M_u := 2070 kip \cdot in = 172.5 \cdot kip \cdot ft$

Unbraced lengths from LPile output (pages 40-41)

Upper segment $L_1 := 4.7 \cdot ft$

Lower segment $L_2 := 10.2 \cdot ft$

Step 5 - Determine if the applied moment on the pile will cause pile head plastic deformation considering the interaction of combined axial and flexural load effects on a single pile (LRFD 6.9.2.2)

a. Obtain the unbraced lengths of the top and lower segments of the pile and calculate the column slenderness factor (λ) for each segment.

See above for unbraced lengths (critical lengths L_1 and L_2).

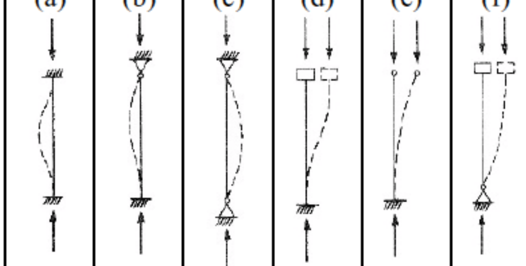
Upper segment slenderness factor

$$\lambda_1 := \frac{(L_1)}{r_y} = 16.0$$

Lower segment slenderness factor

$$\lambda_2 := \frac{(L_2)}{r_y} = 34.7$$

b. Determine K values for top and bottom of the pile per LRFD Table C4.6.2.5-1

	(a)	(b)	(c)	(d)	(e)	(f)
Buckled shape of column is shown by dashed line						
Theoretical K value	0.5	0.7	1.0	1.0	2.0	2.0
Design value of K when ideal conditions are approximated	0.65	0.80	1.0	1.2	2.1	2.0
End condition code		Rotation fixed Translation fixed Rotation free Translation fixed Rotation fixed Translation free Rotation free Translation free				

Upper segment K value (Type d) $K_1 := 1.2$

Lower segment K value (Type c) $K_2 := 1$

c. Calculate the nominal and factored structural pile resistance P_n, per AASHTO LRFD 6.9.4.1 using the λ values

Elastic critical buckling resistance, P_e, based on flexural buckling (AASHTO LRFD Eq. 6.9.4.1.2-1)

Upper P_e

$$P_{e1} := \frac{(\pi^2 \cdot E) \cdot A_g}{(K_1 \cdot \lambda_1)^2} = 20322 \cdot kip$$

Lower P_e

$$P_{e2} := \frac{(\pi^2 \cdot E) \cdot A_g}{(K_2 \cdot \lambda_2)^2} = 6213 \cdot kip$$

Nominal yield resistance, P_o

$$P_o := F_{y50} \cdot A_g = 1305 \cdot kip$$

Check that the ratio of Pe to Po is > 0.44

If $P_e/P_o > 0.44$ then use AASHTO LRFD Eq. 6.9.4.1.1-1
If $P_e/P_o < 0.44$ then use AASHTO LRFD Eq. 6.9.4.1.1-2

$$P_n = \left[0.658^{\left(\frac{P_o}{P_e}\right)} \right] P_o \qquad (6.9.4.1.1\text{-}1)$$

$$P_n = 0.877 P_e \qquad (6.9.4.1.1\text{-}2)$$

$$\frac{P_{e1}}{P_o} = 15.572 \qquad \frac{P_{e2}}{P_o} = 4.761$$

Both ratios are greater than 0.44, therefore, use AASHTO LRFD Eq. 6.9.4.1.1-1: Nominal structural axial Pile resistance, P_n for both segments

$$P_{n1} := \left[0.658^{\left(\frac{P_o}{P_{e1}}\right)} \right] \cdot P_o = 1270 \cdot kip$$

$$P_{n2} := \left[0.658^{\left(\frac{P_o}{P_{e2}}\right)} \right] \cdot P_o = 1195 \cdot kip$$

Factored structural axialPile Resistance, $P_r = \phi_c (P_n)$

$$\phi_c := 0.7$$ for axial resistance according to AASHTO LRFD 6.5.4.2

$$P_{r1} := \phi_c \cdot P_{n1} = 889.3 \cdot kip$$

$$P_{r2} := \phi_c \cdot P_{n2} = 836.6 \cdot kip$$

d. Compare the ratio of P_u, the maximum factored axial load, to P_r, the structural resistance in the specified portion of the pile - the pile size should be such that the ratio is not less than 0.20.

Check for both segments

$$\frac{P_u}{P_{r1}} = 0.423$$ > 0.20, OK

$$\frac{P_u}{P_{r2}} = 0.449$$ > 0.20, OK

e. Determine the nominal and factored flexural resistance about H-Pile weak axis, (AASHTO LRFD Eq. 6.12.2.2)

Check slenderness ratio for flange, limiting slenderness ratio for compact flange, and limiting slenderness ratio for a noncompact flange.

$$\lambda_f := \frac{b_f}{2 \cdot t_f} = 11.951$$ slenderness ratio for flange (AASHTO LRFD Eq. 6.12.2.2.1-3)

$$\lambda_{pf} := 0.38 \cdot \left(\frac{E}{F_{y50}}\right)^{.5} = 9.152$$

$$\lambda_{rf} := 0.83 \cdot \left(\frac{E}{F_{y50}}\right)^{.5} = 19.989$$

If $\lambda_{pf} < \lambda_f < \lambda_{rf}$ Use ASSHTO LRFD Eq. 6.12.2.2.1-2 to find the nominal flexural resistance

$$M_n := \left[1 - \left(1 - \frac{S_y}{Z_y}\right) \cdot \left[\frac{\lambda_f - \lambda_{pf}}{0.45 \cdot \left(\frac{E}{F_{y50}}\right)^{.5}}\right]\right] \cdot F_{y50} \cdot Z_y = 256.9 \cdot ft \cdot kip$$

$\phi_f := 1.0$ for flexural resistance according to AASHTO LRFD 6.5.4.2

$M_r := M_n \cdot \phi_f = 256.9 \cdot ft \cdot kip$

$M_u = 172.5 \cdot ft \cdot kip$

$\frac{P_u}{P_{r1}} + \frac{8}{9} \cdot \frac{M_u}{M_r} = 1.02$ If less than 1, remains in elastic zone. Since it exceeds 1, yielding is expected at the base of the pile cap.

f. Calculate the moment that will cause a plastic hinge at the top of the pile, M_p',
Note: M_p' will be lower than M_n due to the inclusion of the axial load in the interaction equation for pile overstresses

$$\frac{P_u}{P_r} + \frac{8.0}{9.0}\left(\frac{M_{ux}}{M_{rx}} + \frac{M_{uy}}{M_{ry}}\right) \leq 1.0$$

AASHTO LRFD Eq. 6.9.2.2 Interaction equation

Use the interaction equation to find the moment that will cause a plastic hinge at the top of the pile. Assume M_{ux} and M_{rx} = 0 (out-of-plane), $M_{ry} = M_r$ and $M_u = M_p$', solve for Mp'

$M_p := \left(\frac{9}{8}\right) \cdot \left[1 - \left(\frac{P_u}{P_{r1}}\right)\right] \cdot M_r = 166.8 \cdot ft \cdot kip$ $\quad M_p = 2001730.3 \cdot in \cdot lbf$

g. The calculated moment from LPile Run 1 (shown in step 4) exceeds the moment that would cause a plastic hinge (above), therefore a plastic hinge forms, and the moment (M_p') represents the limiting moment reaction at the pile top for the subsequent analysis.

