GEOTECHNICAL DESIGN REPORT

WAGNER BRIDGE NO. 2 (#2905)

WALDOBORO, MAINE

State Route 32 over Hoch Brook
MaineDOT WIN 18230.00

FOR

Fuss & O'Neill, Inc.

Manchester, New Hampshire

BY
NOBIS GROUP®

(800) 394-4182

www.nobis-group.com

Nobis Project No. 94140.00

AUGUST 29, 2019

nobis

August 29, 2019

Jaime French, P.E.
Project Manager
Fuss & O'Neill, Inc.
540 North Commercial Street
Manchester, New Hampshire 03101
JFrench@fando.com

Re: Geotechnical Design Report
Wagner Bridge No. 2
Route 32 over Hoch Brook
Waldoboro, Maine
WIN 18230.00

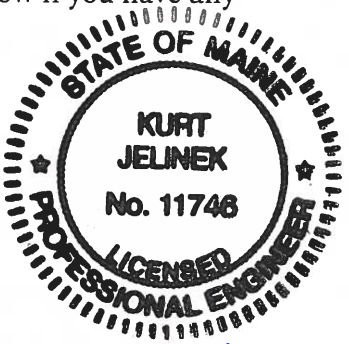
Dear Ms. French,

We are pleased to provide this Geotechnical Design Report to Fuss & O'Neill for the Wagner Bridge No. 2 which carries Route 32 over Hoch Brook in Waldoboro, Maine. This report has been prepared on behalf of, and for the exclusive use of Fuss & O'Neill for the stated purposes and location identified in our proposal and/or report. This report has been completed in accordance with our proposal dated June 20, 2017, and our proposal addendum dated June 4, 2019.

It has been a pleasure serving Fuss & O'Neill on this project. Please let us know if you have any questions regarding this report.

Very truly yours,

Nobis Group



8/29/2019

Kamil Kocia
Staff Engineer

Kurt Jelinek, P.E.
Director, Transportation

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1.0 INTRODUCTION

This geotechnical design report presents Nobis Group's (Nobis) recommendations for the MaineDOT Wagner Bridge No. 2 located in Waldoboro, Maine. This report is subject to the limitations contained in **Appendix A**. Nobis performed geotechnical services in accordance with the subconsultant agreement dated October 19, 2017 including our proposal dated June 20, 2017, and the master service task authorization dated June 24, 2019 including our proposal addendum No. 1 dated June 4, 2019. Elevations referenced in this report are relative to the North American Vertical Datum of 1988 (NAVD 88).

2.0 PROJECT AND SITE DESCRIPTION

Nobis understands that MaineDOT intends to replace the bridge carrying State Route 32 over Hoch Brook in Waldoboro, Maine (the Site). A Site Locus Plan is included as **Figure 1**. The new structure will consist of a precast concrete full-box culvert (i.e. 4-sided) with a span/hydraulic opening of 14 feet and a rise of 10.5 feet. Two (2) to four (4) feet of Special Fill will be placed inside the proposed culvert to create a natural streambed. We understand that the proposed culvert will have a new alignment having a skew of 23 degrees, and the bottom of the proposed culvert will be approximately at elevation (El.) 59.5 which is near the top of the encountered glaciomarine deposits.

The existing full box cast-in-place culvert type bridge was constructed approximately in 1929 and has a total curb-to-curb roadway width of approximately 22 feet with no sidewalks. The current hydraulic opening is approximately 14 feet wide with a rise of 6.5 to 7.5 feet. The existing foundations consist of concrete abutments supported by a spread footing which is supported by a wooden log raft platform.

Photo 1: Wagner Bridge No. 2 – Waldoboro, Maine

The top of the roadway at the existing bridge approach descends in elevation towards the bridge deck which is at approximately El. 72.5, whereas the bed of the brook is at approximately El. 63.5 to 64.5. Refer to **Figure 2** for the approximate location of existing and proposed site features.

We understand that the roadway profile will be raised by up to two (2) feet and will be widened by up to 10 feet toward the west. This raise-in-grade and widening will require up to approximately five (5) feet of fill being placed along the proposed west approach embankment slopes.

Preliminary analyses indicated that the bearing resistance is approximately 1.2 ksf and anticipated settlement is approximately 5 inches if the proposed culvert would be placed on top of the glaciomarine deposits. Refer to **Appendix F.1** for these preliminary analyses. Because the glaciomarine deposits are an unsuitable foundation material, we understand that the proposed culvert will be supported on approximately 5 to 9 feet of Compacted Granular Borrow.

3.0 SUBSURFACE EXPLORATIONS

To collect subsurface information and assess generalized subsurface conditions at the site, Nobis coordinated two rounds of subsurface explorations consisting of a total of six (6) test borings in support of the culvert and roadway design as well as two (2) streambed soil samples in support of the bridge scour analyses performed by others. Nobis performed two (2) test borings referred to as BB-WHB-101 and BB-WHB-102 in support of preparing the Design Basis Memorandum in 2017. Nobis visited the site on October 31, 2017 to pre-mark the boring locations using taped measurements from prominent site features and to collected two (2) streambed soil samples referred to as SS-1 and SS-2. Streambed soil samples were collected using hand tools approximately 0.5 to 2 feet below grades. Sample SS-1 was collected from the southern bank and sample SS-2 was collected from the approximate center of Hoch Brook.

In support of preparing this Geotechnical Design Report, Nobis performed an additional four (4) test borings referred to as BB-WHB-103 through BB-WHB-105 and BB-WHB-107. These additional test borings were performed to determine the extent of the glaciomarine deposits at the proposed culvert as well as at the southern approach embankment. These borings were field-located at the site by Nobis personnel on July 5, 2019. Refer to the attached **Figure 2** for the approximate locations of the subsurface explorations, and a plan view of the site.

New England Boring Contractors (NEBC), of Hermon, Maine drilled both rounds of test borings between December 5th and 6th, 2017, and July 22 through July 24, 2019. Borings BB-WHB-101, BB-WHB-102, BB-WHB-103, and BB-WHB-107 were performed approximately 5 feet behind the existing bridge abutments and test boring BB-WHB-104 was performed through the existing bridge deck and culvert. Boring BB-WHB-105 was performed approximately 40 feet south of the existing bridge. The borings were advanced using drive and wash drilling methods with an automatic hammer and were observed and logged by Nobis personnel. For the NEBC automatic hammer energy transfer ratio calibration reports, refer to **Appendix B**.
Borings BB-WHB-101 and BB-WHB-102 were advanced to approximately 34.7 feet below ground surface (bgs) and 27.7 feet bgs, respectively. Approximately 5 feet of NQ2-size bedrock cores were collected from both borings. Borings BB-WHB-103, BB-WHB-104, BB-WHB-105, and BB-WHB-107 were advanced to approximately 27.5 feet, 22 feet, 23.1 feet and 23.1 feet bgs, respectively. Boring BB-WHB-106 was planned as an optional boring to be performed through the existing bridge deck and culvert, but was not performed due to time constraints.

Boring logs are included in **Appendix C**, and Photo Logs of the Rock Core samples are included as **Appendix D**.

4.0 LABORATORY TESTING

Soil and bedrock samples obtained from the subsurface exploration program were selected by Nobis and submitted to GeoTesting Express of Acton, Massachusetts for laboratory testing. Laboratory tests performed include the following:

- Two (2) particle size analyses – sieve only (in accordance with ASTM D422);
- Seven (7) particle size analyses – sieve and hydrometer (in accordance with ASTM D422);
- Four (4) moisture content tests (ASTM D2216);
- Four (4) Atterberg limit tests (ASTM D4318);
- One (1) unconfined compressive strength rock test (ASTM D7012); and

- One (1) incremental consolidation test (ASTM D2435).

The laboratory test results are provided in **Appendix E**.

Streambed Soil Sample Testing

Based on the particle size analysis performed on a soil sample obtained by Nobis, streambed soils consist of gray, fine to coarse sand with high variance in fine to coarse gravel and silt content, with trace amounts of clay. Based on laboratory testing, the D_{50} of the streambed samples was approximately 0.65 millimeters.

5.0 SUBSURFACE CONDITIONS

Existing Information

Based on a review of surficial geologic maps, the surficial geologic conditions at the site likely consist of stream alluvium or wetland deposits overlying glaciomarine deposits. A site-focused 2014 USGS surficial geologic map entitled "Surficial Geology of the Jefferson Quadrangle, Maine" (Thompson, Johnston, Tucker, Marvinney, Tucker, and Halsted) along with the corresponding description of geologic units are provided on **Figure 3**.

Per a 2008 USGS bedrock geologic map entitled "Bedrock Geology of the Jefferson Quadrangle, Maine" (Berry IV and Osberg), bedrock at the site is that of the Waldoboro Pluton (Granite), which consists of "…white to light gray, medium grained biotite-muscovite granite. Massive to weakly foliated…" and Bucksport Formation, which consists of "…gray-weathering to dull brown-weathering, thin-bedded to medium-bedded, fine-grained to medium-grained granofels…" For a site-focused plan view of the bedrock geologic map, including a more detailed description of the bedrock at the site, please refer to **Figure 4**.

Subsurface Conditions Encountered

The generalized stratigraphy encountered in the borings consisted of asphalt pavement overlying granular fill, wetland deposits, glaciomarine deposits, glacial till, and bedrock. Boring BB-WHB-102 did not encounter the glaciomarine stratum underlying the wetland deposits. Generalized descriptions of the subsurface conditions encountered in the borings are discussed below, in order of increasing depth. Additional details are included on the boring logs included in **Appendix C** and shown on the Subsurface Profile, **Figure 5**.

Asphalt Pavement: Approximately eleven (11) to twelve (12) inches of roadway Hot Mix Asphalt (HMA) pavement was encountered in the borings.
Fill: The fill consisted of dry, brown to grey, very loose to dense, fine to coarse sand, with trace to some fine to coarse gravel, and trace to little silt, occasionally including asphalt and brick particles and fragments. The bottom of fill was encountered at approximately 4 to 9 feet below roadway grades. SPT-N values generally ranged from 3 to 48 blows per foot (bpf).

Wetland Deposits: The wetland deposits generally consisted of orangish-brown to grey, moist to wet, very soft to stiff clayey silt with varying amounts of sand and trace amounts of gravel. Based on the borings, the bottom of the alluvium deposits was encountered approximately 9.5 to 16 feet below roadway grades. SPT-N values generally ranged from 2 to 13 bpf.

Glaciomarine Deposits: A layer of grey to olive, wet, very soft to stiff, silt & clay/silty clay was encountered below the wetland deposits. Trace amounts of fine sand were present and the SPT-N value for the strata was 0 to 9 bpf, due to weight of hammer (WOH) to weight of rods (WOR). SPT-N values observed were generally higher at the top portion of the strata (similar to a stiff crust) with lower SPT-N values with depth. The layer is approximately 7.4 to 12.5 feet in thickness and may vary in thickness throughout the site. Numerous field vane shear tests were performed throughout the glaciomarine strata, with values of approximately 12.5 to greater than 50 foot-pounds in shear strength.

Photo 2: Split-Spoon Sample S-6 from BB-WHB-101 containing Glaciomarine Deposits.

Glacial Till w/ Inferred Cobbles / Boulders: The glacial till encountered generally consisted of medium dense to very dense, silt and/little fine to coarse sand, with varying amounts of gravel and trace amounts of clay. SPT-N values generally ranged from 13 to 80 bpf to refusal. A 4.2 feet thick layer of inferred cobbles/boulders was encountered in test boring BB-WHB-102 due to heavy grinding and resistance from the roller cone and driving of casing.

Bedrock: Bedrock was encountered at approximately 29.7 feet (corresponding to El. 42.8) and 22.7 feet (El. 49.8) bgs in test borings BB-WHB-101 and BB-WHB-102, respectively. Core samples generally consisted of light grey to tan, fresh to moderately weathered, fine to coarse grained granite/mica/gneiss (possible Bucksport Formation), with very close to close joints. Rock quality designations (RQDs) varied between 75% (fair quality) and 77% (good). Based on laboratory testing, the uniaxial peak compressive strength of the intact bedrock cores is approximately 7,133 pounds per square inch (psi).

Groundwater: Groundwater measurements were obtained within cased borehole conditions after at least ten (10) minutes of stabilization. Measurements varied between approximately 6.3 and 9.8 feet bgs, or El. 66.2 and El. 62.7, respectively. Note that water was introduced to the boreholes during the test boring rotary wash process, and that fluctuations in the observed groundwater levels will occur due to variations in precipitation, brook water level, temperature, and other factors different from those existing at the time the measurements were made.

6.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

In our Design Basis Memorandum dated January 26, 2018, several foundation alternatives were discussed including ground improvement with rammed aggregate piers or stones, over-excavate and replacement with compacted fill, and driven piles. We understand that MaineDOT and/or Fuss & O'Neill choose the over-excavation and replacement as the preferred option for this project. The following sections present our geotechnical engineering recommendations for the proposed over-excavation and replacement option for the proposed culvert as well our assessment regarding anticipated settlements due to placing additional fill over the compressible glaciomarine deposits at the approach embankment. References to AASHTO refer to the AASHTO LRFD Bridge Design Specifications, 8th Edition, September 2017 unless otherwise noted.

6.1 Over-Excavation and Replacement for Proposed Culvert

Based on the Typical Bridge Section received from Fuss & O'Neill on May 1, 2019, we understand that the bottom of the proposed culvert will be at approximately El. 59 to El. 59.5. Based on the performed borings we anticipate that the bottom of the proposed culvert is near the top of the encountered glaciomarine deposits, and the bottom of the glaciomarine deposits are approximately at El. 50.1 to 54.3. To improve the bearing resistance and reduce the settlements, we recommend that the glaciomarine deposits be over-excavated down to the top of glacial till, including the zone of influence. Thereafter, the excavated area should be dewatered and backfilled with compacted Granular Borrow up to the bottom of the proposed culvert. Backfill against the proposed culvert up to the bottom of the roadway section should also consist of compacted Granular Borrow. Refer to the Subgrade Preparation Procedures for additional information regarding the extent of the compacted Granular Borrow.

Bearing Resistance and Settlement

Nobis evaluated the bearing resistance for the proposed precast full-box concrete culvert based on the assumption that the proposed bottom of the culvert is at El. 59.5 feet and that the glaciomarine deposits has been replaced with compacted Gravel Borrow. Based on our analysis we estimate that the bearing resistance, $q_{R,}$ is 17.6 ksf. Settlements of approximately 1 inch are anticipated for an applied vertical stress of 4.6 ksf and approximately 2 inches for an applied vertical stress of 9.2 ksf. Actual anticipated settlements can be estimated by interpolating between the actual applied vertical stress. Our bearing resistance and settlement calculations are included in **Appendix F.1**.

Frost Depth

Based on Figure 5-1 of the MaineDOT Bridge Design Guide), the town of Waldoboro has a design freezing index of 1,330. Additionally, the top 10 feet of soil below existing grades consists of both coarse and fine deposits (i.e. sand and gravel fill or wetland deposits). We assumed the moisture content of the soil within the top 10 feet below grades is approximately 20 percent. Based on a design freezing index of 1,330, and deposits with a moisture content of 20 percent, we recommend a design frost penetration depth of 5.3 feet.

6.2 Lateral Earth Pressures

We recommend that the proposed culvert be designed for lateral earth pressures using backfill material properties for Soil Type 4 (MaineDOT Bridge Design Guide Section 3.6.1). We recommend that the culvert be designed based on the following soil parameters:

At-rest earth pressure coefficient, $k_a = 0.47$
Sliding resistance factor for precast culvert, $\varphi_t = 0.9$ (AASHTO Table 10.5.5.2.2-1)
Friction angle, $\phi = 32$ deg. for retained soil
Soil density, $\gamma = 125$ pcf for retained soil

The at-rest earth pressure coefficient is based on a vertical back-face for the culvert and level backfill behind the culvert. The at-rest earth pressure calculation is included in **Appendix F.2**.

In addition, a live load surcharge should be applied to account for vehicular traffic (AASHTO Article 3.11.6.4). The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil in accordance with MaineDOT Bridge Design Guide Table 3-4.

A sliding coefficient of friction (C * tan ϕ_f) of 0.5 is recommended for the culvert, where a value of C = 0.8 is used for precast concrete (AASHTO Article 10.6.3.4-2).

6.3 Approach Embankments

Embankment Settlement

Nobis used the Settle 3D 4.0 software by RocScience to estimate the settlement due to the roadway raise-in-grade and widening. A model was created focusing on the critical section at STA 15+00. The subsurface information was based on the soil conditions encountered in boring BB-WHB-105. The wetland deposits were modeled as a Lean Clayey Silt with an over-consolidation ratio (OCR) of 1.0, and the glaciomarine deposits were modeled as silt and clay with an OCR of approximately 1.8. This OCR was based on our effective stress calculation as well as the maximum past pressure estimate determined from laboratory consolidation tests performed on a undisturbed soil sample from boring BB-WHB-103. Our model estimates that the south approach embankment will result in approximately 0.7 inches of settlements of the roadway grade and up to approximately 4 inches of settlements at the approach embankment slopes within 30 days of additional fill placement. Approximately an additional 3.3 inches of settlement could occur within 50 years after the construction. The model and settlement graphs along the southern approach embankment are shown in **Appendix F.1**.

Global Slope Stability

The 2D limit equilibrium software Slide 8.0 by RocScience, Inc. was used to evaluate the global slope stability under static conditions to determine the suitability of the proposed approach embankments. The proposed embankment model includes the proposed raise-in-grades and roadway widening at STA 15+00. A surcharge load of 250 pounds per square foot (psf) was assumed along the roadway surface. The required resistance factor against global stability according to AASHTO Section 11.6.2.3 is 0.75 for the proposed approach embankment, which corresponds to a factor of safety of approximately 1.3, due to the embankment not supporting a structural element.

Based on our analysis, we estimate that the factor of safety against global slope stability failure for the proposed southern approach embankment is 1.3. As long as STA 15+00 is the most critical section, a global slope stability of 1.3 or greater is expected for the northern approach embankment. The global stability analysis is included in **Appendix F.2**.

6.4 Seismic Design Considerations

Based on the SPT-N values and using Method B (AASHTO Table C3.10.3.1-1), the SPT blow count is approximately 5 to 50 in the area of the culvert, corresponding to a Site Class "E".

The seismic parameters developed for the proposed bridge are provided below per the AASHTO 8th Edition:

Mapped Ground and Spectral Response Coefficients (USGS Seismic Design Maps):

- Horizontal Peak Ground Acceleration (PGA): 0.066
- Horizontal Response Spectral Acceleration, 0.2 Sec (S_S): 0.142
- Horizontal Response Spectral Acceleration, 1.0 Sec (S_1): 0.042

Site Class: E (AASHTO Table 3.10.1-1):

- Site Factors for Site Class "E" (AASHTO Tables 3.10.3.2-1, -2, and -3): Zero-Period (F_{pga}) = 2.5, Short-Period, 0.2 Sec (F_a) = 2.5, and Long Period, 1.0 Sec (F_v) = 3.5.

- Design Spectral Response Parameters for Site Class "E":
  A_S = 0.165, S_{DS} = 0.355, S_{D1} = 0.148.

Per AASHTO Article 3.10.6 the site is assigned Seismic Zone 1 based on a calculated S_{D1} of 0.117. Seismic design parameters are included in **Appendix F.3**.

6.5 Construction Considerations

Subgrade Preparation Procedures

We recommend the following subgrade preparation procedures for the proposed bridge replacement:

- All wetland and glaciomarine deposits should be removed below the proposed culvert.

- Placement and compaction of the Granular Borrow below the proposed culvert should be completed in the dry.

- Granular Borrow should be placed below the proposed culvert footing including the zone of influence which is defined as that area within a line projecting outward and downward from the outside edges of the culvert footings at a one horizontal to one vertical (1H:1V) slope.

  Alternatively, if the Contractor elects to drive sheet piles around the excavation and plans to leave at least the portion of the sheet piles below the bottom of the proposed culvert permanently in-place, then the compacted Gravel Borrow below the proposed culvert needs only be placed within the sheet pile wall. For this case we recommend that the sheet piles be driven at least 1.5 feet directly behind the edge of the bottom of culvert footing.

- Granular Borrow should be placed in maximum 12-inch thick loose lifts and compacted to at least 95 percent of its maximum dry density as determined by ASTM D-1557, Method C (Modified Proctor).

Re-Use of On-site Soil

Based on soils encountered in test borings, the existing fill material generally consisted of sand and gravel with varying amounts of fines (silt and/or clay). Materials with fines up to 20% can be difficult to reuse if wet. We recommend those materials be reused in landscape areas or be disposed of offsite.

Construction Dewatering and Temporary Excavation Support

Groundwater was encountered above the bottom of the proposed culvert. Temporary excavation dewatering should be performed so that the work conducted is completed in the dry. The Contractor will be required to manage groundwater, control the Hoch Brook water during excavation, as well as to control surface water from entering excavations to provide a stable subgrade during over-excavate and replacement with compacted Granular Borrow as well as for installing the culvert.

Based on the nature of the existing soils near the bottom of culvert elevation, we anticipate that several wells/sumps could be required to manage large quantities of groundwater. An alternative option is to use sheet-pile walls to restrict water flow during the construction phase, however removing the sheet-pile wall may impact existing soils and stability of the proposed culvert. The Contractor should be responsible for selecting the dewatering methods based on his proposed methods and equipment used for excavation and excavation support. The method of dewatering will depend on time of year that the work is performed, size of the open excavation, and the length of time the excavation is left open. Dewatering efforts must satisfy requirements of local, state, and federal environmental and conservation authorities.

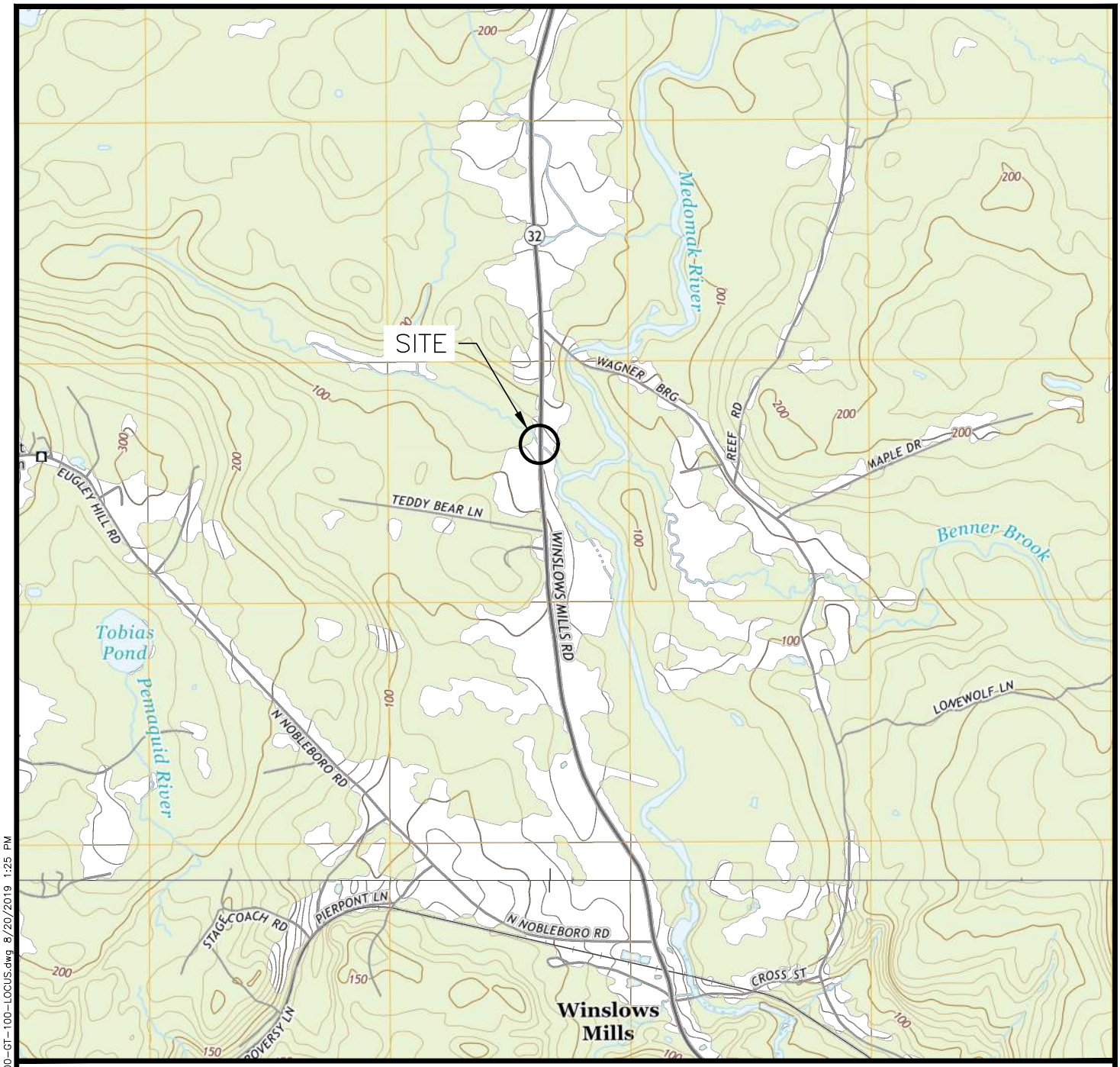
Temporary earth support and dewatering systems should be selected by the Contractor and designed by a Professional Engineer registered in the State of Maine and retained by the Contractor. The earth support and dewatering designs are integral with one another and should be submitted as a single submittal for review by MaineDOT.

Where excavation sides are cut back and sloped, they should be in accordance with Occupational Safety and Health Administration (OSHA) Construction Industry Standards. Excavation geometry should conform to OSHA excavation regulations contained in 29 CFR Part 1926, latest edition. In general, temporary soil slopes of 1.5H:1V (Soil Profile Type C), or flatter, appear appropriate but should be confirmed during construction based on conditions at the time of excavation.

Removal of Existing Foundations

The existing bridge including the wooden log raft platform should be completely removed prior to placing the compacted Gravel Borrow below the proposed culvert.

FIGURES



NORTH

2014 USGS TOPOGRAPHIC MAP

WALDOBORO WEST AND JEFFERSON QUADRANGLES
WALDOBORO, MAINE
CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

APPROXIMATE SCALE
1 INCH = 2,000 FEET

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QUADRANGLE LOCATION

FIGURE 1

SITE LOCUS PLAN
WAGNER NO. 2 BRIDGE
ROUTE 32 OVER HOCH BROOK
WALDOBORO, MAINE

PROJECT NO. 94140.00

DATE: AUGUST 2019

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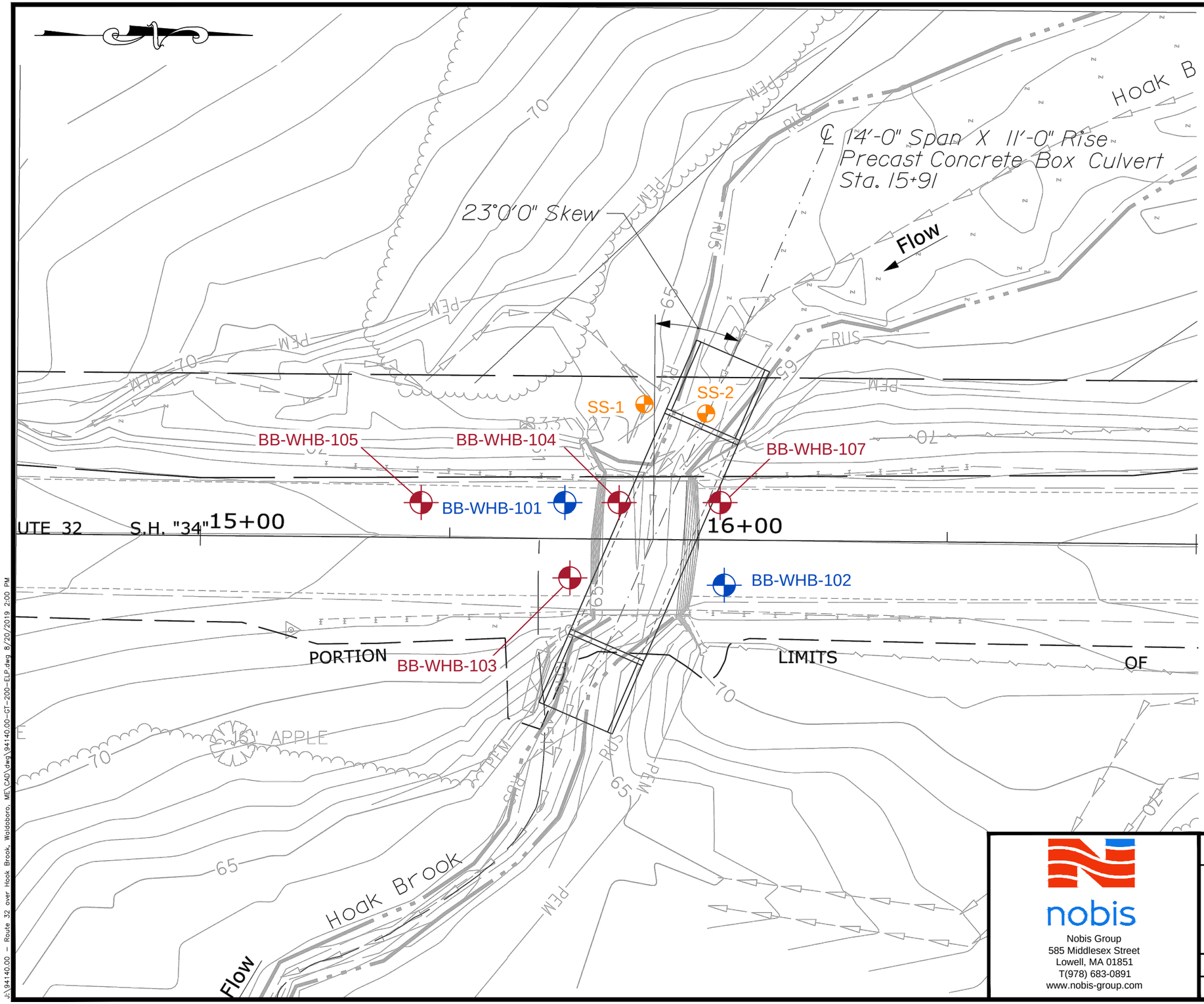

NOTES:

1. THE BASE PLAN WAS DEVELOPED FROM .DGN FILES PROVIDED BY FUSS & O'NEILL ON OCTOBER 23, 2017 AND AUGUST 15, 2019.
2. SOIL BORINGS WERE DRILLED BY NEW ENGLAND BORING CONTRACTORS OF HERMON, MAINE, AND OBSERVED BY NOBIS BETWEEN DECEMBER 5 AND 6, 2017, IN ADDITION TO JUNE 22, 2019 THROUGH JUNE 24, 2019.
3. LOCATIONS AND SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
4. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
5. REFER TO FIGURE 5 FOR SUBSURFACE PROFILE.

LEGEND

BB-WHB-101	BORING LOCATION OBSERVED BY NOBIS (2017)
BB-WHB-103	BORING LOCATION OBSERVED BY NOBIS (2019)
SS-1	SEDIMENT SAMPLE LOCATION OBTAINED BY NOBIS (2017)

0 20' 40'

Scale of Feet

WIN NO. 18230.00

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FIGURE 2

BORING LOCATION PLAN
WAGNER NO. 2 BRIDGE
ROUTE 32 OVER HOCH BROOK
WALDOBORO, MAINE

DRAWN BY:	KAK	CHECKED BY:	KJ
PROJECT NO.	94140.00	DATE:	AUGUST 2019

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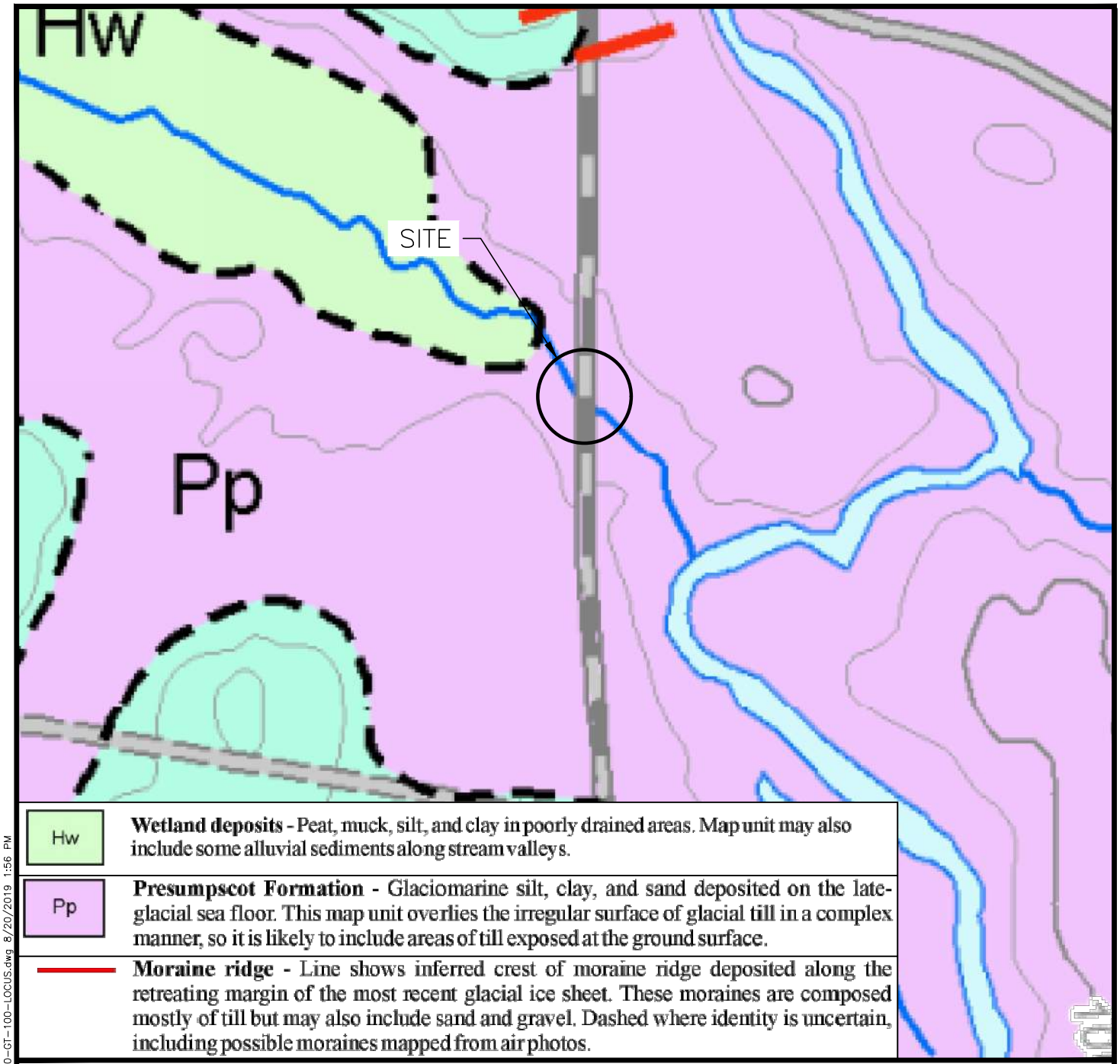

Hw	**Wetland deposits** - Peat, muck, silt, and clay in poorly drained areas. Map unit may also include some alluvial sediments along stream valleys.
Pp	**Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor. This map unit overlies the irregular surface of glacial till in a complex manner, so it is likely to include areas of till exposed at the ground surface.
———	**Moraine ridge** - Line shows inferred crest of moraine ridge deposited along the retreating margin of the most recent glacial ice sheet. These moraines are composed mostly of till but may also include sand and gravel. Dashed where identity is uncertain, including possible moraines mapped from air photos.