Step 6 - For fixed head piles, run a second LPILE analysis with end conditions 1) Top moment = M_p', top translation = 0.542 in; and axial load equal to P_u. Recalculate unbraced lengths from the moment vs. depth curve.

New unbraced lengths were determined from the second LPile analysis

Upper segment $L_{1p} := 4.6 \cdot ft$

Lower segment $L_{2p} := 10.3 \cdot ft$

6a. Repeat steps 5a through 5d above.

6b - If the pile size is such that the ratio of Pu to structural resistance exceeds 0.2, check the upper segment of the pile with the interaction equation of AASHTO LRFD Eq. 6.9.2.2. If a plastic hinge forms at the top of the pile, the K value of the upper segment changes from 1.2, for a rotation fixed head condition, to 2.1, for a rotation free head condition. With the new K value and lengths repeat step 5.

5a.

Upper segment slenderness factor $\lambda_{1p} := \dfrac{(L_{1p})}{r_y} = 15.637$

Lower segment slenderness factor $\lambda_{2p} := \dfrac{(L_{2p})}{r_y} = 35.014$

5b.

Upper segment K value (Type e) $K_{1p} := 2.1$

Lower segment K value (Type c) $K_{2p} := 1$

5c.

Elastic critical buckling resistance, P_e, based on flexural buckling

Upper P_e $P_{ep1} := \dfrac{(\pi^2 \cdot E) \cdot A_g}{(K_{1p} \cdot \lambda_{1p})^2} = 6927 \cdot kip$

Lower P_e $P_{ep2} := \dfrac{(\pi^2 \cdot E) \cdot A_g}{(K_{2p} \cdot \lambda_{2p})^2} = 6093 \cdot kip$

Nominal yield resistance, P_o $P_o := F_{y50} \cdot A_g = 1305 \cdot kip$

Check that the ratio of Pe to Po is > 0.44

If $P_e/P_o > 0.44$ then use equation 6.9.4.1.1-1
If $P_e/P_o < 0.44$ then use equation 6.9.4.1.1-2

$$\frac{P_{ep1}}{P_o} = 5.308 \qquad \frac{P_{ep2}}{P_o} = 4.669$$

Both ratios are greater than 0.44, therefore, use eq. 6.9.4.1.1-1: Nominal structural Pile resistance, P_n for both segments

$$P_{np1} := \left[0.658^{\left(\frac{P_o}{P_{ep1}}\right)}\right]\cdot P_o = 1206\cdot kip$$

$$P_{np2} := \left[0.658^{\left(\frac{P_o}{P_{ep2}}\right)}\right]\cdot P_o = 1193\cdot kip$$

Factored structural Pile Resistance, $P_r = \phi_c (P_n)$

$$P_{rp1} := \phi_c \cdot P_{np1} = 844.2\cdot kip$$

$$P_{rp2} := \phi_c \cdot P_{np2} = 835.2\cdot kip$$

5d. Compare the ratio of P_u to the structural resistance in the upper portion of the pile - the pile size should be such that the ratio is not less than 0.20.

Check for both segments

$\frac{P_u}{P_{rp1}} = 0.445$ > 0.20, OK $\qquad$ $\frac{P_u}{P_{rp2}} = 0.45$ > 0.20, OK

From VTrans Integral Abutment Design Section 4.5.2 - Check the axial capacity of the upper segment and the interaction equation for the second segment to assess suitability of pile section.

Upper Segment

Check that P_u/P_{rp1} is < 1

$\frac{P_u}{P_{rp1}} = 0.445$ < 1, OK

Lower Segment

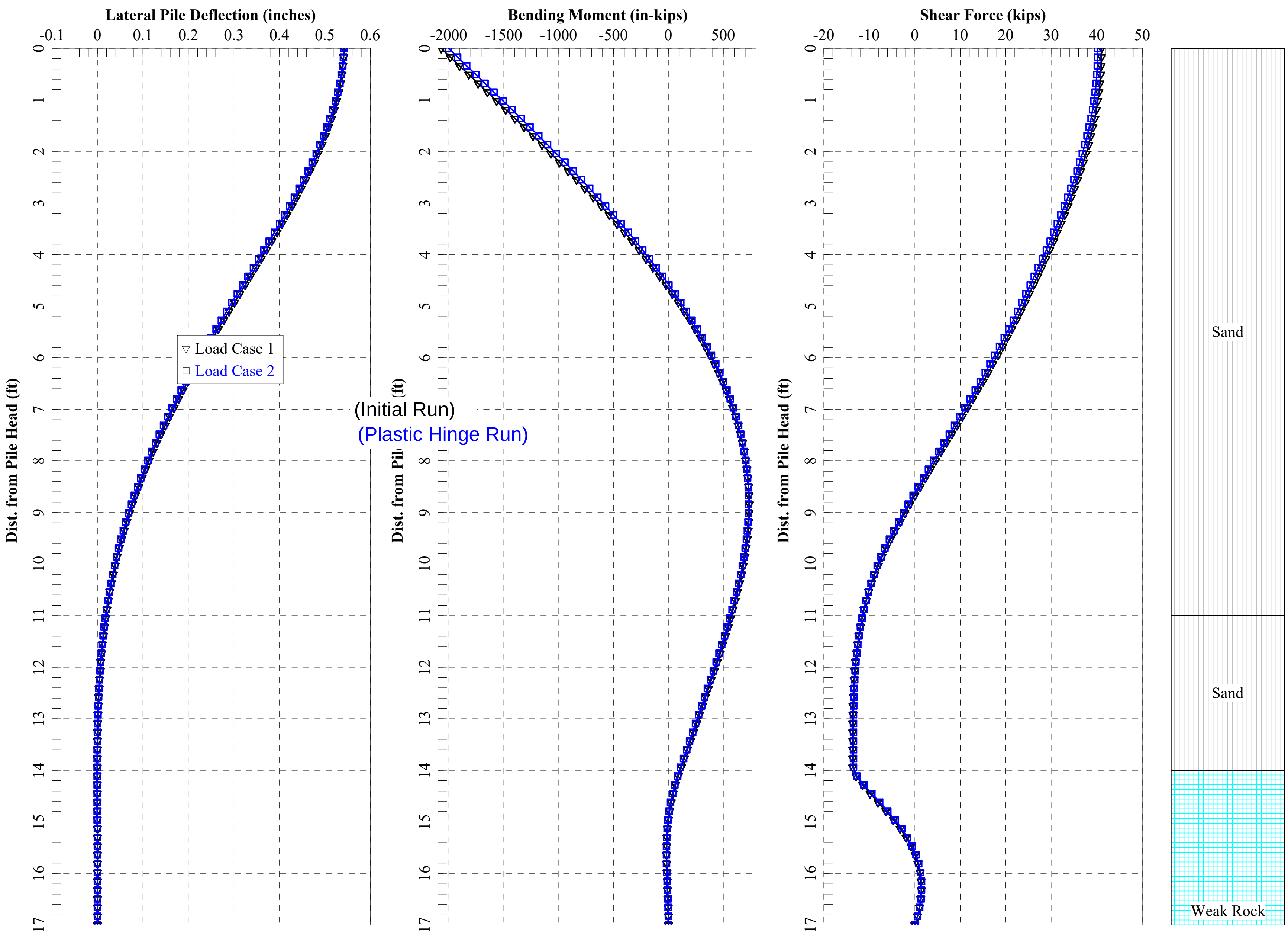
Ultimate moment along the lower segment from LPile output