2014 USGS SURFICIAL GEOLOGIC MAP

NORTH

"SURFICIAL GEOLOGY OF THE JEFFERSON QUADRANGLE, MAINE"
(THOMPSON, JOHNSTON, TUCKER, MARVINNEY, TUCKER, AND HALSTED)
NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)
CONTOUR INTERVAL 10 FEET
ORIGINAL SCALE 1:24,000

APPROXIMATE SCALE
1 INCH = 1,000 FEET

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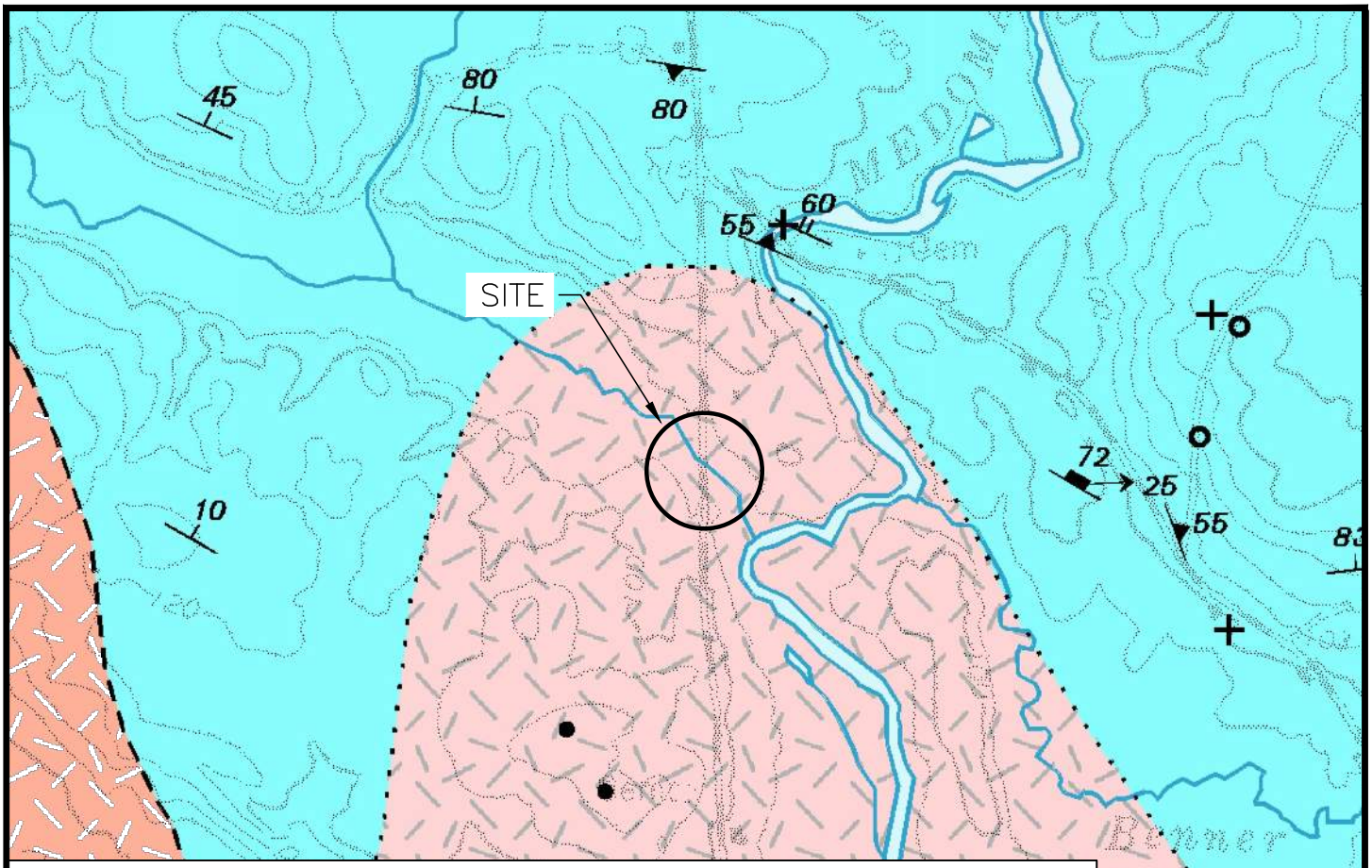
QUADRANGLE LOCATION

FIGURE 3

SURFICIAL GEOLOGY MAP
WAGNER NO. 2 BRIDGE
ROUTE 32 OVER HOCH BROOK
WALDOBORO, MAINE

PROJECT NO. 94140.00

DATE: AUGUST 2019



Dwg	**Granite.** White to light gray, medium-grained biotite-muscovite granite. Massive to weakly foliated. A high precision U-Pb zircon age of 368 ± 2 Ma was obtained for this granite from the Waldoboro West quadrangle (Tucker and others, 2001).
SOb	**Bucksport Formation.** Gray-weathering to dull brown-weathering, thin-bedded to medium-bedded, fine-grained to medium-grained granofels. Natural outcrops exhibit a flaggy or slabby break along the layering. Includes light gray to medium gray to purplish-gray quartz-feldspar-biotite granofels, and light green to medium greenish-gray quartz-plagioclase-diopside ± biotite ± actinolite ± garnet calc-silicate granofels. While calc-silicate rock is commonly present in subordinate amounts, its percentage in outcrop ranges from 0 to 100. The compositional layering is interpreted as bedding in many places, as indicated by symbols on the map. In other places, especially where cross-cutting calc-silicate veins are present, it is not certain whether the compositional layering represents bedding or a metamorphic layering. Where the gray granofels locally has higher biotite concentrations and rarely also muscovite, the rock has a schistose texture. Finer-grained varieties dominated by quartz and feldspar are massive and hard to break, like quartzite.

2008 BEDROCK GEOLOGIC MAP

"BEDROCK GEOLOGY OF THE JEFFERSON QUADRANGLE, MAINE"
(BERRY IV AND OSBERG)
CONTOUR INTERVAL 20 FEET
ORIGINAL SCALE 1:24,000

NORTH

APPROXIMATE SCALE
1 INCH = 1,000 FEET

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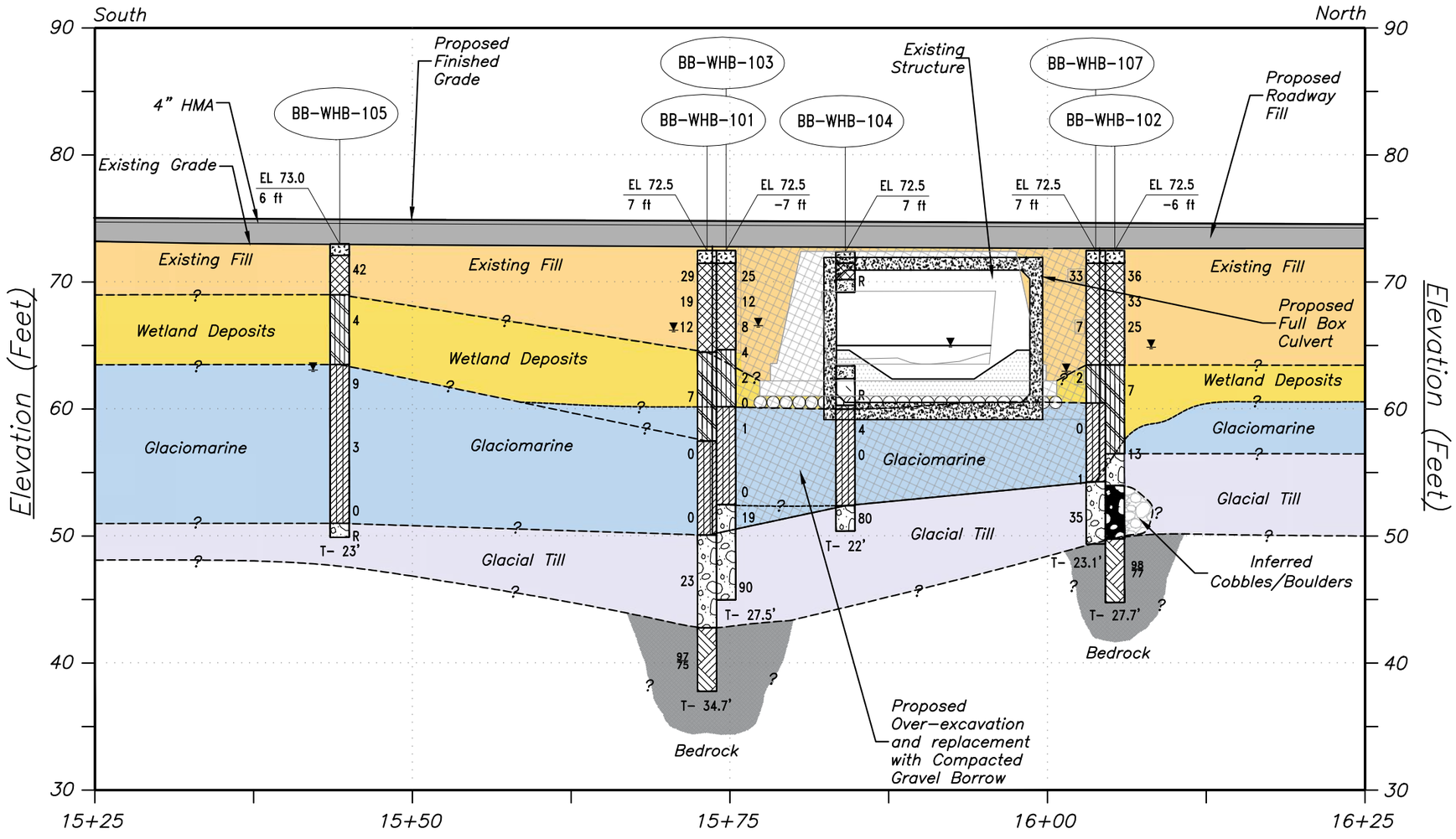
QUADRANGLE LOCATION

FIGURE 4

BEDROCK GEOLOGY MAP
WAGNER NO. 2 BRIDGE
ROUTE 32 OVER HOCH BROOK
WALDOBORO, MAINE

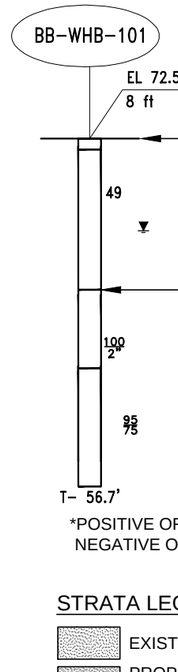
PROJECT NO. 94140.00 | DATE: AUGUST 2019



Subsurface Profile

Station along Centerline of Proposed Bridge #2905 (feet)

EXPLORATION LEGEND



*POSITIVE OFFSETS ARE IN THE WEST DIRECTION.
NEGATIVE OFFSETS ARE IN THE EAST DIRECTION.

STRATA LEGEND

- EXISTING FILL
- PROPOSED ROADWAY FILL
- COMPACTED GRAVEL BORROW
- CONCRETE
- WETLAND DEPOSIT
- GLACIOMARINE
- GLACIAL TILL
- INFERRED COBBLES / BOULDERS
- CORED BEDROCK

HORIZONTAL SCALE IN FEET
0 10' 20'
0 10' 20'
VERTICAL SCALE IN FEET

NOTES:

1. THIS SUBSURFACE PROFILE WAS DEVELOPED USING gINT LOGS PROFESSIONAL FROM BORING LOG INFORMATION OBTAINED AT THE SITE FROM DECEMBER, 2017 AND JULY, 2019.
2. LINES REPRESENTING LIMITS OF STRATA ARE INTERPOLATED FROM SUBSURFACE EXPLORATION LOGS. THE SUBSURFACE EXPLORATIONS ARE WIDELY SPACED AND ARE BASED ON LIMITED SUBSURFACE INFORMATION COLLECTED DURING DRILLING. OTHER INTERPRETATIONS ARE POSSIBLE AND ACTUAL CONDITIONS MAY VARY FROM THOSE PRESENTED.
3. TOP OF BEDROCK SHOULD BE CONSIDERED APPROXIMATE AND CAN VARY SIGNIFICANTLY OVER SHORT DISTANCES.
4. WATER LEVELS PRESENTED WERE COLLECTED DURING DRILLING AND MAY NOT REPRESENT STABILIZED GROUNDWATER CONDITIONS. GROUNDWATER LEVELS WILL FLUCTUATE WITH SEASON, PRECIPITATION, AND NEARBY ACTIVITIES.
5. EXISTING AND PROPOSED SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
6. SOIL BORINGS WERE DRILLED BY NEW ENGLAND BORING CONTRACTORS OF HERMON, MAINE, AND OBSERVED BY NOBIS IN DECEMBER, 2017 AND JULY, 2019.
7. SUBSURFACE PROFILE SHOWS APPROXIMATE LOCATION FOR FULL BOX CULVERT DESIGN AT BOTTOM OF FOOTING ELEVATION OF 59.17 FT.
8. ELEVATIONS ARE PROVIDED IN FEET, AND ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
9. REFER TO FIGURE 2 FOR SUBSURFACE EXPLORATION LOCATIONS AND A PLAN VIEW OF THE SITE.

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FIGURE 5

SUBSURFACE PROFILE
WAGNER NO. 2 BRIDGE
ROUTE 32 OVER HOCH BROOK
WALDOBORO, MAINE

DRAWN BY:	KAK	CHECKED BY:	KJ
PROJECT NO.	94140.00	DATE:	AUGUST 2019

J:\94140.00 - Route 32 over Hoch Brook, Waldoboro, ME\CAD\dwg\94140.00-GT-300-PRF.dwg 8/29/2019 12:02 PM

APPENDIX A – Limitations

GEOTECHNICAL LIMITATIONS

Explorations and Subsurface Conditions

1. The analyses and design recommendations submitted in this report are based in part upon the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

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

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the exploration logs.

3. Water level readings have been made in the explorations at times and under conditions stated on the logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made. The water table encountered in the course of the work may differ from that indicated in the Report.

   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.

4. Nobis' geotechnical 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.

Additional Services

5. Nobis recommends that we be retained to provide services during 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 recommendations, design concepts and/or opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design recommendations; and iv) assess the consequences of changes in technologies and/or regulations.

Use of Report

6. Nobis prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in our proposal 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). Reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to Nobis.

   This report is for design purposes only and is not sufficient to prepare an accurate construction bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only.

7. Nobis' findings and conclusions are based on the work conducted as part of the scope of work set forth in our proposal 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 considering 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 project design has been altered in any way, Nobis shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions.

8. Nobis' 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.

Compliance with Codes and Regulations

9. Nobis 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.

Opinion of Cost

10. This report may contain or be based on comparative cost opinions for the purpose of evaluating alternative foundation schemes. These opinions may also involve approximate quantity evaluations. It should be noted that quantity estimates may not be accurate enough for construction bids. In addition, since we are not professional estimators of labor and materials cost, the evaluation of construction costs should be considered as approximate guidelines and could vary significantly from actual costs. Nobis does not guarantee the accuracy of our cost opinions as compared to contractor's bids for construction costs.