$$M_{maxp2} := 731655 \cdot in \cdot lbf$$

$$\frac{P_u}{P_{rp2}} + \frac{8}{9} \cdot \frac{M_{maxp2}}{M_r} = 0.661$$

< 1, OK

Contraction



```
===============================================================================

                    LPile for Windows, Version 2022-12.011

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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===============================================================================

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-------------------------------------------------------------------------------
                            Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\09 Jobs\0026200s\09.0026255.00 - MEDOT - Hemlock Str. Br., Argyle TWP\Work\Lpile\

Name of input data file:
14x89_Contraction.lp12d

Name of output report file:
14x89_Contraction.lp12o

Name of plot output file:
14x89_Contraction.lp12p

Name of runtime message file:
14x89_Contraction.lp12r


-------------------------------------------------------------------------------
                           Date and Time of Analysis
-------------------------------------------------------------------------------

              Date:  June 10, 2025              Time:   8:52:25


-------------------------------------------------------------------------------
                                 Problem Title
-------------------------------------------------------------------------------

Project Name: Hemlock Stream Bridge #3735


Job Number: 09.0026255.00


Client: MEDOT


Engineer: E. Tome


Description:




-------------------------------------------------------------------------------
                         Program Options and Settings
-------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)
```

```
Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
 - Number of pile increments                          =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                       =            1
Total length of pile                                  =       17.000 ft
Depth of ground surface below top of pile             =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.
```

```
            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.7000
  2           17.000           14.7000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H weak axis steel pile
   Length of section                                  =    17.000000 ft
   Pile width                                         =    13.800000 in


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =       0.0000 ft
   Distance from top of pile to bottom of layer       =    11.000000 ft
   Effective unit weight at top of layer              =   125.000000 pcf
   Effective unit weight at bottom of layer           =   125.000000 pcf
   Friction angle at top of layer                     =    32.000000 deg.
   Friction angle at bottom of layer                  =    32.000000 deg.
   Subgrade k at top of layer                         =    83.000000 pci
   Subgrade k at bottom of layer                      =    83.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    11.000000 ft
   Distance from top of pile to bottom of layer       =    14.000000 ft
   Effective unit weight at top of layer              =   125.000000 pcf
```

Effective unit weight at bottom of layer = 125.000000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 83.000000 pci
Subgrade k at bottom of layer = 83.000000 pci

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer = 14.000000 ft
Distance from top of pile to bottom of layer = 25.000000 ft
Effective unit weight at top of layer = 169.000000 pcf
Effective unit weight at bottom of layer = 169.000000 pcf
Uniaxial compressive strength at top of layer = 2000. psi
Uniaxial compressive strength at bottom of layer = 2000. psi
Initial modulus of rock at top of layer = 10500. psi
Initial modulus of rock at bottom of layer = 10500. psi
RQD of rock at top of layer = 62.000000 %
RQD of rock at bottom of layer = 62.000000 %
k rm of rock at top of layer = 0.0005000
k rm of rock at bottom of layer = 0.0005000

(Depth of the lowest soil layer extends 8.000 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of 50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 169.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	32.0000	--	--	--	83.0000	--
	(Reese, et al.)	11.0000	125.0000	32.0000	--	--	--	83.0000	--
2	Sand	11.0000	125.0000	32.0000	--	--	--	83.0000	--
	(Reese, et al.)	14.0000	125.0000	32.0000	--	--	--	83.0000	--
3	Weak	14.0000	169.0000	--	2000.	62.0000	5.00E-04	--	10500.
	Rock	25.0000	169.0000	--	2000.	62.0000	5.00E-04	--	10500.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis	
1	5	y = 0.542000 in	S = 0.0000 in/in	376000.	N.A.	Yes	(Initial Run)
2	4	y = 0.542000 in	M = -2001730. in-lbs	376000.	N.A.	Yes	(Plastic Hinge Run)

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel H Weak Axis:

Length of Section	=	17.000000 ft
Flange Width	=	14.700000 in
Section Depth	=	13.800000 in
Flange Thickness	=	0.615000 in
Web Thickness	=	0.615000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	25.811550 sq. in.
Moment of Inertia	=	325.837265 in^4
Elastic Bending Stiffness	=	9449281. kip-in^2
Plastic Modulus, Z	=	67.636247in^3
Plastic Moment Capacity = Fy Z	=	3382.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1290.578 kips
Nominal Axial Tensile Capacity	=	-1290.578 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	376.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 376.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000440	41.5715426	9448389.	121.5161626	15.4955729	
0.00000880	83.1430852	9448389.	64.4330813	16.4240237	
0.00001320	124.7146278	9448389.	45.4053875	17.3524747	
0.00001760	166.2861703	9448389.	35.8915406	18.2809255	
0.00002200	207.8577129	9448389.	30.1832325	19.2093760	
0.00002640	249.4292555	9448389.	26.3776938	20.1378269	
0.00003080	291.0007981	9448389.	23.6594518	21.0662777	
0.00003520	332.5723407	9448389.	21.6207703	21.9947285	
0.00003960	374.1438833	9448389.	20.0351292	22.9231793	
0.00004400	415.7154258	9448389.	18.7666163	23.8516300	
0.00004840	457.2869684	9448389.	17.7287421	24.7800809	
0.00005280	498.8585110	9448389.	16.8638469	25.7085317	
0.00005720	540.4300536	9448389.	16.1320125	26.6369824	
0.00006160	582.0015962	9448389.	15.5047259	27.5654333	
0.00006600	623.5731388	9448389.	14.9610775	28.4938841	
0.00007040	665.1446813	9448389.	14.4853852	29.4223349	
0.00007480	706.7162239	9448389.	14.0656566	30.3507857	
0.00007920	748.2877665	9448389.	13.6925646	31.2792365	
0.00008360	789.8593091	9448389.	13.3587454	32.2076873	
0.00008800	831.4308517	9448389.	13.0583081	33.1361381	
0.00009240	873.0023943	9448389.	12.7864839	34.0645889	
0.00009680	914.5739368	9448389.	12.5393710	34.9930397	
0.0001012	956.1454794	9448389.	12.3137462	35.9214905	
0.0001056	997.7170220	9448389.	12.1069234	36.8499413	

0.0001100	1039.	9448389.	11.9166465	37.7783921	
0.0001144	1081.	9448389.	11.7410063	38.7068429	
0.0001188	1122.	9448389.	11.5783764	39.6352937	
0.0001232	1164.	9448389.	11.4273629	40.5637445	
0.0001276	1206.	9448389.	11.2867642	41.4921953	
0.0001320	1247.	9448389.	11.1555388	42.4206461	
0.0001364	1289.	9448389.	11.0327794	43.3490969	
0.0001408	1330.	9448389.	10.9176926	44.2775477	
0.0001452	1372.	9448389.	10.8095807	45.2059985	
0.0001496	1413.	9448389.	10.7078283	46.1344493	
0.0001540	1455.	9448389.	10.6118904	47.0629002	
0.0001584	1497.	9448389.	10.5212823	47.9913509	
0.0001628	1538.	9448389.	10.4355720	48.9198018	
0.0001672	1580.	9448389.	10.3543727	49.8482526	
0.0001716	1620.	9442006.	10.2785109	50.0000000	Y
0.0001804	1697.	9404746.	10.1426965	50.0000000	Y
0.0001892	1768.	9344087.	10.0248119	50.0000000	Y
0.0001980	1835.	9266049.	9.9221100	50.0000000	Y
0.0002068	1897.	9175503.	9.8322907	50.0000000	Y
0.0002156	1957.	9076399.	9.7534083	50.0000000	Y
0.0002244	2013.	8971948.	9.6838001	50.0000000	Y
0.0002332	2067.	8863225.	9.6224238	50.0000000	Y
0.0002420	2118.	8753077.	9.5678906	50.0000000	Y
0.0002508	2167.	8641592.	9.5195811	50.0000000	Y
0.0002596	2215.	8530771.	9.4764371	50.0000000	Y
0.0002684	2260.	8421006.	9.4378806	50.0000000	Y
0.0002772	2304.	8312038.	9.4035813	50.0000000	Y
0.0002860	2347.	8205023.	9.3728357	50.0000000	Y
0.0002948	2388.	8100163.	9.3452502	50.0000000	Y
0.0003036	2428.	7997626.	9.3204741	50.0000000	Y
0.0003124	2467.	7897548.	9.2981940	50.0000000	Y
0.0003212	2505.	7800038.	9.2781279	50.0000000	Y
0.0003300	2541.	7700496.	9.2588509	50.0000000	Y
0.0003388	2574.	7598194.	9.2400184	50.0000000	Y
0.0003476	2605.	7494632.	9.2215001	50.0000000	Y
0.0003564	2634.	7390641.	9.2032503	50.0000000	Y
0.0003652	2661.	7286269.	9.1853257	50.0000000	Y
0.0003740	2686.	7181958.	9.1678573	50.0000000	Y
0.0003828	2710.	7078834.	9.1505323	50.0000000	Y
0.0003916	2732.	6976422.	9.1337616	50.0000000	Y
0.0004004	2753.	6875661.	9.1172593	50.0000000	Y
0.0004092	2773.	6776194.	9.1010914	50.0000000	Y
0.0004180	2791.	6677848.	9.0850292	50.0000000	Y
0.0004268	2809.	6581450.	9.0694012	50.0000000	Y
0.0004356	2826.	6487230.	9.0541304	50.0000000	Y
0.0004444	2841.	6393828.	9.0389426	50.0000000	Y
0.0004532	2856.	6303153.	9.0239710	50.0000000	Y
0.0004620	2871.	6213715.	9.0096017	50.0000000	Y
0.0004708	2884.	6126267.	8.9951500	50.0000000	Y
0.0004796	2897.	6041126.	8.9811796	50.0000000	Y
0.0004884	2909.	5956972.	8.9672822	50.0000000	Y
0.0004972	2921.	5875626.	8.9537945	50.0000000	Y
0.0005060	2932.	5795193.	8.9401850	50.0000000	Y
0.0005148	2943.	5717148.	8.9273281	50.0000000	Y
0.0005236	2953.	5640282.	8.9141441	50.0000000	Y
0.0005588	2990.	5350984.	8.8644637	50.0000000	Y
0.0005940	3021.	5086449.	8.8178341	50.0000000	Y
0.0006292	3048.	4844558.	8.7740532	50.0000000	Y
0.0006644	3071.	4622815.	8.7325815	50.0000000	Y
0.0006996	3092.	4419336.	8.6935213	50.0000000	Y
0.0007348	3110.	4231926.	8.6568133	50.0000000	Y
0.0007700	3125.	4059160.	8.6217515	50.0000000	Y
0.0008052	3140.	3899184.	8.5888249	50.0000000	Y
0.0008404	3152.	3751012.	8.5574130	50.0000000	Y
0.0008756	3164.	3613451.	8.5276286	50.0000000	Y
0.0009108	3174.	3485012.	8.4993032	50.0000000	Y
0.0009460	3183.	3365204.	8.4720851	50.0000000	Y
0.0009812	3192.	3253455.	8.4462397	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	376.0000000000	3192.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	140069.
2	11.0000	11.0000	Yes	No	140069.	133089.
3	14.0000	14.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Initial LPile Run