END OF LIMITATIONS

APPENDIX B.1 – Automatic Hammer Calibration Report – SPT Report LIC 4368 7-25-17

Summary of Energy Measurements - Chelsea, Massachusettes

Test Boring No.	Drill Rig	Type of Test Hammer Type	Sample No.	Sample Depth top bottom	SPT Blows per 6" from field logs				N-Value	Distance to bottom of sampler from center of instrumented rod (feet)	Rated Energy (ft.-lbs.)	Average Transferred Energy (2) (ft.-lbs.)	Average Transfer Efficiency (2) (%)	Average Hammer Blow Rate (2) (blows/min.)
Test Boring 7-13-2017	Truck 83 Mobile B-59 International USDOT 383455 LIC#: 4368	Mobile 140 lb. Automatic Hammer	S1	17' 19'	8	9	9	10	18	21'	350	305	87.1	55.7
		Mobile 140 lb. Automatic Hammer	S2	10' 12'	4	7	9	11	16	14'	350	298	85.2	57.0
		Mobile 140 lb. Automatic Hammer	S3	12' 14'	15	14	14	15	28	16'	350	310	88.5	57.0

NOTES: (1) Driller of Test Boring : Jerry Rednicki - New England Boring Contractors
(2) Averaged only for impacts during the middle 1 ft. of the test which relates to the observed N-Value

APPENDIX B.2 – Automatic Hammer Calibration Report – SPT Report LIC 4275 7-12-19

Table 1 - Summary of Energy Measurements - Winterport, ME

Drill Rig	Test Date	Type of Test Hammer Type	Sample No.	Sample Depth (feet) top bottom	SPT Blows per 6"				N-Value (middle ft.)	Distance to bottom of sampler from center of instrumented rod (feet)	Rated Energy (ft.-kips)	Average Transferred Energy (ft.-kips.)	Average Transfer Efficiency (%)	Average Hammer Blow Rate (blows/min.)
ATV Mounted Mobile Rig No. D-19	7/8/2019	NE Geotech Custom 140 lb. Automatic	S1	10 12	12	15	15	15	30	14.0	0.350	0.238	67.9	52.1
		NE Geotech Custom 140 lb. Automatic	S2	13 15	14	21	27	32	48	19.0	0.350	0.249	71.3	53.3
		NE Geotech Custom 140 lb. Automatic	S3	15 17	26	38	33	38	71	19.0	0.350	0.244	69.6	55.1
		NE Geotech Custom 140 lb. Automatic	S4	20 22	30	43	34	20	77	24.0	0.350	0.248	71.0	55.8
		NE Geotech Custom 140 lb. Automatic	S5	25 27	10	11	11	14	22	29.0	0.350	0.254	72.5	56.3
		NE Geotech Custom 140 lb. Automatic	S6	30 32	11	11	11	12	22	34.0	0.350	0.250	71.5	56.5

Notes: (1) Driller Name: Tom Shaefer - New England Boring Contractors
(2) Averaged only for impacts during the middle one ft. of the test which relates to the observed N-Value.

APPENDIX C – Test Boring Logs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-101
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	3"/3.25"
Operator:	M. Porter	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	December 6, 2017/December 6, 2017	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2
Boring Location:	STA 15+72.43, 7' LT	**Casing ID/OD:**	4"/4.5" ; 3"/3.5"	**Water Level*:**	6.3' bgs
Hammer Efficiency Factor: 0.869		**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							RC	71.5		Asphalt (12").	
										1.0	
	1D	24/13	1.00 - 3.00	19/13/7/7	20	29				Brown-grey, dry, medium dense, fine to coarse SAND, little fine gravel, trace silt, several asphalt particles and fragments, (Fill).	
							80				
	2D	24/11	3.00 - 5.00	6/8/5/6	13	19				Brown-grey, dry medium dense, fine to coarse SAND, trace fine gravel, trace silt, few asphalt particles and fragments, (Fill).	
5											
	3D	24/11	5.00 - 7.00	4/4/4/3	8	12				Brown-grey, dry, medium dense, fine to coarse SAND, little fine gravel, trace silt, few asphalt particles and fragments, (Fill).	
								64.5		8.0	
							50				
10											
	4D	24/17	10.50 - 12.50	WOH/2/3/2	5	7				Grey, wet, medium stiff, Clayey SILT, some fine sand, very few organic fibers and staining, faint redoximorphic staining, (Wetland Deposit).	A-7-6, MH WC=52.0% LL=51 PL=29 PI=22
15								57.5		15.0	
	5D	24/22	15.00 - 17.00	WOH/WOH/WOH/ WOH	--					Grey-olive, wet, very soft, SILT & CLAY , (Glaciomarine).	A-6, CL WC=35.7% LL=40 PL=20 PI=20
							30				
20	6D	24/23	20.00 - 22.00	WOR/WOR/WOR/ WOR	--					Grey-olive, wet, very soft, Clayey SILT, trace fine sand, (Glaciomarine).	
								50.1		22.4	
							100				
25											

Remarks:

-Borehole backfilled with 5 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# B-24.

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: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-101
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	3"/3.25"
Operator:	M. Porter	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	December 6, 2017/December 6, 2017	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2
Boring Location:	STA 15+72.43, 7' LT	**Casing ID/OD:**	4"/4.5" ; 3"/3.5"	**Water Level*:**	6.3' bgs
Hammer Efficiency Factor: 0.869		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
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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 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 Information: 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	7D	24/10	25.00 - 27.00	11/8/8/8	16	23	RC			Grey-olive, wet, medium dense, fine to coarse SAND, little silt, little fine gravel, (Glacial Till).	A-4
							180				
	R1	60/58	29.70 - 34.70	RQD = 75%			NQ2	42.8		29.7	
30										Top of Bedrock at Elev. 42.80 ft R1: Bedrock: Grey-tan, fine to medium-grained, GRANITE/MICA/ GNIESS, medium hard to hard, fresh to moderately weathered, slightly dipping to 45 degree-angle-dipping, very close to close joints, (Waldoboro Pluton). Rock Mass Quality = Fair. R1: Core Times (min:sec) 29.7-30.7 feet (2:30) 30.7-31.7 feet (1:45) 31.7-32.7 feet (1:15) 32.7-33.7 feet (1:15) 33.7-34.7 feet (1:30)	
35								37.8		34.7 **Bottom of Exploration at 34.7 feet below ground surface**	
40											
45											
50											

Remarks:

-Borehole backfilled with 5 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# B-24.

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: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-102
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	3"/3.25"
Operator:	M. Porter	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-59 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	December 5, 2017/December 5, 2017	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ2
Boring Location:	STA 16+06.52, 6' RT	**Casing ID/OD:**	4"/4.5" ; 3"/3.5"	**Water Level*:**	7.6' bgs
Hammer Efficiency Factor: 0.869		**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.
0							RC			Asphalt (12").	
								71.5		1.0	
	1D	24/14	1.00 - 3.00	18/13/12/8	25	36				Brown-grey, dry, medium dense, fine to coarse SAND, little fine gravel, trace silt, very few asphalt particles/fragments, (Fill).	
	2D	24/12	3.00 - 5.00	13/13/10/8	23	33				Brown-grey, dry, medium dense, fine to coarse SAND, little fine gravel, trace silt, very few asphalt and brick particles/fragments, (Fill).	
							75				
5	3D	24/8	5.00 - 7.00	7/5/12/10	17	25				Brown-grey, dry, medium dense, fine to coarse SAND, some fine to coarse gravel, trace silt, very few brick and asphalt particles/ fragments, (Fill).	A-1-a
								63.5		9.0	
							50				
10	4D	24/13	10.00 - 12.00	1/3/2/2	5	7				Grey, wet, medium stiff, SILT, some fine sand, very few wooden/ organic fibers, (Wetland Deposit).	
	5D	24/6	15.00 - 17.00	1/2/7/10	9	13				Grey, wet, stiff, sandy SILT, little fine to coarse gravel, very few wooden organic fibers, (Wetland Deposit).	A-2-4
								56.5		16.0	
15							115			Increase in roller cone resistance. Inferred Glacial Till encountered.	
							210	54.0		18.5	
	R1	10/2	19.30 - 20.13	RQD = 0%			NQ2			R1: Cobble Fragments: Grey, fine-grained, hard to very hard, fresh, (Glacial Till).	
20	R2	15/14	20.10 - 21.35	RQD = 60%						R2: Cobble and Boulder Fragments: Grey, fine-grained, hard to very hard, fresh, (Glacial Till).	
	R3	60/59	22.70 - 27.70	RQD = 77%				49.8		22.7	UCT q_p= 7,133 psi
										Top of Bedrock at Elev. 49.80 ft	
25										R3: Bedrock: Light grey-tan, fine to coarse-grained, GRANITE/ MICA/GNIESS, medium hard to very hard, fresh to slightly weathered, vertical to slightly dipping, very close to close joints,	

Remarks:

-Borehole backfilled with 9 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# B-24.

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

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Maine Department of Transportation

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US CUSTOMARY UNITS

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WIN: 18230.00

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Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-59 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
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Boring Location:	STA 16+06.52, 6' RT	**Casing ID/OD:**	4"/4.5" ; 3"/3.5"	**Water Level*:**	7.6' bgs
Hammer Efficiency Factor: 0.869		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

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N-uncorrected = Raw Field SPT N-value
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N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
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WC = Water Content, percent
LL = Liquid Limit
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G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample Information: 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							NQ2			(Waldoboro Pluton).	
										Rock Mass Quality = Good.	
										R1: Core Times (min:sec)	
										22.7-23.7 feet (1:45)	
										23.7-24.7 feet (2:00)	
								44.8		24.7-25.7 feet (1:45)	
										25.7-26.7 feet (1:45)	
										26.7-27.7 feet (2:00)	
										27.7-	
										Bottom of Exploration at 27.7 feet below ground surface	
30											
35											
40											
45											
50											

Remarks:

-Borehole backfilled with 9 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# B-24.

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: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-103
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	3"/3.25"
Operator:	T. Schaffer	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	June 22, 2019/June 22, 2019	**Drilling Method:**	Auger/Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	STA 15+73.55, 6' RT	**Casing ID/OD:**	4"/4.5"	**Water Level*:**	5.6' bgs
Hammer Efficiency Factor: 0.707		**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							HSA			Asphalt (11.7").	
								71.5		1.0	
	1D	24/14	1.00 - 3.00	9/13/12/10	25	29				Brown-grey, dry, medium dense, fine to coarse SAND, little fine to coarse gravel, trace silt, few asphalt particles/fragments, (Fill).	
	2D	24/12	3.00 - 5.00	5/6/6/5	12	14				Brown-grey, dry, medium dense, fine to coarse SAND, trace fine gravel, trace silt, very few asphalt particles/fragments, (Fill).	
5	3D	24/11	5.00 - 7.00	5/4/4/5	8	9	26			Brown, dry, loose, fine to coarse SAND, little fine gravel, trace silt, very few asphalt particles/fragments, (Fill).	
	4D	24/12	7.00 - 9.00	4/2/1/1	3	4	12			4D-A (6.5"-thick) Brown, dry, very loose, fine to coarse SAND, little fine gravel, trace silt, (Fill).	
								64.7		7.8	
	1MV						5			4D-B (5.5"-thick) Orangish-brown-grey, moist-wet, soft, Clayey SILT, some fine to coarse sand, few wooden/organic fibers, faint redoximorphic staining present, (Wetland Deposit).	
	5D	24/10	9.00 - 11.00	3/1/1/1	2	2	7			Brownish-grey, wet, very soft, Clayey SILT, trace fine to medium sand, several organic fibers, (Wetland Deposit).	
10							3				
	6D	24/15	11.00 - 13.00	WOH/WOH/WOH/3	0	0	2			6D-A(9"-thick) Brownish-gray, wet, very soft, Clayey SILT, some fine to coarse sand, several organic fibers, (Wetland Deposit) .	
	2V			22.5			5	60.2		12.3	
	7D	24/24	13.00 - 15.00	WOH/WOH/1/2	1	1	PUSH			6D-B(6"-thick) Grey, wet, very soft, SILT & CLAY, (Glaciomarine). Grey-olive, wet, very soft, SILT & CLAY, (Glaciomarine).	
	3V			47							
15	1U	24/23	15.00 - 17.00	PUSH			PUSH			Dark Grey, wet, Silty CLAY, trace fine sand, (Glaciomarine).	A-7-6, CL WC=49.2% LL=41 PL=20 PI=21 Cc=0.68 Cr=0.0125
	8D	24/24	18.00 - 20.00	WOR/WOR/WOR/ WOR	0	0	PUSH			Grey, wet, very soft, SILT & CLAY, (Glaciomarine).	
20	9D	24/9	20.00 - 22.00	9/8/11/14	19	22	25	52.5		20.0	
							62			Grey, wet, medium dense, SILT, some fine to coarse sand, trace fine to coarse gravel, trace clay, (Glacial Till).	
							80				
							64				
25							62				

Remarks:

-Borehole backfilled with 5 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# D-19.

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-WHB-103

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-103
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	3"/3.25"
Operator:	T. Schaffer	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	June 22, 2019/June 22, 2019	**Drilling Method:**	Auger/Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	STA 15+73.55, 6' RT	**Casing ID/OD:**	4"/4.5"	**Water Level*:**	5.6' bgs
Hammer Efficiency Factor: 0.707		**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 Information: 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	10D	24/9	25.50 - 27.50	35/45/45/28	90	106				Grey, fine to coarse SAND, some silt, trace fine gravel, trace clay, (Glacial Till). Tip of sample with weathered rock present.	
								45.0		27.5 **Bottom of Exploration at 27.5 feet below ground surface**	
30											
35											
40											
45											
50											

Remarks:

-Borehole backfilled with 5 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# D-19.

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: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-104
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	N/A
Operator:	T. Schaffer	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	June 23, 2019/June 23, 2019	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	STA 15+81.05, 6' LT	**Casing ID/OD:**	4"/4.5"	**Water Level*:**	7.6' bgs
Hammer Efficiency Factor: 0.707		**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							RC	71.6		Asphalt (11").	
										0.9	
										Grab sample: Brown-grey, dry, fine to coarse GRAVEL and fine to coarse SAND, trace silt, (Fill).	
	1D	3/3	2.20 - 2.45	50	>100					Light grey, dry, concrete fragments/pieces, (Concrete). Rebar present at approximately 3 feet bgs.	
								69.3		3.2	
5											
								65.0		7.5	
										Hoch Brook Water Table at approximately 7.5 feet bgs.	
								63.5		9.0	
							RC			Encountered concrete slab at bottom of concrete culvert, (Concrete).	
10								62.5		10.0	
										Timber platform encountered at approximately 10 feet bgs, with wood pieces/fragments encountered in wash cuttings, (Wood).	
	2D	7/5	11.00 - 11.58	45/50	100	118				Orange-brown, wet, very dense, wood pieces/fibers, (Wood).	
								60.4		12.1	
								60.1		Thin-layer (approximately 3 to 4"-thick) of Wetland Deposit encountered with trace organics.	
	3D	24/3	13.00 - 15.00	2/2/2/2	4	5				12.4	
										Grey, wet, soft, SILT & CLAY, trace fine to medium sand, several wood fibers, (Glaciomarine).	
15	4D	24/15	15.00 - 17.00	WOH/WOH/WOH/ WOH	0	0				Grey, wet, very soft, SILT & CLAY, (Glaciomarine).	
	1V			20							
20								52.5		20.0	
	5D	24/9	20.00 - 22.00	15/32/48/16	80	94				Grey, wet, very dense, SILT, little fine to coarse sand, trace fine gravel, trace clay, (Glacial Till).	
								50.5		22.0	
										Bottom of Exploration at 22.0 feet below ground surface.	
25											

Remarks:

-Borehole grouted to bottom of existing concrete culvert, in addition grouted cuvlert penetrations.
-bgs = below ground surface.
-Automatic Hammer ID# D-19.

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: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-105
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	73	**Auger ID/OD:**	3"/3.25"
Operator:	T. Schaffer	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	June 23, 2019/June 24, 2019	**Drilling Method:**	Auger/Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	STA 15+45.75, 6' LT	**Casing ID/OD:**	4"/4.5"	**Water Level*:**	9.8' bgs
Hammer Efficiency Factor: 0.707		**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							HSA	72.1		Asphalt (11").	
										0.9	
	1D	24/8	1.00 - 3.00	20/24/18/11	41	48				Black-brown-grey, dry, dense, fine to coarse SAND, little fine gravel, trace silt, several asphalt particles/fragments, (Fill).	
								69.0		4.0	
5	2D	24/24	5.00 - 7.00	WOH/2/2/2	4	5	PUSH			Brownish-grey, dry-moist, soft, Clayey SILT, little fine to medium sand, few wood/peat pieces/fibers, (Wetland Deposit).	A-4, CL WC=28.8% LL=27 PL=19 PI=8
							10	63.5		9.5	
10	3D	24/21	10.00 - 12.00	5/5/4/5	9	11	PUSH			Grey, wet, stiff, SILT & CLAY, faint redoximorphic staining present, (Glaciomarine).	
	MV			>50			PUSH				
15	4D	24/23	15.00 - 17.00	WOH/1/2/2	3	4	PUSH			Grey, wet, soft, SILT & CLAY, (Glaciomarine).	
20	5D	24/21	20.00 - 22.00	WOR/WOH/WOH/ WOH	0	0	PUSH			Grey, wet, very soft, SILT & CLAY, trace fine to medium sand, (Glaciomarine).	
							120	51.0		22.0	
	6D	0/0	23.00 - 23.00	50	>100			49.9		No Recovery, (Glacial Till).	
25										23.1 **Bottom of Exploration at 23.1 feet below ground surface**	

Remarks:

-Borehole backfilled with 6 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# D-19.