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.542000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 376000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5420	-2070213.	41060.	0.00	61265.	8.85E+09	0.00	0.00	0.00
0.1700	0.5415	-1986315.	41017.	-4.67E-04	59373.	8.85E+09	-19.197	72.3183	0.00
0.3400	0.5401	-1902145.	40956.	-9.08E-04	57474.	9.17E+09	-40.566	153.2225	0.00
0.5100	0.5378	-1817820.	40850.	-0.00132	55572.	9.29E+09	-63.652	241.4408	0.00
0.6800	0.5347	-1733453.	40696.	-0.00171	53669.	9.37E+09	-87.919	335.4224	0.00
0.8500	0.5308	-1649163.	40491.	-0.00207	51768.	9.43E+09	-112.784	433.4233	0.00
1.0200	0.5262	-1565068.	40235.	-0.00242	49871.	9.45E+09	-137.849	534.3729	0.00
1.1900	0.5210	-1481288.	39929.	-0.00275	47981.	9.45E+09	-162.642	636.8776	0.00
1.3600	0.5150	-1397939.	39572.	-0.00306	46101.	9.45E+09	-187.116	741.1633	0.00
1.5300	0.5085	-1315138.	39166.	-0.00335	44233.	9.45E+09	-210.687	845.2812	0.00
1.7000	0.5013	-1232995.	38714.	-0.00363	42380.	9.45E+09	-232.842	947.4592	0.00
1.8700	0.4937	-1151617.	38217.	-0.00389	40544.	9.45E+09	-253.712	1048.	0.00
2.0400	0.4855	-1071105.	37678.	-0.00413	38728.	9.45E+09	-275.100	1156.	0.00
2.2100	0.4768	-991560.	37097.	-0.00435	36934.	9.45E+09	-294.691	1261.	0.00
2.3800	0.4677	-913077.	36478.	-0.00456	35164.	9.45E+09	-312.168	1362.	0.00
2.5500	0.4582	-835741.	35824.	-0.00474	33419.	9.45E+09	-328.455	1462.	0.00
2.7200	0.4484	-759635.	35139.	-0.00492	31702.	9.45E+09	-343.259	1562.	0.00
2.8900	0.4382	-684831.	34427.	-0.00507	30015.	9.45E+09	-355.570	1655.	0.00
3.0600	0.4277	-611394.	33691.	-0.00521	28358.	9.45E+09	-365.162	1742.	0.00
3.2300	0.4169	-539374.	32933.	-0.00534	26734.	9.45E+09	-378.129	1850.	0.00
3.4000	0.4059	-468840.	32151.	-0.00545	25143.	9.45E+09	-388.882	1954.	0.00
3.5700	0.3947	-399845.	31349.	-0.00554	23587.	9.45E+09	-397.128	2053.	0.00
3.7400	0.3833	-332438.	30530.	-0.00562	22066.	9.45E+09	-406.360	2163.	0.00
3.9100	0.3718	-266666.	29687.	-0.00568	20582.	9.45E+09	-419.490	2302.	0.00
4.0800	0.3601	-202596.	28820.	-0.00573	19137.	9.45E+09	-430.743	2440.	0.00
4.2500	0.3484	-140285.	27932.	-0.00577	17732.	9.45E+09	-439.945	2576.	0.00
4.4200	0.3366	-79782.	27027.	-0.00579	16367.	9.45E+09	-446.919	2709.	0.00
4.5900	0.3247	-21125.	26111.	-0.00581	15044.	9.45E+09	-451.495	2836.	0.00
4.7600	0.3129	35656.	25188.	-0.00580	15371.	9.45E+09	-453.503	2957.	0.00
4.9300	0.3011	90544.	24261.	-0.00579	16610.	9.45E+09	-455.547	3087.	0.00
5.1000	0.2893	143521.	23318.	-0.00576	17805.	9.45E+09	-468.802	3306.	0.00
5.2700	0.2775	194524.	22349.	-0.00573	18955.	9.45E+09	-481.092	3536.	0.00
5.4400	0.2659	243492.	21356.	-0.00568	20060.	9.45E+09	-492.363	3777.	0.00
5.6100	0.2544	290371.	20341.	-0.00562	21117.	9.45E+09	-502.567	4031.	0.00
5.7800	0.2430	335110.	19307.	-0.00556	22126.	9.45E+09	-511.655	4296.	0.00
5.9500	0.2317	377664.	18255.	-0.00548	23086.	9.45E+09	-519.406	4573.	0.00
6.1200	0.2206	417995.	17189.	-0.00539	23996.	9.45E+09	-525.664	4861.	0.00
6.2900	0.2097	456068.	16107.	-0.00530	24855.	9.45E+09	-535.280	5207.	0.00
6.4600	0.1990	491838.	15006.	-0.00520	25662.	9.45E+09	-544.002	5577.	0.00
6.6300	0.1885	525263.	13888.	-0.00509	26416.	9.45E+09	-551.650	5970.	0.00