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: Route 32 over Hoch Brook at Wagner No. 2 Bridge #2905
Location: Waldoboro, Maine

Boring No.: BB-WHB-107
WIN: 18230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	72.5	**Auger ID/OD:**	3"/3.25"
Operator:	T. Schaffer	**Datum:**	NAVD-88	**Sampler:**	1-3/8" Split-Spoon
Logged By:	K. Kocia (Nobis)	**Rig Type:**	B-53 Mobile Truck	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	June 24, 2019/June 24, 2019	**Drilling Method:**	Auger/Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	STA 16+05.80, 6' LT	**Casing ID/OD:**	4"/4.5"	**Water Level*:**	9.8' bgs
Hammer Efficiency Factor: 0.707		**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							HSA			Asphalt (12").	
	1D	24/12	1.00 - 3.00	15/19/14/12	33	39		71.5		1.0 Black-brown-grey, dry, dense, fine to coarse SAND, trace fine gravel, trace silt, several asphalt particles/fragments, (Fill).	
5	2D	24/12	5.00 - 7.00	5/4/3/3	7	8	25			Brown-grey, dry, loose, fine to coarse SAND, trace fine gravel, trace silt, very few asphalt fragments, (Fill).	
	3D	24/<0.5	9.00 - 11.00	WOH/WOH/2/2	2	2	PUSH	63.5		9.0 No recovery. Tip containing Brown Clayey SILT, (Wetland Deposit).	
10											
	V			25			PUSH	60.5		12.0	
	4D	24/23	13.00 - 15.00	WOH/WOH/WOH/ WOH	0	0	PUSH			Grey, wet, very soft, SILT & CLAY, trace fine sand, (Glaciomarine).	
15	1U	24/21	15.00 - 17.00	PUSH			PUSH			Grey, wet, SILT & CLAY, little fine to coarse sand, trace fine gravel, (Glaciomarine).	
	5D	24/21	17.00 - 19.00	WOR/WOH/1/11	1	1	PUSH			5D-A(9"-thick) Grey, wet, very soft, SILT & CLAY, trace fine to sand, (Glaciomarine).	
								54.3		18.2 5D-B(8"-thick) Grey, wet, very loose, SILT, some fine to medium sand, trace fine to coarse gravel, trace clay, (Glacial Till).	
20	6D	24/8	20.00 - 22.00	10/16/19/21	35	41	120			Grey, wet, dense, Fine to coarse GRAVEL, some fine to coarse sand, some silt, (Glacial Till).	
								49.4		23.1 **Bottom of Exploration at 23.1 feet below ground surface**	
25											

Remarks:

-Borehole backfilled with 6 bags of gravel and native soils.
-Pavement restored with asphalt cold patch.
-bgs = below ground surface.
-Automatic Hammer ID# D-19.

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

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APPENDIX D – Photo Logs of Rock Cores

94140.00 – Route 32 Wagner Bridge (#02) over Hoch Brook – Waldoboro, ME – Bedrock Core Photo Log

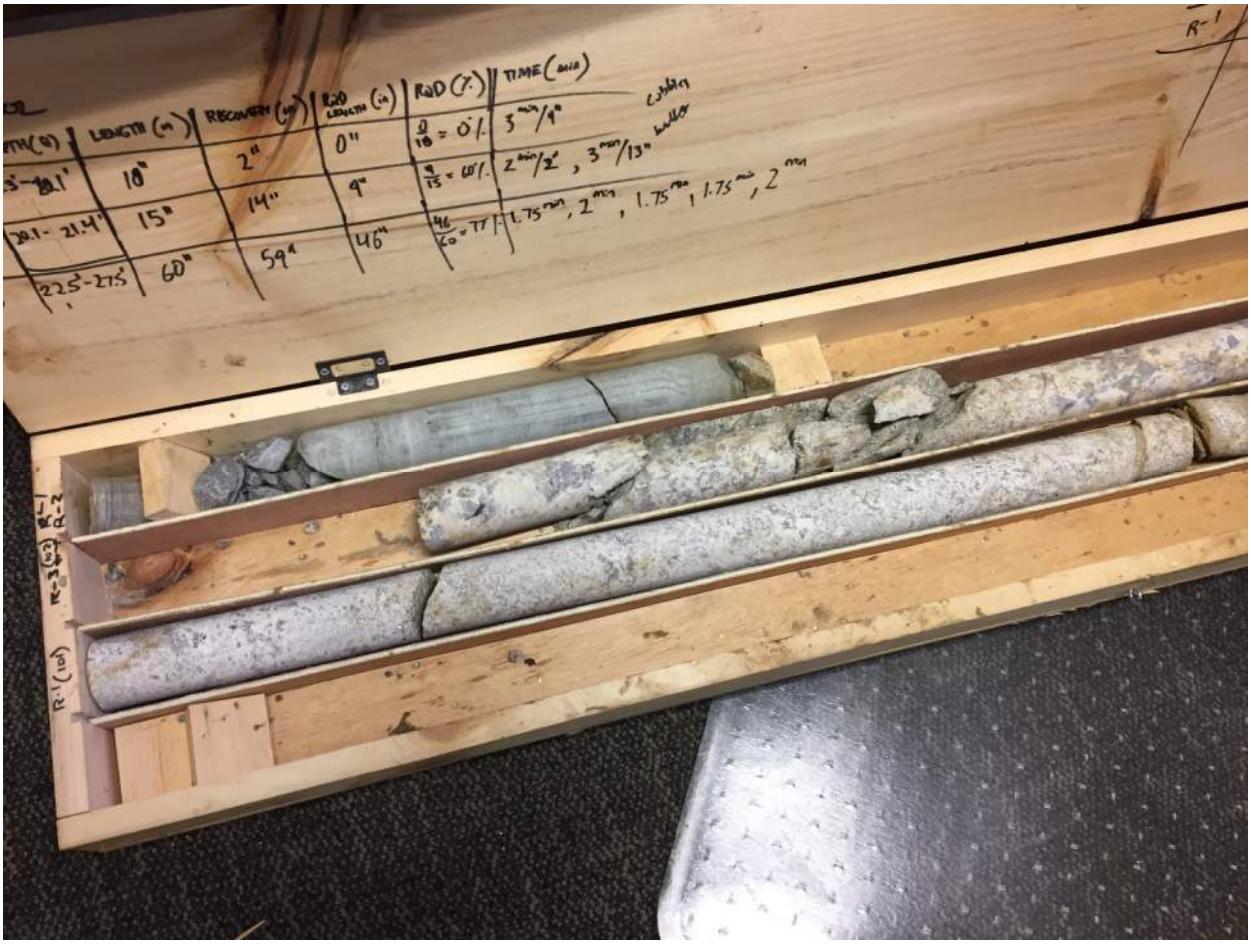


Photo 1. Boring BB-WHB-102: Rock Core Samples R-1 and R-2 (Row 1), R-3 (Row 2); Boring BB-WHB-101: Rock Core Sample R-1 (Row 3). Picture shows first 2.5 feet of each row.

Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T (978) 683-0891

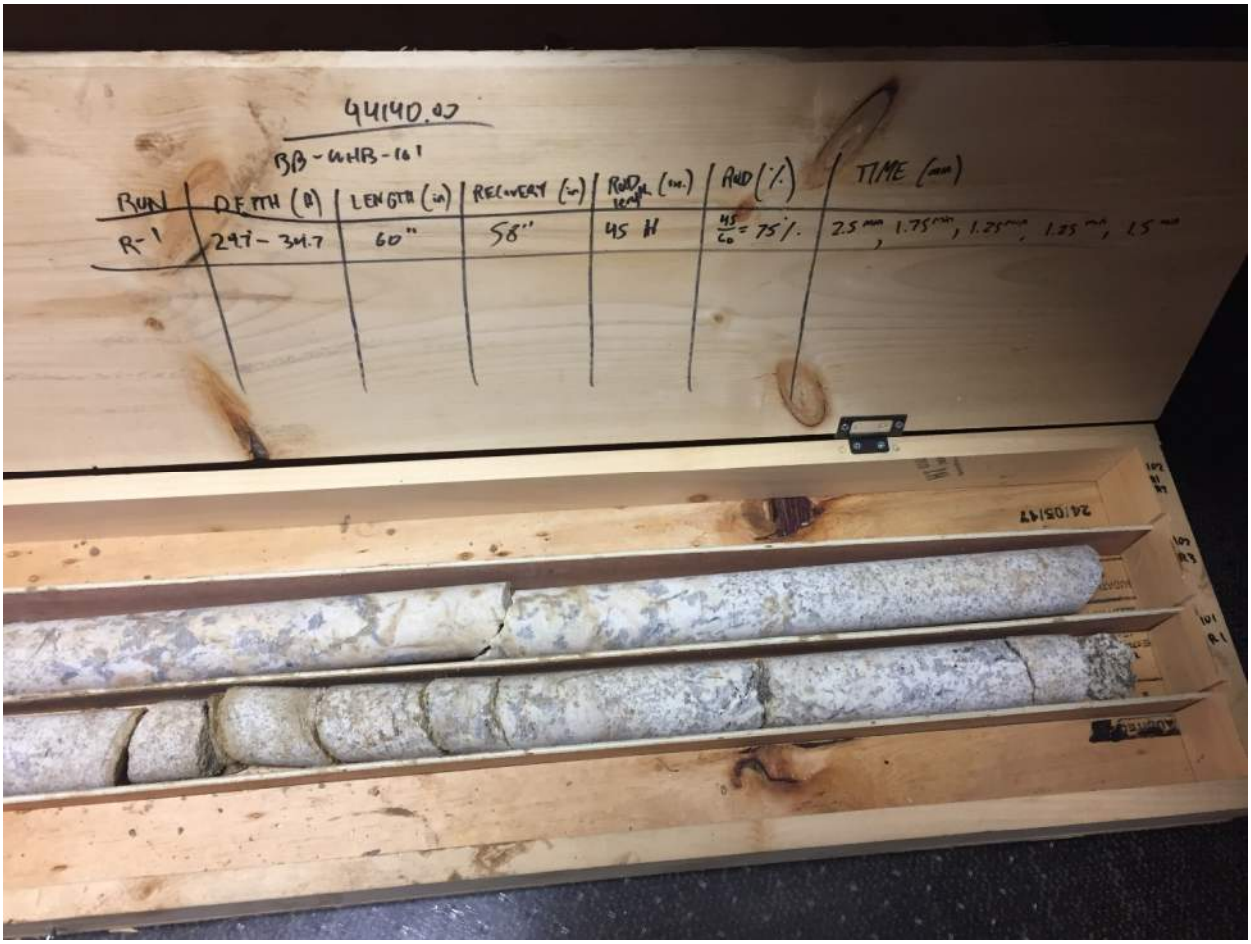


Photo 2. Boring BB-WHB-102: R-3 (Row 2); Boring BB-WHB-101: Rock Core Sample R-1 (Row 3). Picture shows bottom 2.5 feet of each row.

APPENDIX E.1 – Laboratory Test Results – Test Results from 2017 – Test Boring Samples

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	---	Sample Type:	---	Tested By:	jbr
Sample ID:	---	Test Date:	12/19/17	Checked By:	emm
Depth :	---	Test Id:	436861		

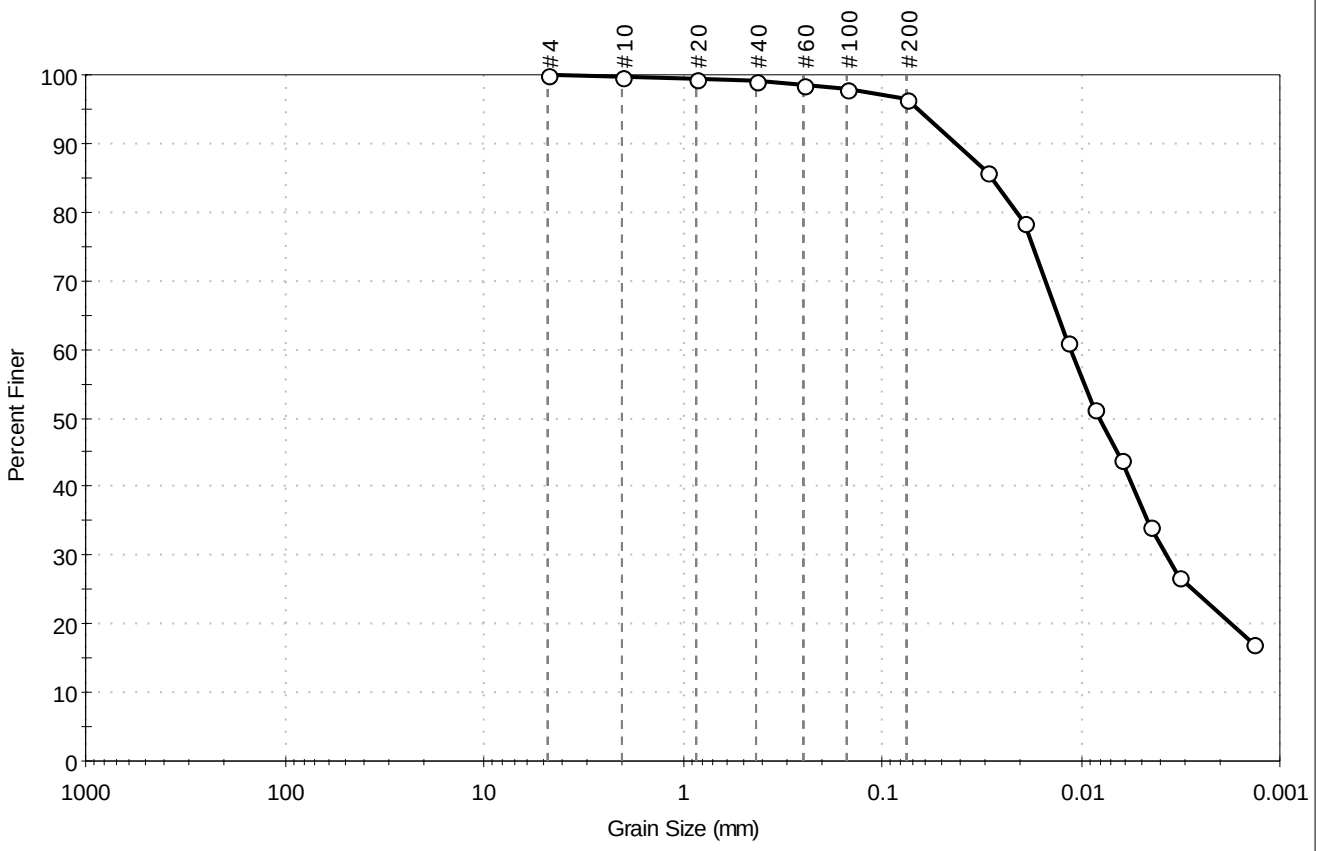
Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content, %
BB-WHB-101	4D	10.5-12.5	Moist, dark gray silt	52.0
BB-WHB-101	5D	15-17 ft	Moist, gray clay	35.7

Notes: Temperature of Drying : 110º Celsius

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-101	Sample Type:	jar	Tested By:	jbr
Sample ID:	4D	Test Date:	12/20/17	Checked By:	emm
Depth :	10.5-12.5	Test Id:	436857		
Test Comment:	---				
Visual Description:	Moist, dark gray silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	0.0	3.4	96.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	99		
#60	0.25	99		
#100	0.15	98		
#200	0.075	97		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0294	86		
---	0.0194	79		
---	0.0116	61		
---	0.0086	51		
---	0.0062	44		
---	0.0045	34		
---	0.0032	27		
---	0.0014	17		

Coefficients

D_{85} = 0.0279 mm	D_{30} = 0.0037 mm
D_{60} = 0.0112 mm	D_{15} = N/A
D_{50} = 0.0081 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM Elastic SILT (MH)

AASHTO Clayey Soils (A-7-6 (25))