L1=4.7 ft

6.8000	0.1782	556306.	12756.	-0.00497	27116.	9.45E+09	-558.185	6389.	0.00
6.9700	0.1682	584933.	11612.	-0.00485	27762.	9.45E+09	-563.574	6834.	0.00
7.1400	0.1585	611118.	10458.	-0.00472	28352.	9.45E+09	-567.788	7309.	0.00
7.3100	0.1490	634838.	9297.	-0.00458	28887.	9.45E+09	-570.800	7816.	0.00
7.4800	0.1398	656079.	8130.	-0.00444	29366.	9.45E+09	-572.591	8357.	0.00
7.6500	0.1308	674827.	6962.	-0.00430	29789.	9.45E+09	-573.141	8936.	0.00
7.8200	0.1222	691079.	5793.	-0.00415	30156.	9.45E+09	-572.441	9554.	0.00
7.9900	0.1139	704834.	4628.	-0.00400	30466.	9.45E+09	-570.481	10217.	0.00
8.1600	0.1059	716098.	3467.	-0.00385	30720.	9.45E+09	-567.259	10928.	0.00
8.3300	0.09820	724883.	2314.	-0.00369	30919.	9.45E+09	-562.776	11690.	0.00
8.5000	0.09083	731206.	1172.	-0.00354	31061.	9.45E+09	-557.040	12511.	0.00
8.6700	0.08378	735089.	42.9780	-0.00338	31149.	9.45E+09	-550.061	13394.	0.00
8.8400	0.07705	736562.	-1071.	-0.00322	31182.	9.45E+09	-541.856	14346.	0.00
9.0100	0.07065	735658.	-2167.	-0.00306	31162.	9.45E+09	-532.447	15374.	0.00
9.1800	0.06457	732416.	-3242.	-0.00290	31088.	9.45E+09	-521.857	16487.	0.00
9.3500	0.05881	726881.	-4295.	-0.00274	30964.	9.45E+09	-510.119	17694.	0.00
9.5200	0.05338	719102.	-5322.	-0.00259	30788.	9.45E+09	-497.268	19004.	0.00
9.6900	0.04826	709135.	-6304.	-0.00243	30563.	9.45E+09	-465.760	19689.	0.00
9.8600	0.04345	697113.	-7215.	-0.00228	30292.	9.45E+09	-426.723	20034.	0.00
10.0300	0.03895	683199.	-8047.	-0.00213	29978.	9.45E+09	-389.125	20379.	0.00
10.2000	0.03475	667552.	-8804.	-0.00199	29625.	9.45E+09	-353.060	20725.	0.00
10.3700	0.03085	650326.	-9489.	-0.00184	29237.	9.45E+09	-318.610	21070.	0.00
10.5400	0.02723	631666.	-10106.	-0.00171	28816.	9.45E+09	-285.845	21416.	0.00
10.7100	0.02389	611712.	-10657.	-0.00157	28366.	9.45E+09	-254.822	21761.	0.00
10.8800	0.02082	590596.	-11147.	-0.00144	27889.	9.45E+09	-225.587	22106.	0.00
11.0500	0.01801	568443.	-11579.	-0.00132	27390.	9.45E+09	-198.175	22452.	0.00
11.2200	0.01545	545372.	-11958.	-0.00120	26869.	9.45E+09	-172.610	22797.	0.00
11.3900	0.01313	521492.	-12285.	-0.00108	26331.	9.45E+09	-148.902	23143.	0.00
11.5600	0.01103	496906.	-12567.	-9.71E-04	25776.	9.45E+09	-127.054	23488.	0.00
11.7300	0.00916	471709.	-12806.	-8.67E-04	25208.	9.45E+09	-107.054	23833.	0.00
11.9000	0.00750	445988.	-13006.	-7.68E-04	24627.	9.45E+09	-88.883	24179.	0.00
12.0700	0.00603	419824.	-13170.	-6.74E-04	24037.	9.45E+09	-72.510	24524.	0.00
12.2400	0.00475	393288.	-13303.	-5.86E-04	23439.	9.45E+09	-57.895	24870.	0.00
12.4100	0.00364	366446.	-13408.	-5.04E-04	22833.	9.45E+09	-44.986	25215.	0.00
12.5800	0.00269	339356.	-13488.	-4.28E-04	22222.	9.45E+09	-33.724	25561.	0.00
12.7500	0.00189	312070.	-13547.	-3.58E-04	21607.	9.45E+09	-24.039	25906.	0.00
12.9200	0.00123	284632.	-13588.	-2.93E-04	20988.	9.45E+09	-15.852	26251.	0.00
13.0900	6.96E-04	257081.	-13613.	-2.35E-04	20366.	9.45E+09	-9.076	26597.	0.00
13.2600	2.74E-04	229449.	-13626.	-1.82E-04	19743.	9.45E+09	-3.614	26942.	0.00
13.4300	-4.78E-05	201765.	-13629.	-1.36E-04	19118.	9.45E+09	0.6393	27288.	0.00
13.6000	-2.80E-04	174049.	-13625.	-9.52E-05	18493.	9.45E+09	3.7976	27633.	0.00
13.7700	-4.36E-04	146321.	-13615.	-6.06E-05	17868.	9.45E+09	5.9833	27978.	0.00
13.9400	-5.28E-04	118593.	-13601.	-3.20E-05	17242.	9.45E+09	7.3270	28324.	0.00

14.1100	-5.67E-04	90877.	-12914.	-9.42E-06	16617.	9.45E+09	666.5598	2398457.	0.00
14.2800	-5.66E-04	65919.	-11443.	7.51E-06	16054.	9.45E+09	775.6041	2794800.	0.00
14.4500	-5.36E-04	44178.	-9796.	1.94E-05	15564.	9.45E+09	838.9173	3191143.	0.00
14.6200	-4.87E-04	25921.	-8067.	2.70E-05	15152.	9.45E+09	856.4164	3587486.	0.00
14.7900	-4.26E-04	11223.	-6344.	3.10E-05	14820.	9.45E+09	832.4640	3983829.	0.00
14.9600	-3.61E-04	-11.514	-4705.	3.22E-05	14567.	9.45E+09	774.3051	4380171.	0.00
15.1300	-2.95E-04	-8024.	-3211.	3.13E-05	14748.	9.45E+09	690.6450	4776514.	0.00
15.3000	-2.33E-04	-13161.	-1904.	2.90E-05	14864.	9.45E+09	590.4354	5172857.	0.00
15.4700	-1.77E-04	-15839.	-810.625	2.59E-05	14924.	9.45E+09	481.9132	5569200.	0.00
15.6400	-1.27E-04	-16508.	60.2705	2.24E-05	14939.	9.45E+09	371.9059	5965543.	0.00
15.8100	-8.51E-05	-15627.	710.3217	1.89E-05	14920.	9.45E+09	265.3993	6361886.	0.00
15.9800	-4.99E-05	-13639.	1150.	1.58E-05	14875.	9.45E+09	165.3457	6758229.	0.00
16.1500	-2.07E-05	-10961.	1392.	1.31E-05	14814.	9.45E+09	72.6861	7154571.	0.00
16.3200	3.63E-06	-7978.	1453.	1.11E-05	14747.	9.45E+09	-13.445	7550914.	0.00
16.4900	2.45E-05	-5050.	1342.	9.67E-06	14681.	9.45E+09	-95.352	7947257.	0.00
16.6600	4.31E-05	-2518.	1065.	8.86E-06	14624.	9.45E+09	-176.261	8343600.	0.00
16.8300	6.06E-05	-718.557	620.2498	8.51E-06	14583.	9.45E+09	-259.654	8739943.	0.00
17.0000	7.78E-05	0.00	0.00	8.43E-06	14567.	9.45E+09	-348.434	4568143.	0.00

L2=14.9-4.7=10.2 ft

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.54200000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =      -2070213. inch-lbs
Maximum shear force              =         41060. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =              8
Number of zero deflection points =              2
```

Plastic Hinge LPile Run

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Displacement and Moment (Loading Type 4)

Displacement of pile head	=	0.542000 inches
Moment at pile head	=	-2001730.3 in-lbs
Axial load at pile head	=	376000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5420	-2001730.	40201.	-2.78E-04	59721.	8.99E+09	0.00	0.00	0.00
0.1700	0.5410	-1919334.	40181.	-7.22E-04	57862.	8.99E+09	-19.188	72.3587	0.00
0.3400	0.5391	-1836684.	40120.	-0.00114	55998.	9.26E+09	-40.531	153.3848	0.00
0.5100	0.5363	-1753892.	40014.	-0.00154	54130.	9.36E+09	-63.570	241.8056	0.00
0.6800	0.5328	-1671071.	39860.	-0.00191	52262.	9.42E+09	-87.771	336.0696	0.00
0.8500	0.5285	-1588338.	39655.	-0.00226	50396.	9.45E+09	-112.554	434.4351	0.00
1.0200	0.5236	-1505810.	39400.	-0.00259	48534.	9.45E+09	-137.519	535.8254	0.00
1.1900	0.5179	-1423605.	39094.	-0.00291	46680.	9.45E+09	-162.197	638.8415	0.00
1.3600	0.5117	-1341839.	38739.	-0.00321	44835.	9.45E+09	-186.544	743.7124	0.00
1.5300	0.5048	-1260628.	38334.	-0.00349	43003.	9.45E+09	-209.976	848.4787	0.00
1.7000	0.4974	-1180081.	37883.	-0.00375	41187.	9.45E+09	-231.986	951.3566	0.00
1.8700	0.4895	-1100305.	37389.	-0.00400	39387.	9.45E+09	-252.704	1053.	0.00
2.0400	0.4811	-1021398.	36852.	-0.00423	37607.	9.45E+09	-273.927	1161.	0.00
2.2100	0.4723	-943461.	36273.	-0.00444	35849.	9.45E+09	-293.349	1267.	0.00
2.3800	0.4630	-866589.	35657.	-0.00464	34115.	9.45E+09	-310.657	1369.	0.00
2.5500	0.4534	-790867.	35007.	-0.00482	32407.	9.45E+09	-326.777	1470.	0.00
2.7200	0.4434	-716374.	34325.	-0.00498	30727.	9.45E+09	-341.420	1571.	0.00
2.8900	0.4330	-643182.	33617.	-0.00512	29076.	9.45E+09	-353.578	1666.	0.00
3.0600	0.4225	-571356.	32886.	-0.00526	27455.	9.45E+09	-363.026	1753.	0.00
3.2300	0.4116	-500946.	32132.	-0.00537	25867.	9.45E+09	-375.793	1863.	0.00
3.4000	0.4005	-432017.	31355.	-0.00547	24312.	9.45E+09	-386.345	1968.	0.00
3.5700	0.3893	-364624.	30558.	-0.00556	22792.	9.45E+09	-394.391	2067.	0.00
3.7400	0.3779	-298811.	29745.	-0.00563	21307.	9.45E+09	-403.401	2178.	0.00
3.9100	0.3663	-234629.	28908.	-0.00569	19860.	9.45E+09	-416.262	2318.	0.00
4.0800	0.3547	-172139.	28048.	-0.00573	18450.	9.45E+09	-427.242	2458.	0.00
4.2500	0.3429	-111400.	27167.	-0.00576	17080.	9.45E+09	-436.166	2595.	0.00
4.4200	0.3311	-52456.	26271.	-0.00578	15750.	9.45E+09	-442.861	2728.	0.00
4.5900	0.3193	4652.	25363.	-0.00579	14672.	9.45E+09	-447.157	2857.	0.00
4.7600	0.3075	59899.	24449.	-0.00578	15918.	9.45E+09	-448.885	2978.	0.00
4.9300	0.2958	113269.	23532.	-0.00576	17122.	9.45E+09	-450.655	3108.	0.00
5.1000	0.2840	164744.	22599.	-0.00573	18283.	9.45E+09	-463.655	3330.	0.00
5.2700	0.2724	214262.	21641.	-0.00569	19400.	9.45E+09	-475.698	3563.	0.00

Lp1=4.6 ft

5.4400	0.2608	261765.	20659.	-0.00564	20472.	9.45E+09	-486.731	3807.	0.00
5.6100	0.2494	307199.	19656.	-0.00558	21497.	9.45E+09	-496.705	4063.	0.00
5.7800	0.2381	350515.	18634.	-0.00550	22474.	9.45E+09	-505.529	4332.	0.00
5.9500	0.2269	391669.	17595.	-0.00542	23402.	9.45E+09	-512.953	4611.	0.00
6.1200	0.2159	430623.	16542.	-0.00534	24281.	9.45E+09	-518.887	4902.	0.00
6.2900	0.2052	467347.	15474.	-0.00524	25109.	9.45E+09	-528.202	5252.	0.00
6.4600	0.1946	501796.	14388.	-0.00513	25886.	9.45E+09	-536.629	5626.	0.00
6.6300	0.1842	533928.	13286.	-0.00502	26611.	9.45E+09	-543.986	6024.	0.00
6.8000	0.1741	563707.	12170.	-0.00490	27283.	9.45E+09	-550.236	6448.	0.00
6.9700	0.1642	591104.	11042.	-0.00478	27901.	9.45E+09	-555.347	6899.	0.00
7.1400	0.1546	616091.	9905.	-0.00465	28464.	9.45E+09	-559.291	7381.	0.00
7.3100	0.1452	638649.	8762.	-0.00451	28973.	9.45E+09	-562.042	7895.	0.00
7.4800	0.1362	658762.	7613.	-0.00437	29427.	9.45E+09	-563.580	8443.	0.00
7.6500	0.1274	676421.	6463.	-0.00423	29825.	9.45E+09	-563.890	9030.	0.00
7.8200	0.1189	691621.	5314.	-0.00408	30168.	9.45E+09	-562.960	9658.	0.00
7.9900	0.1107	704364.	4168.	[illegible]	[illegible]	9.45E+09	-560.783	10331.	0.00
8.1600	0.1029	714656.	3027.	-0.00378	30688.	9.45E+09	-557.358	11052.	0.00
8.3300	0.09533	722510.	1895.	-0.00362	30865.	9.45E+09	-552.685	11828.	0.00
8.5000	0.08810	727945.	773.5731	-0.00347	30988.	9.45E+09	-546.773	12661.	0.00
8.6700	0.08119	730983.	-334.563	-0.00331	31056.	9.45E+09	-539.634	13560.	0.00
8.8400	0.07460	731655.	-1427.	-0.00315	31071.	9.45E+09	-531.285	14529.	0.00
9.0100	0.06833	729995.	-2501.	-0.00299	31034.	9.45E+09	-521.747	15577.	0.00