Sample / Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

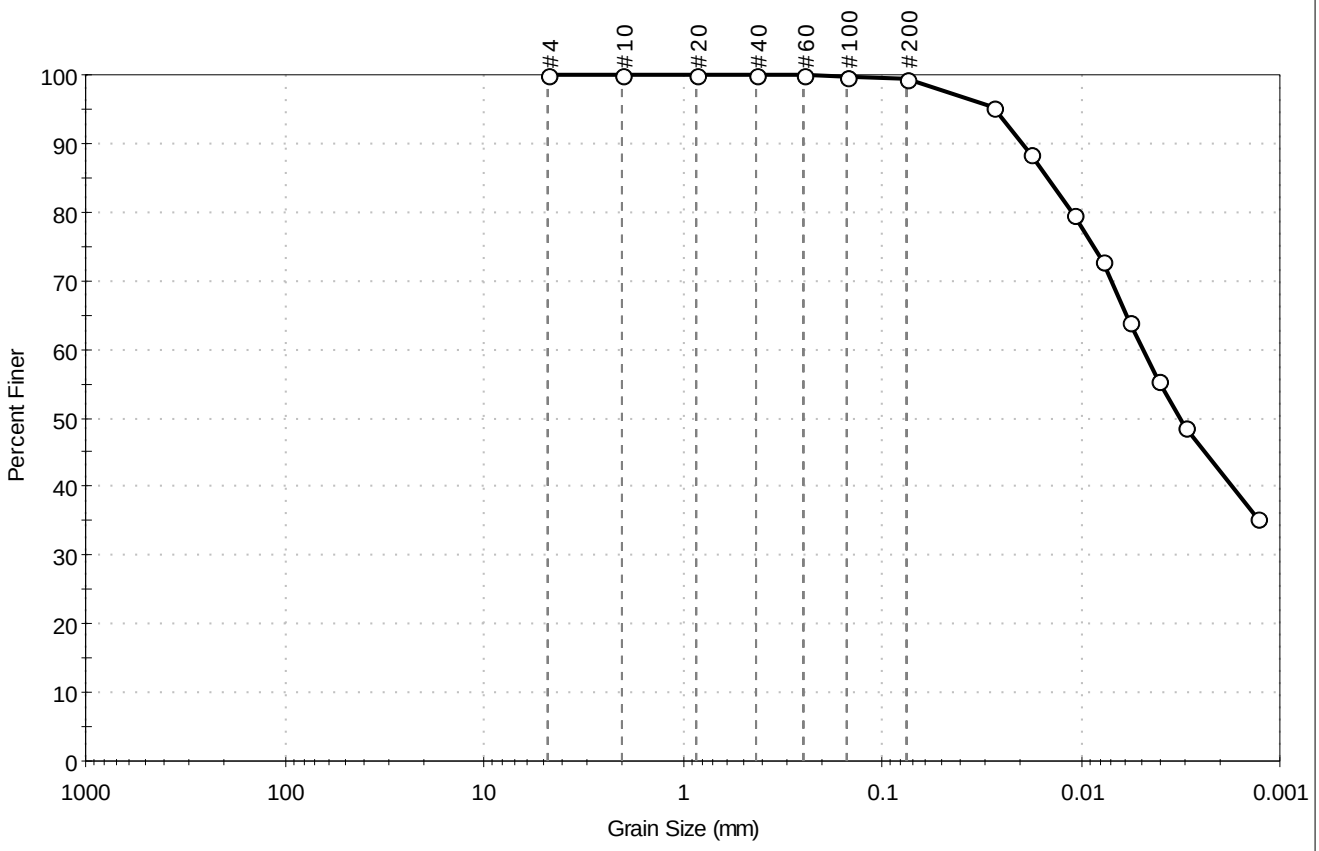
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-101	Sample Type:	jar	Tested By:	jbr
Sample ID:	5D	Test Date:	12/20/17	Checked By:	emm
Depth :	15-17 ft	Test Id:	436858		
Test Comment:	---				
Visual Description:	Moist, gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	0.0	0.6	99.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#200	0.075	99		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0274	95		
---	0.0179	89		
---	0.0110	80		
---	0.0079	73		
---	0.0057	64		
---	0.0041	55		
---	0.0030	49		
---	0.0013	35		

Coefficients

D_{85} = 0.0147 mm	D_{30} = N/A
D_{60} = 0.0049 mm	D_{15} = N/A
D_{50} = 0.0032 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-6 (21))

Sample / Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

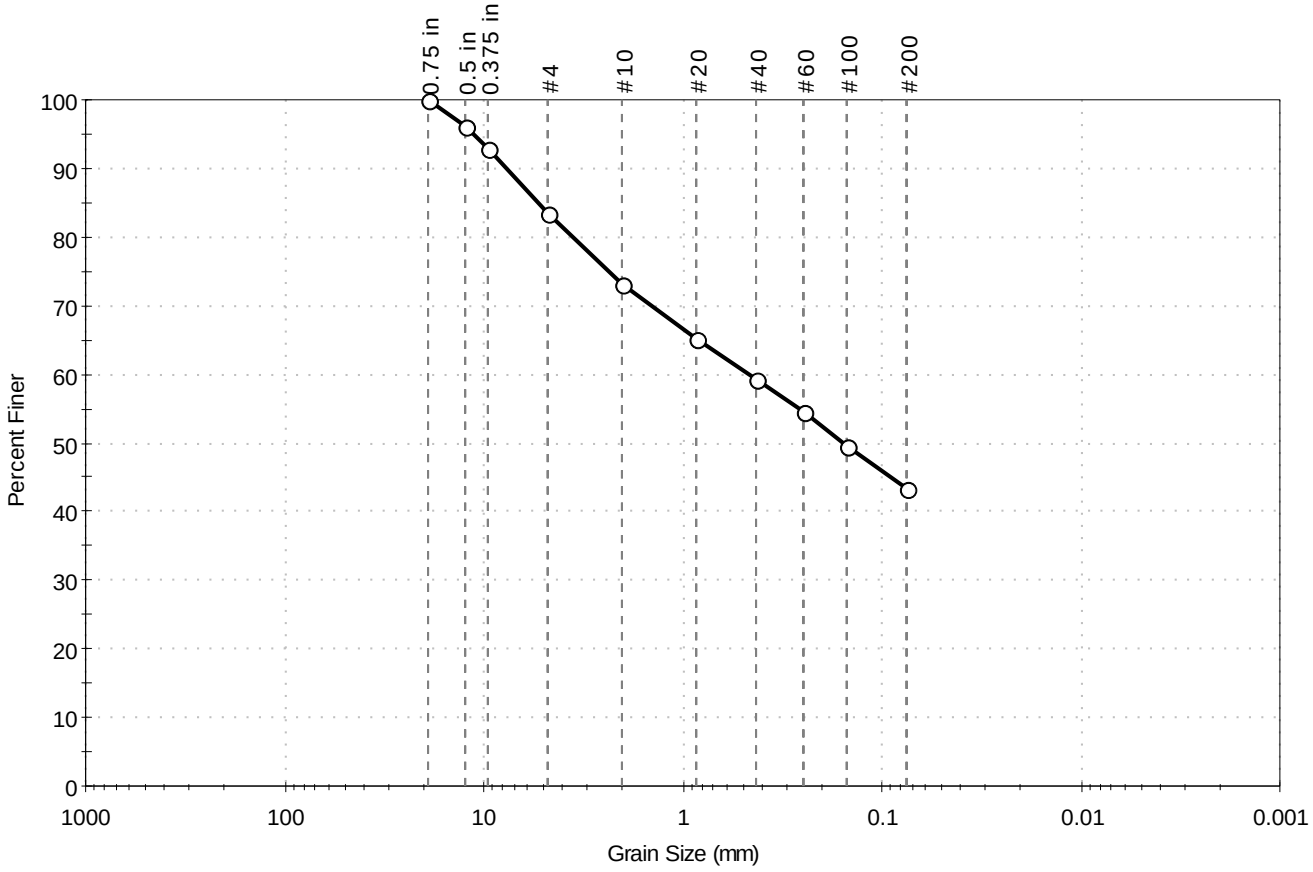
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-101	Sample Type:	jar	Tested By:	jbr
Sample ID:	7D	Test Date:	12/20/17	Checked By:	emm
Depth :	25-27 ft	Test Id:	436855		
Test Comment:	---				
Visual Description:	Moist, gray silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	16.6	40.1	43.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	96		
0.375 in	9.50	93		
#4	4.75	83		
#10	2.00	73		
#20	0.85	65		
#40	0.42	59		
#60	0.25	54		
#100	0.15	49		
#200	0.075	43		

Coefficients

D_{85} = 5.3437 mm D_{30} = N/A

D_{60} = 0.4679 mm D_{15} = N/A

D_{50} = 0.1582 mm D_{10} = N/A

C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

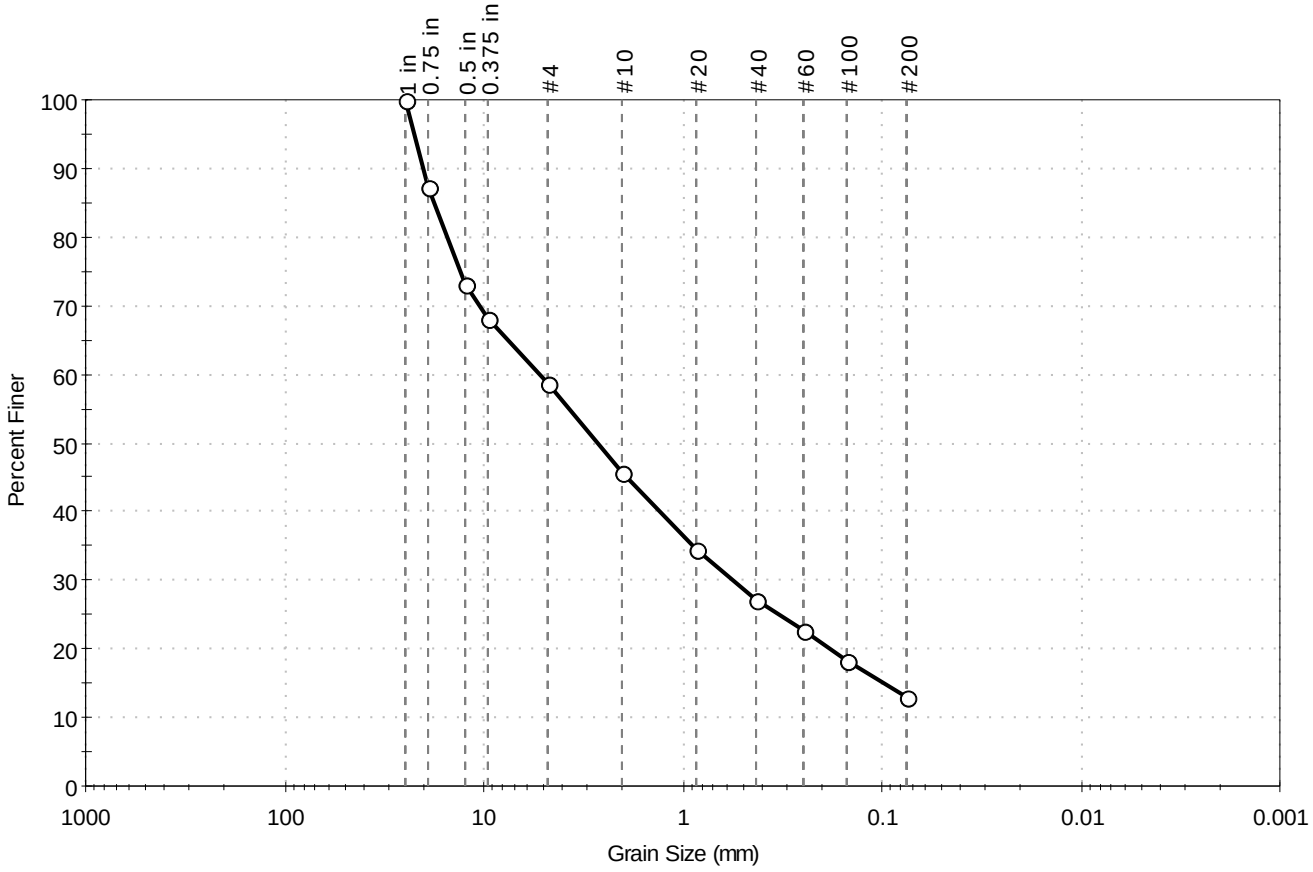
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-102	Sample Type:	jar	Tested By:	jbr
Sample ID:	3D	Test Date:	12/20/17	Checked By:	emm
Depth :	5-7 ft	Test Id:	436854		
Test Comment:	---				
Visual Description:	Moist, brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	41.2	46.0	12.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	87		
0.5 in	12.50	73		
0.375 in	9.50	68		
#4	4.75	59		
#10	2.00	46		
#20	0.85	35		
#40	0.42	27		
#60	0.25	23		
#100	0.15	18		
#200	0.075	13		

Coefficients

D_{85} = 17.6773 mm	D_{30} = 0.5558 mm
D_{60} = 5.1808 mm	D_{15} = 0.0993 mm
D_{50} = 2.6373 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

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

Sample / Test Description

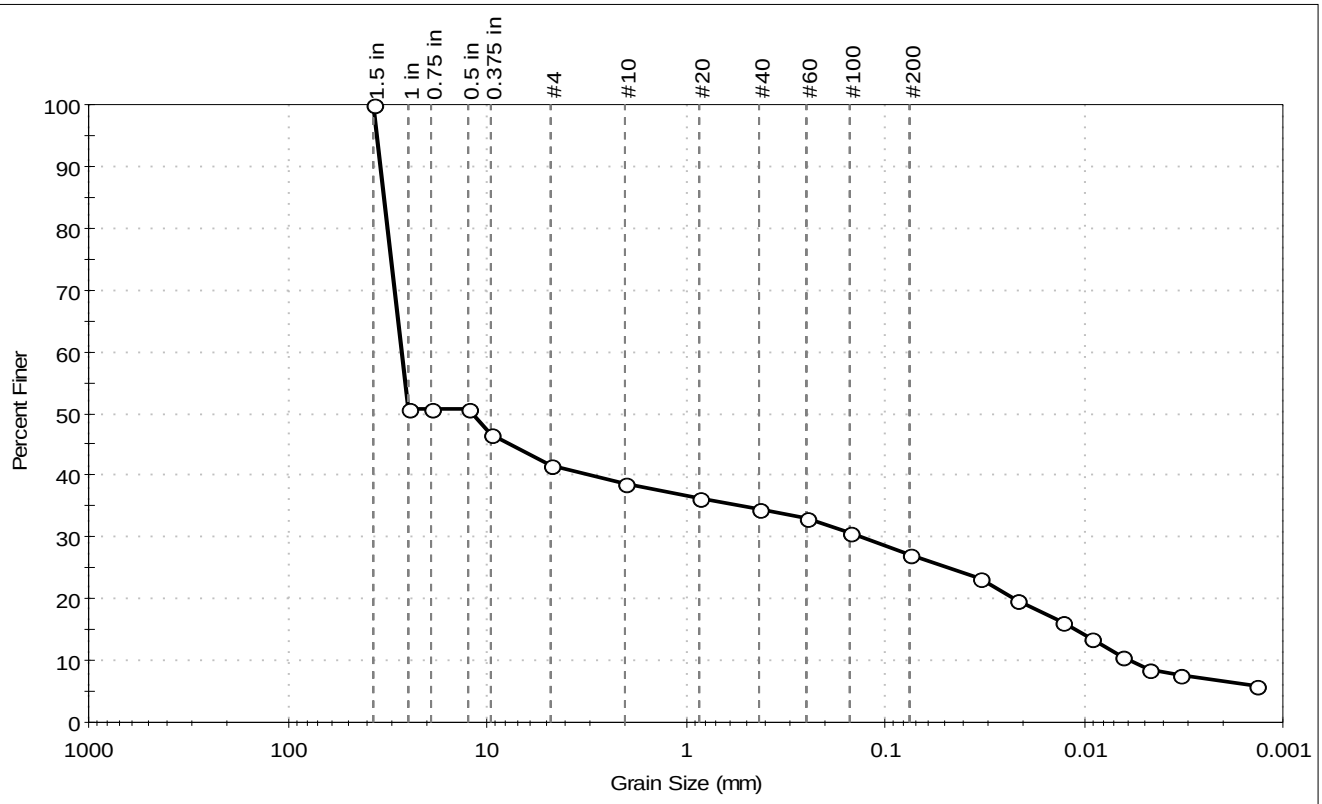
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-102	Sample Type:	jar	Tested By:	jbr
Sample ID:	5D	Test Date:	12/22/17	Checked By:	emm
Depth :	15-17 ft	Test Id:	438685		

Test Comment: ---
Visual Description: Moist, dark gray clayey gravel
Sample Comment: ---

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	58.3	14.6	27.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	51		
0.75 in	19.00	51		
0.5 in	12.50	51		
0.375 in	9.50	46		
#4	4.75	42		
#10	2.00	39		
#20	0.85	36		
#40	0.42	34		
#60	0.25	33		
#100	0.15	31		
#200	0.075	27		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0335	23		
---	0.0217	20		
---	0.0127	16		
---	0.0092	13		
---	0.0065	11		
---	0.0047	9		
---	0.0033	8		
---	0.0014	6		

Coefficients

D_{85} = 33.1500 mm D_{30} = 0.1341 mm
D_{60} = 26.9871 mm D_{15} = 0.0110 mm
D_{50} = 11.9394 mm D_{10} = 0.0058 mm
C_u = 4652.948 C_c = 0.115