9.1800	0.06239	726042.	-3554.	-0.00284	30945.	9.45E+09	-511.047	16711.	0.00
9.3500	0.05676	719843.	-4585.	-0.00268	30805.	9.45E+09	-499.215	17942.	0.00
9.5200	0.05145	711446.	-5590.	-0.00252	30615.	9.45E+09	-486.287	19280.	0.00
9.6900	0.04646	700909.	-6544.	-0.00237	30378.	9.45E+09	-448.398	19689.	0.00
9.8600	0.04177	688389.	-7419.	-0.00222	30095.	9.45E+09	-410.250	20034.	0.00
10.0300	0.03739	674047.	-8219.	-0.00208	29772.	9.45E+09	-373.544	20379.	0.00
10.2000	0.03331	658040.	-8945.	-0.00193	29411.	9.45E+09	-338.371	20725.	0.00
10.3700	0.02951	640515.	-9601.	-0.00179	29015.	9.45E+09	-304.807	21070.	0.00
10.5400	0.02600	621616.	-10190.	-0.00166	28589.	9.45E+09	-272.920	21416.	0.00
10.7100	0.02276	601478.	-10716.	-0.00152	28135.	9.45E+09	-242.763	21761.	0.00
10.8800	0.01978	580230.	-11183.	-0.00140	27656.	9.45E+09	-214.381	22106.	0.00
11.0500	0.01706	557994.	-11593.	-0.00127	27154.	9.45E+09	-187.803	22452.	0.00
11.2200	0.01459	534884.	-11951.	-0.00115	26633.	9.45E+09	-163.051	22797.	0.00
11.3900	0.01235	511007.	-12260.	-0.00104	26094.	9.45E+09	-140.135	23143.	0.00
11.5600	0.01034	486462.	-12524.	-9.34E-04	25540.	9.45E+09	-119.052	23488.	0.00
11.7300	0.00854	461341.	-12747.	-8.32E-04	24974.	9.45E+09	-99.790	23833.	0.00
11.9000	0.00695	435728.	-12933.	-7.35E-04	24396.	9.45E+09	-82.329	24179.	0.00
12.0700	0.00554	409701.	-13085.	-6.44E-04	23809.	9.45E+09	-66.634	24524.	0.00
12.2400	0.00432	383328.	-13207.	-5.58E-04	23214.	9.45E+09	-52.663	24870.	0.00
12.4100	0.00327	356673.	-13302.	-4.78E-04	22613.	9.45E+09	-40.366	25215.	0.00
12.5800	0.00237	329791.	-13373.	-4.04E-04	22006.	9.45E+09	-29.680	25561.	0.00

Mmaxp2

12.7500	0.00162	302730.	-13424.	-3.36E-04	21396.	9.45E+09	-20.534	25906.	0.00
12.9200	9.99E-04	275534.	-13458.	-2.73E-04	20782.	9.45E+09	-12.851	26251.	0.00
13.0900	5.02E-04	248239.	-13478.	-2.17E-04	20167.	9.45E+09	-6.540	26597.	0.00
13.2600	1.14E-04	220875.	-13486.	-1.66E-04	19549.	9.45E+09	-1.504	26942.	0.00
13.4300	-1.77E-04	193469.	-13486.	-1.21E-04	18931.	9.45E+09	2.3612	27288.	0.00
13.6000	-3.82E-04	166041.	-13478.	-8.27E-05	18313.	9.45E+09	5.1705	27633.	0.00
13.7700	-5.14E-04	138606.	-13465.	-4.98E-05	17694.	9.45E+09	7.0464	27978.	0.00
13.9400	-5.85E-04	111178.	-13450.	-2.28E-05	17075.	9.45E+09	8.1193	28324.	0.00
14.1100	-6.07E-04	83765.	-12714.	-1.76E-06	16457.	9.45E+09	713.4583	2398457.	0.00
14.2800	-5.92E-04	59308.	-11159.	1.37E-05	15905.	9.45E+09	811.0092	2794800.	0.00
14.4500	-5.51E-04	38215.	-9453.	2.42E-05	15429.	9.45E+09	861.9261	3191143.	0.00
14.6200	-4.93E-04	20704.	-7689.	3.06E-05	15034.	9.45E+09	867.3208	3587486.	0.00
14.7900	-4.26E-04	6798.	-5955.	3.35E-05	14720.	9.45E+09	832.4451	3983829.	0.00
14.9600	-3.56E-04	-3644.	-4325.	3.39E-05	14649.	9.45E+09	765.1347	4380171.	0.00
15.1300	-2.88E-04	-10902.	-2857.	3.23E-05	14813.	9.45E+09	674.4135	4776514.	0.00
15.3000	-2.25E-04	-15351.	-1589.	2.95E-05	14913.	9.45E+09	569.3229	5172857.	0.00
15.4700	-1.68E-04	-17428.	-540.663	2.59E-05	14960.	9.45E+09	458.0115	5569200.	0.00
15.6400	-1.19E-04	-17597.	280.5465	2.22E-05	14964.	9.45E+09	347.0957	5965543.	0.00
15.8100	-7.74E-05	-16318.	880.6910	1.85E-05	14935.	9.45E+09	241.2812	6361886.	0.00
15.9800	-4.32E-05	-14032.	1273.	1.52E-05	14884.	9.45E+09	143.2191	6758229.	0.00
16.1500	-1.53E-05	-11148.	1474.	1.25E-05	14819.	9.45E+09	53.5675	7154571.	0.00
16.3200	7.77E-06	-8039.	1499.	1.04E-05	14748.	9.45E+09	-28.774	7550914.	0.00
16.4900	2.73E-05	-5048.	1361.	9.02E-06	14681.	9.45E+09	-106.277	7947257.	0.00
16.6600	4.46E-05	-2499.	1067.	8.20E-06	14623.	9.45E+09	-182.266	8343600.	0.00
16.8300	6.07E-05	-708.028	615.4578	7.86E-06	14583.	9.45E+09	-260.255	8739943.	0.00
17.0000	7.66E-05	0.00	0.00	7.78E-06	14567.	9.45E+09	-343.135	4568143.	0.00

Lp1=14.9-4.6=10.3 ft

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection              =     0.54200000 inches
Computed slope at pile head       =     -0.0002776 radians
Maximum bending moment            =      -2001730. inch-lbs
Maximum shear force               =         40201. lbs
Depth of maximum bending moment   =       0.000000 feet below pile head
Depth of maximum shear force      =       0.000000 feet below pile head
Number of iterations              =              8
Number of zero deflection points  =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.5420	S, rad	0.00	376000.	0.5420	0.00	41060.	-2070213.
2	y, in	0.5420	M, in-lb	-2001730.	376000.	0.5420	-2.78E-04	40201.	-2001730.

Maximum pile-head deflection = 0.5420000000 inches
Maximum pile-head rotation = -0.0002775739 radians = -0.015904 deg.

Summary of Warning Messages

The following warning was reported 162 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.