Classification

ASTM N/A

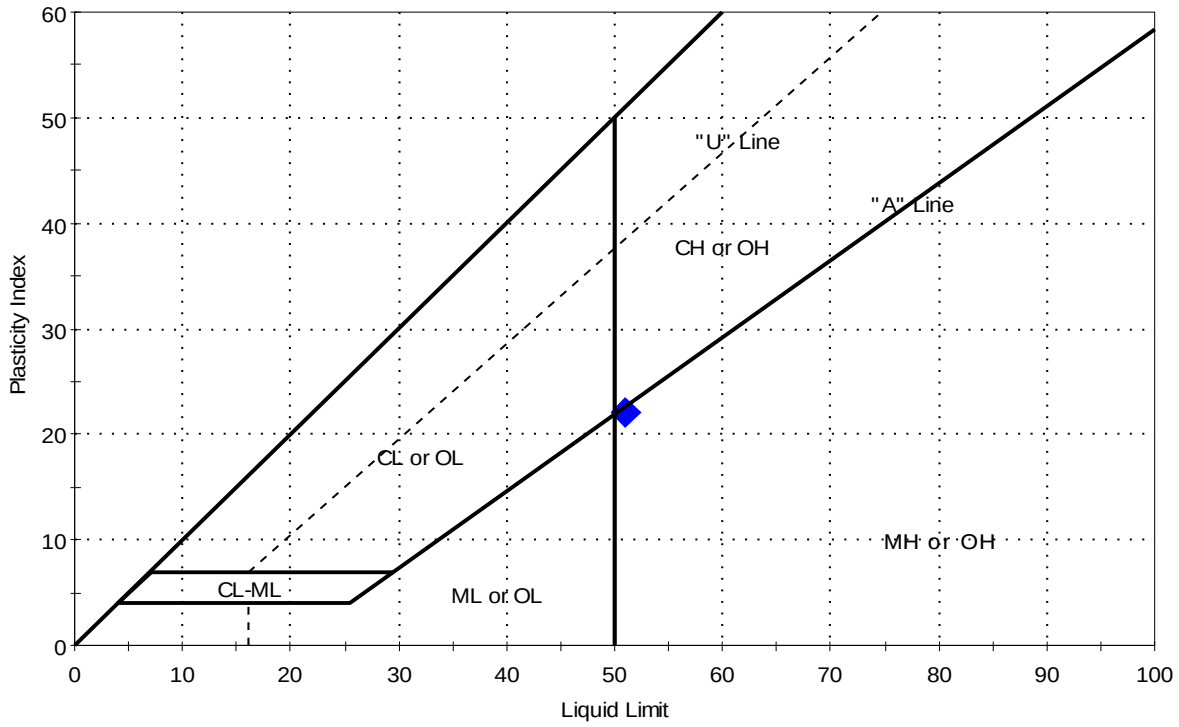
AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR
Sand/Gravel Hardness : HARD
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-101	Sample Type:	jar	Tested By:	cam
Sample ID:	4D	Test Date:	12/20/17	Checked By:	emm
Depth :	10.5-12.5	Test Id:	436862		
Test Comment:	---				
Visual Description:	Moist, dark gray silt				
Sample Comment:	---				

Atterberg Limits - ASTM D4318

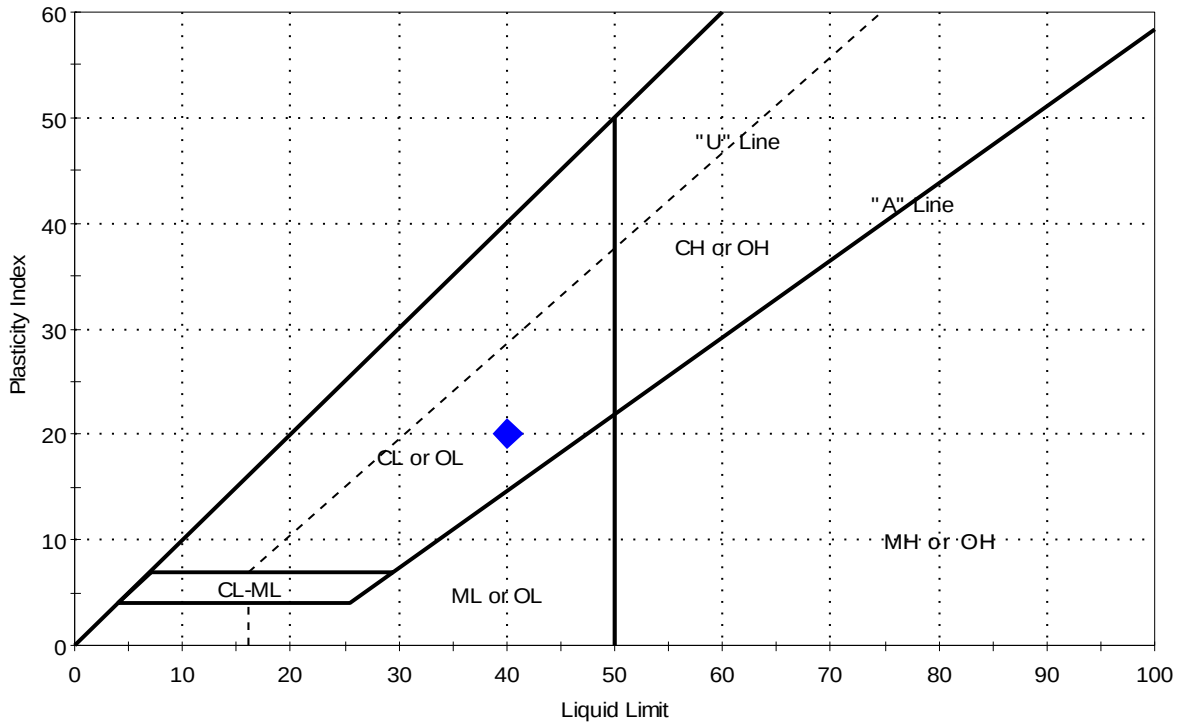


Symbol	Sample ID	Boring	Depth	Natural Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	4D	B-WHB-101	10.5-12.5	52	51	29	22	1	Elastic SILT (MH)

Sample Prepared using the WET method
1% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilatancy: SLOW
Toughness: LOW

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	BB-WHB-101	Sample Type:	jar	Tested By:	cam
Sample ID:	5D	Test Date:	12/20/17	Checked By:	emm
Depth :	15-17 ft	Test Id:	436863		
Test Comment:	---				
Visual Description:	Moist, gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318

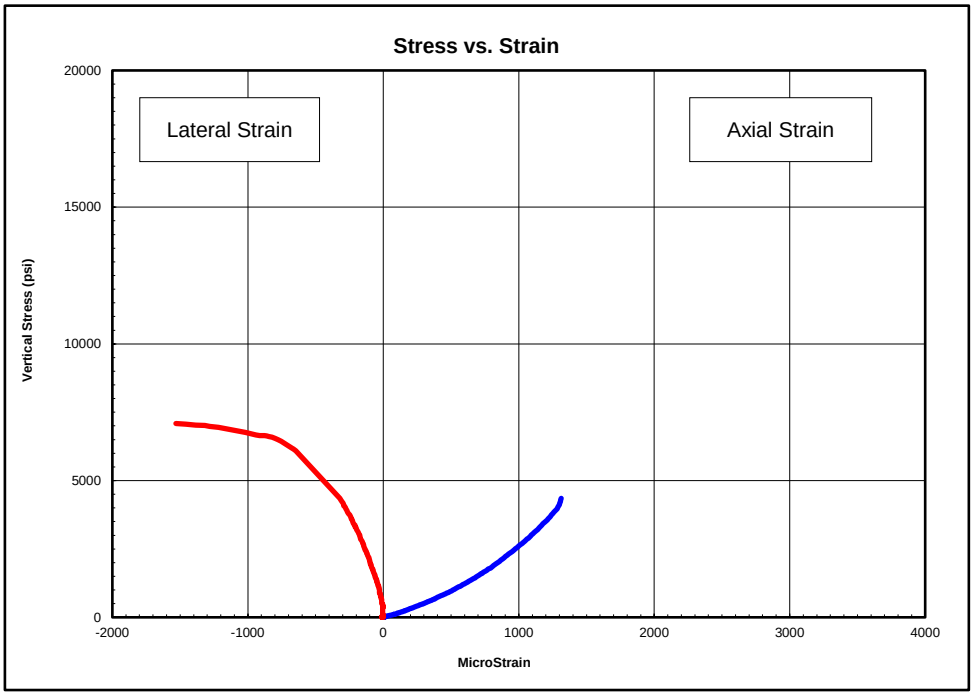


Symbol	Sample ID	Boring	Depth	Natural Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	5D	B-WHB-10	15-17 ft	36	40	20	20	0.8	Lean CLAY (CL)

Sample Prepared using the WET method
0% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilatancy: SLOW
Toughness: LOW

Client:	Nobis Engineering, Inc.
Project Name:	Route 32 over Hook Brook
Project Location:	Waldoboro, ME
GTX #:	307434
Test Date:	12/27/2017
Tested By:	rlc
Checked By:	jsc
Boring ID:	BB-WHB-102
Sample ID:	R3
Depth, ft:	22
Sample Type:	rock core
Sample Description:	See photographs Intact material failure Diameter < ten times maximum mineral size

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



Peak Compressive Stress: 7,133 psi

The graph above does not include values up to the peak stress value. The axial strain gauges failed before the peak value was attained. Young's Modulus and Poisson's Ratio within the 4300-6400 stress range could not be determined.

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
700-2600	3,060,000	0.21
2600-4300	5,180,000	---
4300-6400	---	---

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:	Nobis Engineering, Inc.	Test Date:	12/20/2017
Project Name:	Route 32 over Hook Brook	Tested By:	rlc/trm
Project Location:	Waldoboro, ME	Checked By:	jsc
GTX #:	307434		
Boring ID:	BB-WHB-102		
Sample ID:	R3		
Depth:	22 ft		
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:	4.07	4.07	4.07
Specimen Diameter, in:	1.97	1.98	1.98
Specimen Mass, g:	529.6		
Bulk Density, lb/ft^3	161	**Minimum Diameter Tolerence Met?**	YES
Length to Diameter Ratio:	2.1	**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.? YES

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

END FLATNESS AND PARALLELISM (Procedure FP1)

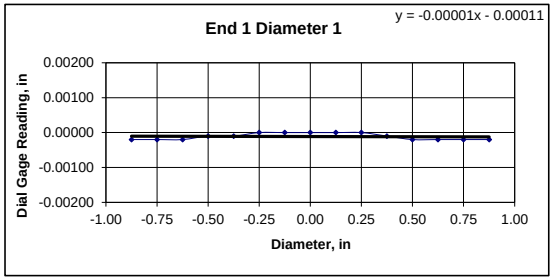
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00020	-0.00020	-0.00020	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00020	-0.00020	-0.00020	-0.00020
Diameter 2, in (rotated 90°)	0.00020	0.00020	0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00020	-0.00020	-0.00020	-0.00020

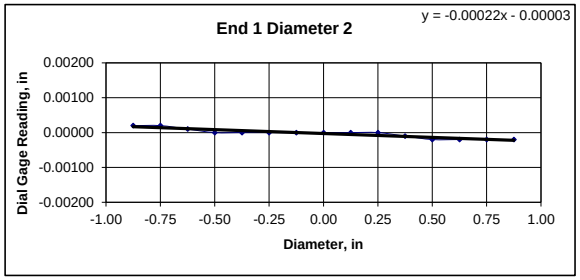
Difference between max and min readings, in:
0° = 0.00020 90° = 0.00040

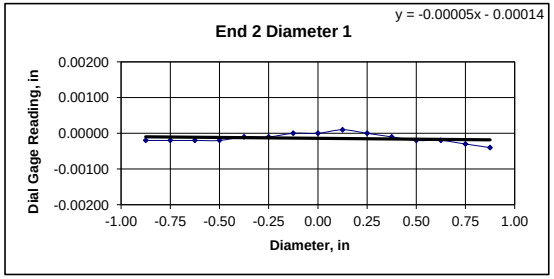
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00020	-0.00020	-0.00020	-0.00020	-0.00010	-0.00010	0.00000	0.00000	0.00010	0.00000	-0.00010	-0.00020	-0.00020	-0.00030	-0.00040
Diameter 2, in (rotated 90°)	-0.00030	-0.00020	-0.00010	0.00000	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00010	0.00020	0.00030	0.00030	0.00020	0.00020

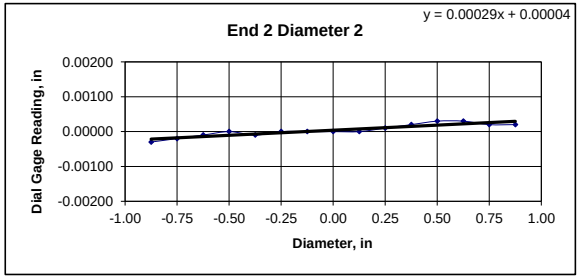
Difference between max and min readings, in:
0° = 0.0005 90° = 0.0006

Maximum difference must be < 0.0020 in. Difference = ± 0.00030
Flatness Tolerance Met? YES









DIAMETER 1

End 1:
Slope of Best Fit Line 0.00001
Angle of Best Fit Line: 0.00057

End 2:
Slope of Best Fit Line 0.00005
Angle of Best Fit Line: 0.00286

Maximum Angular Difference: 0.00229

Parallelism Tolerance Met? YES
Spherically Seated

DIAMETER 2

End 1:
Slope of Best Fit Line 0.00022
Angle of Best Fit Line: 0.01261

End 2:
Slope of Best Fit Line 0.00029
Angle of Best Fit Line: 0.01662

Maximum Angular Difference: 0.00401

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	0.00020	1.975	0.00010	0.006	YES
Diameter 2, in (rotated 90°)	0.00040	1.975	0.00020	0.012	YES
END 2					
Diameter 1, in	0.00050	1.975	0.00025	0.015	YES
Diameter 2, in (rotated 90°)	0.00060	1.975	0.00030	0.017	YES

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

Client:	Nobis Engineering, Inc.
Project Name:	Route 32 over Hook Brook
Project Location:	Waldoboro, ME
GTX #:	307434
Test Date:	12/27/2017
Tested By:	rlc
Checked By:	jsc
Boring ID:	BB-WHB-102
Sample ID:	R3
Depth, ft:	22

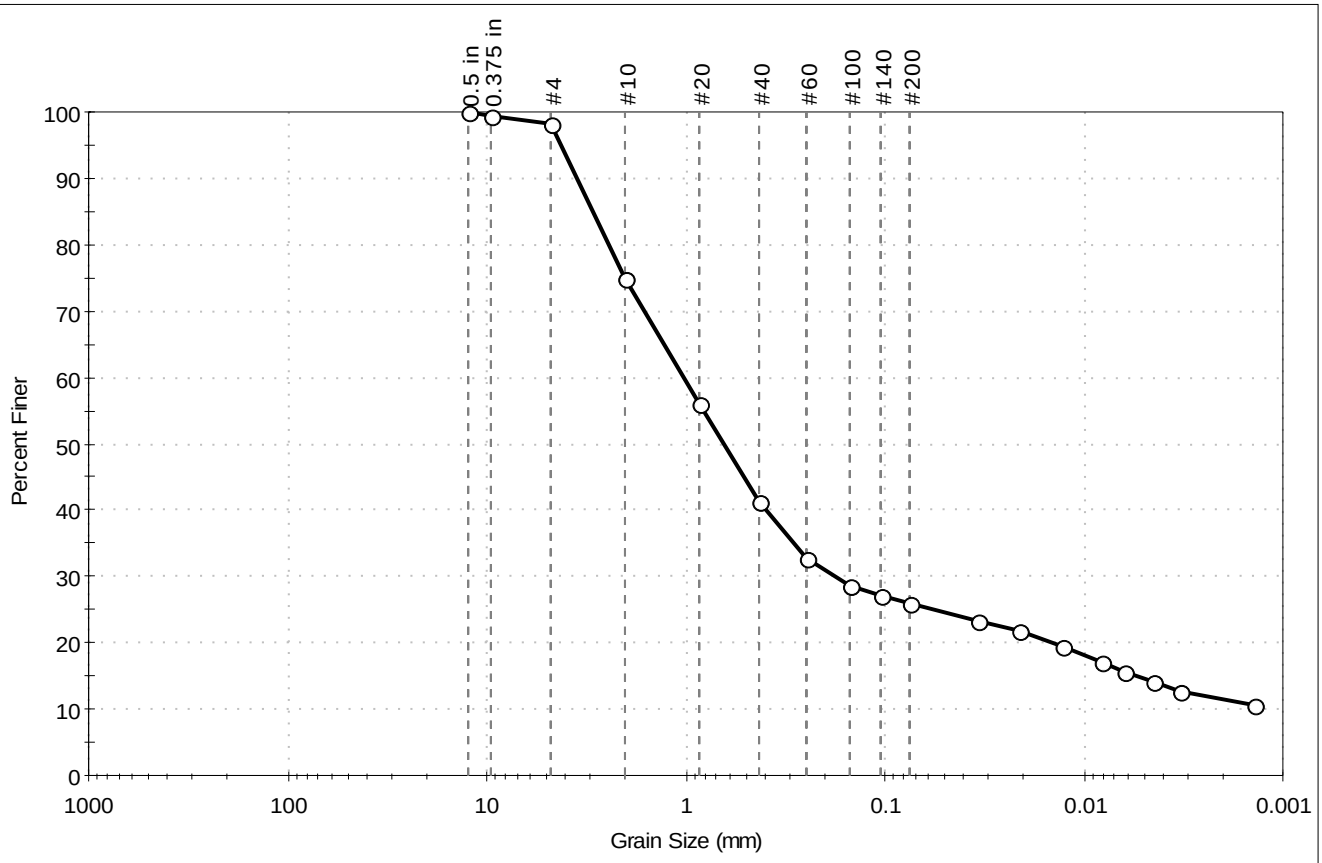
After cutting and grinding

After break

APPENDIX E.2 – Laboratory Test Results – Test Results from 2018 – Sediment Samples

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	SS-1	Test Date:	01/23/18	Checked By:	emm
Depth :	1-2 ft	Test Id:	440199		
Test Comment:	---				
Visual Description:	Moist, gray silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	1.8	72.2	26.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	98		
#10	2.00	75		
#20	0.85	56		
#40	0.42	41		
#60	0.25	33		
#100	0.15	29		
#140	0.11	27		
#200	0.075	26		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0342	23		
---	0.0214	22		
---	0.0128	20		
---	0.0081	17		
---	0.0063	16		
---	0.0045	14		
---	0.0033	13		
---	0.0014	11		

Coefficients

D_{85} = 2.9018 mm	D_{30} = 0.1780 mm
D_{60} = 1.0216 mm	D_{15} = 0.0054 mm
D_{50} = 0.6439 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

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

Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

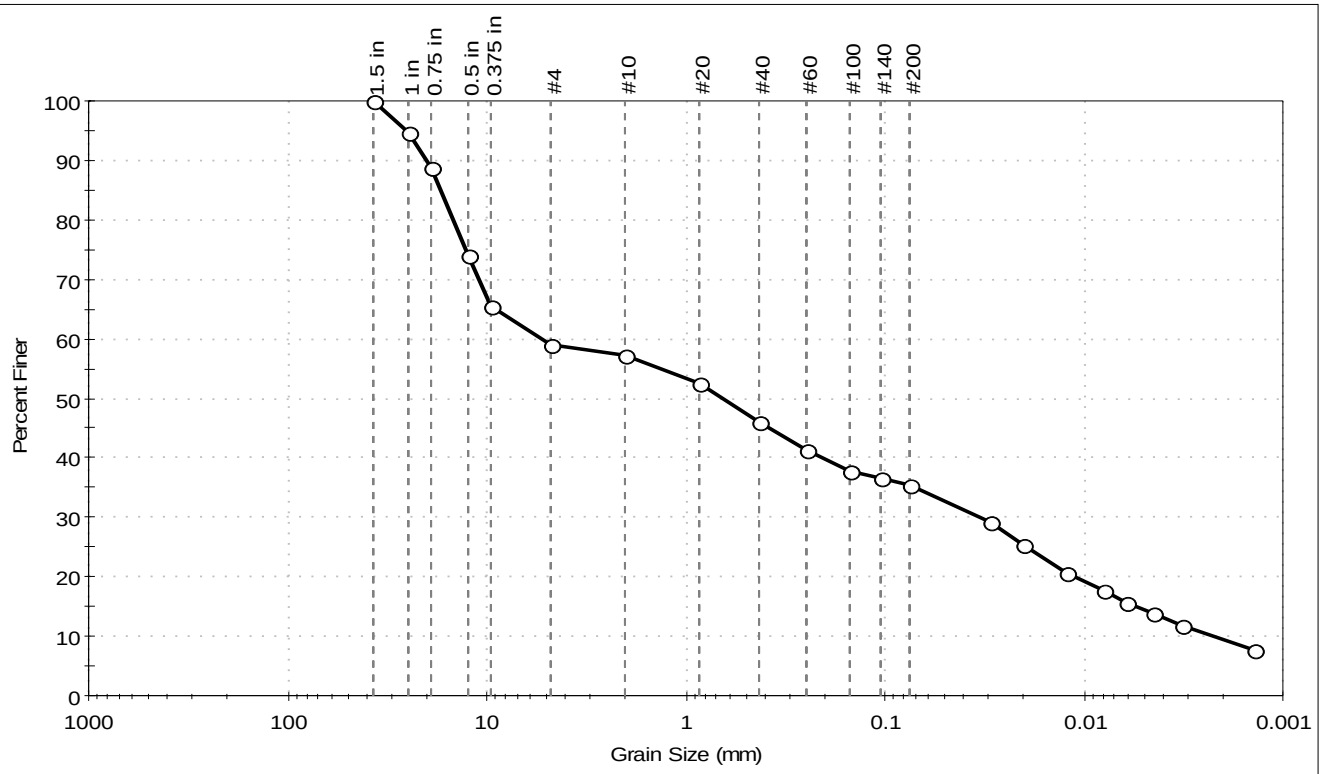
Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldoboro, ME			Project No:	GTX-307434
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	SS-2	Test Date:	01/23/18	Checked By:	emm
Depth :	.5-1 ft	Test Id:	440200		

Test Comment: ---
Visual Description: Moist, gray silty gravel with sand
Sample Comment: ---

Particle Size Analysis - ASTM D422



%Cobble	%Gravel	%Sand	%Silt & Clay Size
---	41.1	23.5	35.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	95		
0.75 in	19.00	89		
0.5 in	12.50	74		
0.375 in	9.50	65		
#4	4.75	59		
#10	2.00	57		
#20	0.85	52		
#40	0.42	46		
#60	0.25	41		
#100	0.15	38		
#140	0.11	37		
#200	0.075	35		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0294	29		
---	0.0200	25		
---	0.0121	21		
---	0.0079	18		
---	0.0062	16		
---	0.0045	14		
---	0.0032	12		
---	0.0014	8		

Coefficients

D_{85} = 17.0780 mm D_{30} = 0.0329 mm
D_{60} = 5.3290 mm D_{15} = 0.0055 mm
D_{50} = 0.6507 mm D_{10} = 0.0022 mm
C_u = 2422.273 C_c = 0.092

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

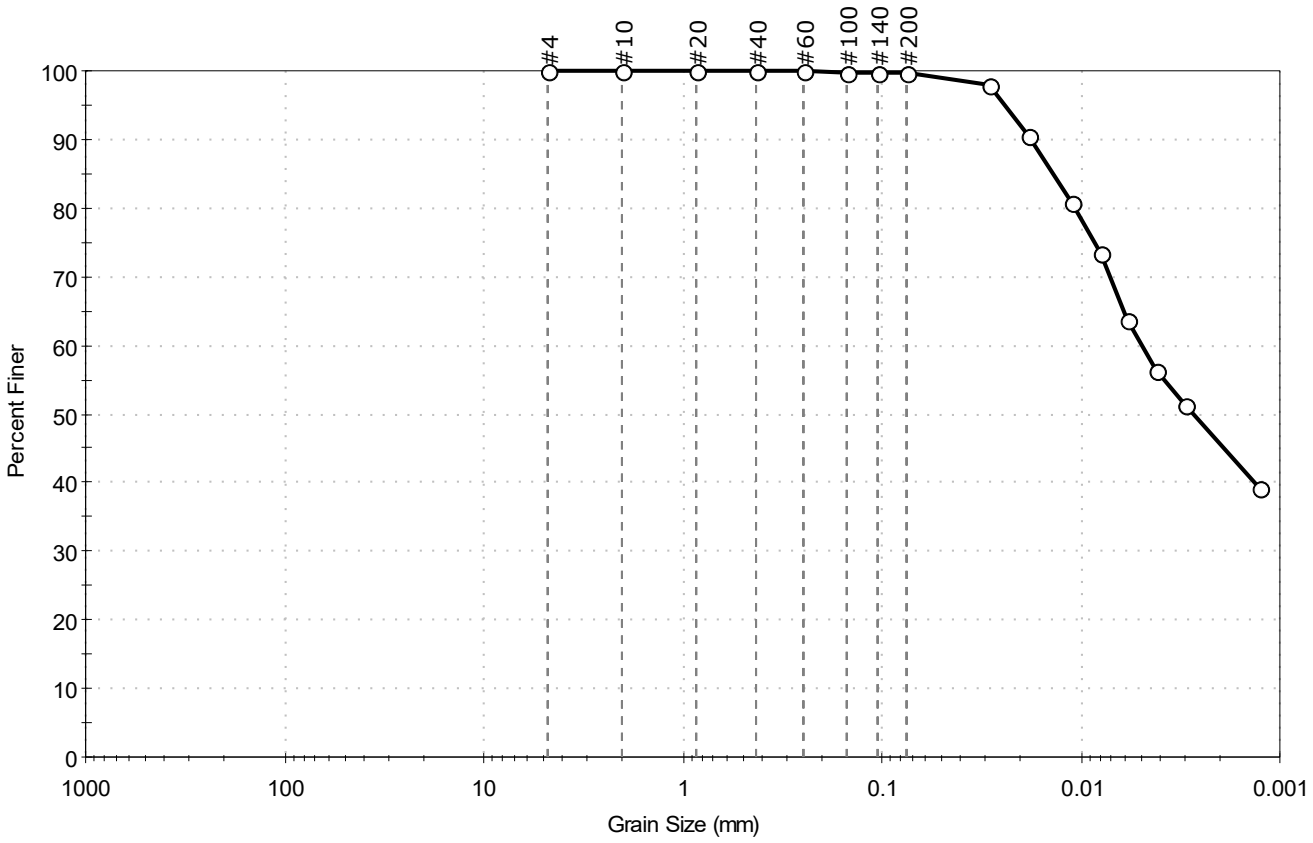
Sample / Test Description

Sand/Gravel Particle Shape : ANGULAR
Sand/Gravel Hardness : HARD
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

APPENDIX E.3 – Laboratory Test Results – Test Results from 2019 – Test Boring Samples

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldeboro, ME			Project No:	GTX-310368
Boring ID:	BB-WHB-103	Sample Type:	tube	Tested By:	ckg
Sample ID:	ST-1	Test Date:	08/09/19	Checked By:	bfs
Depth :	15-17 ft	Test Id:	516210		
Test Comment:	---				
Visual Description:	Wet, dark gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	0.4	99.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#140	0.11	100		
#200	0.075	100		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0287	98		
---	0.0182	91		
---	0.0111	81		
---	0.0079	73		
---	0.0058	64		
---	0.0042	56		
---	0.0030	51		
---	0.0013	39		

Coefficients

D_{85} = 0.0137 mm	D_{30} = N/A
D_{60} = 0.0049 mm	D_{15} = N/A
D_{50} = 0.0027 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Clayey Soils (A-7-6 (23))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

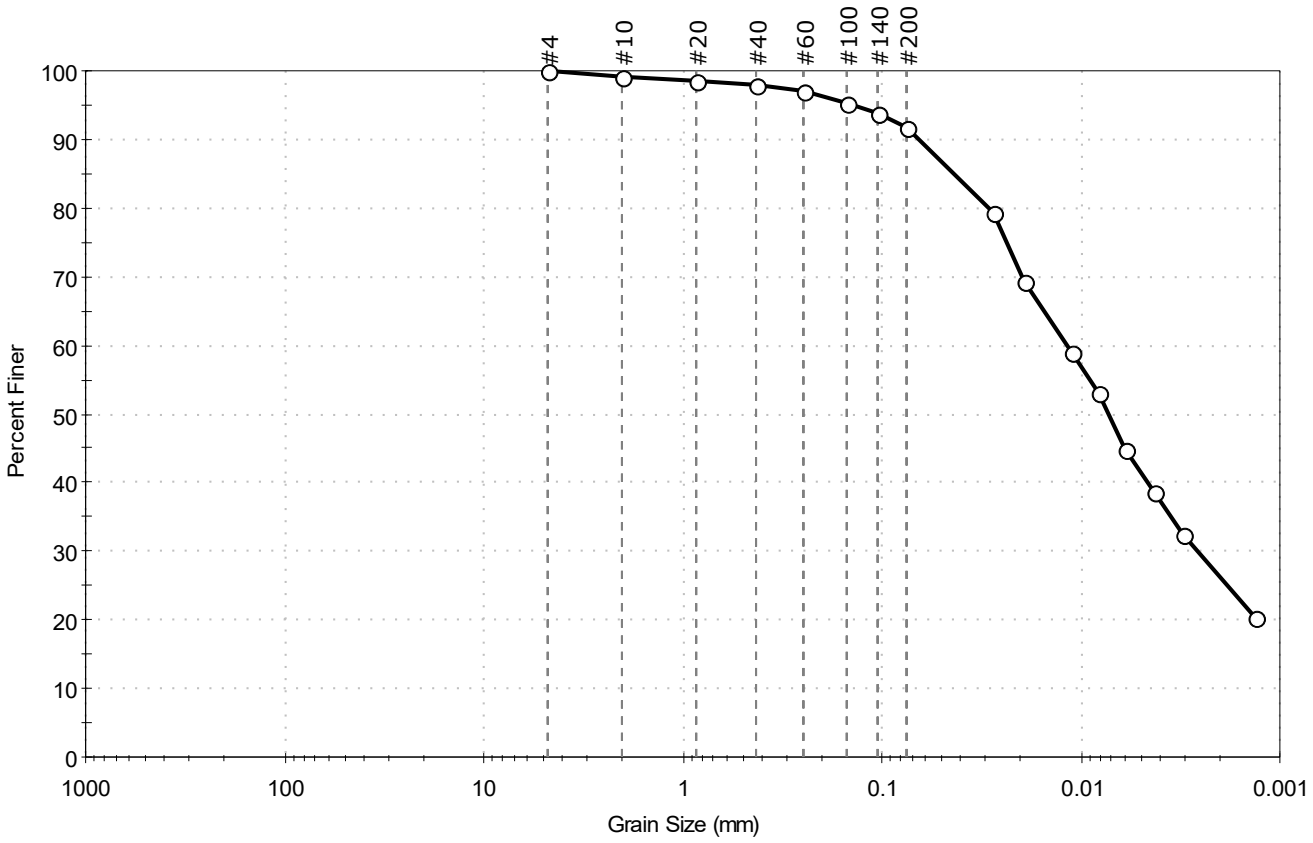
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldeboro, ME			Project No:	GTX-310368
Boring ID:	BB-WHB-105	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-2	Test Date:	08/09/19	Checked By:	bfs
Depth :	5-7 ft	Test Id:	516211		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	8.4	91.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	99		
#20	0.85	98		
#40	0.42	98		
#60	0.25	97		
#100	0.15	95		
#140	0.11	94		
#200	0.075	92		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0279	79		
---	0.0192	69		
---	0.0113	59		
---	0.0082	53		
---	0.0060	45		
---	0.0043	39		
---	0.0031	33		
---	0.0013	20		

Coefficients

D_{85} = 0.0438 mm	D_{30} = 0.0026 mm
D_{60} = 0.0118 mm	D_{15} = N/A
D_{50} = 0.0073 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM Lean CLAY (CL)

AASHTO Silty Soils (A-4 (6))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldeboro, ME			Project No:	GTX-310368
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	08/02/19	Checked By:	bfs
Depth :	---	Test Id:	516213		

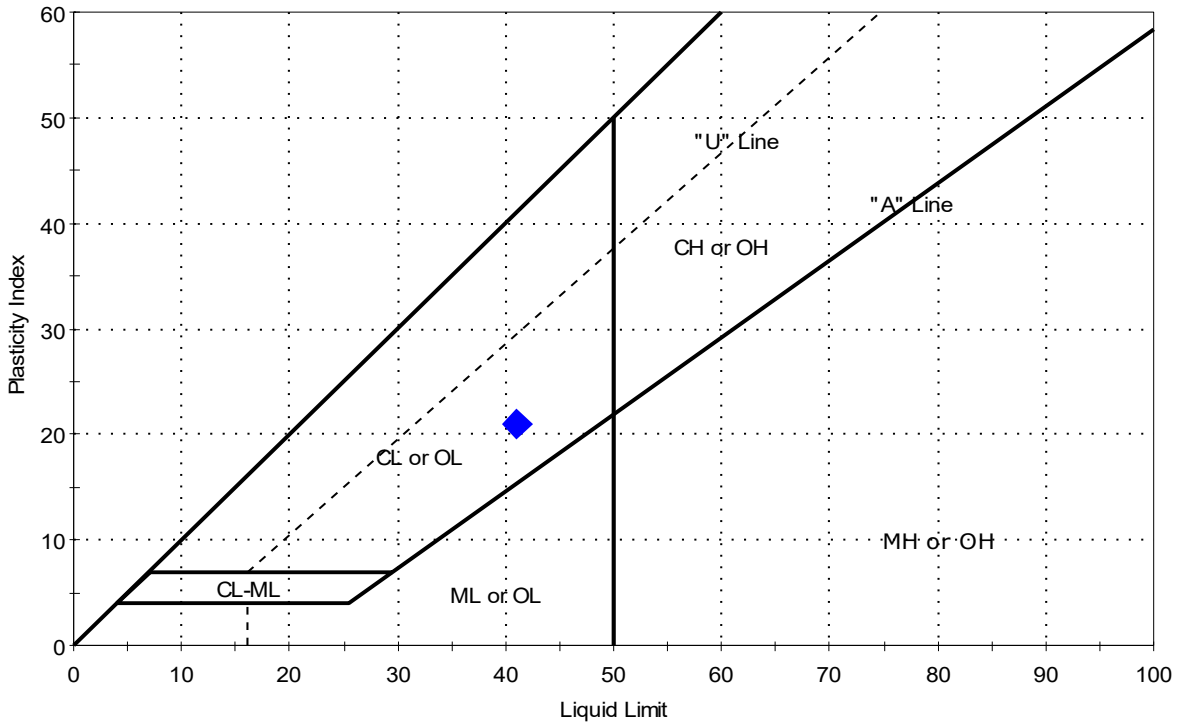
Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
BB-WHB-103	ST- 1	15-17 ft	Wet, dark gray clay	49.2
BB-WHB-105	S- 2	5-7 ft	Moist, dark gray clay	28.8

Notes: Temperature of Drying : 110º Celsius

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldeboro, ME			Project No:	GTX-310368
Boring ID:	BB-WHB-103	Sample Type:	tube	Tested By:	cam
Sample ID:	ST-1	Test Date:	08/06/19	Checked By:	bfs
Depth :	15-17 ft	Test Id:	516208		
Test Comment:	---				
Visual Description:	Wet, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318

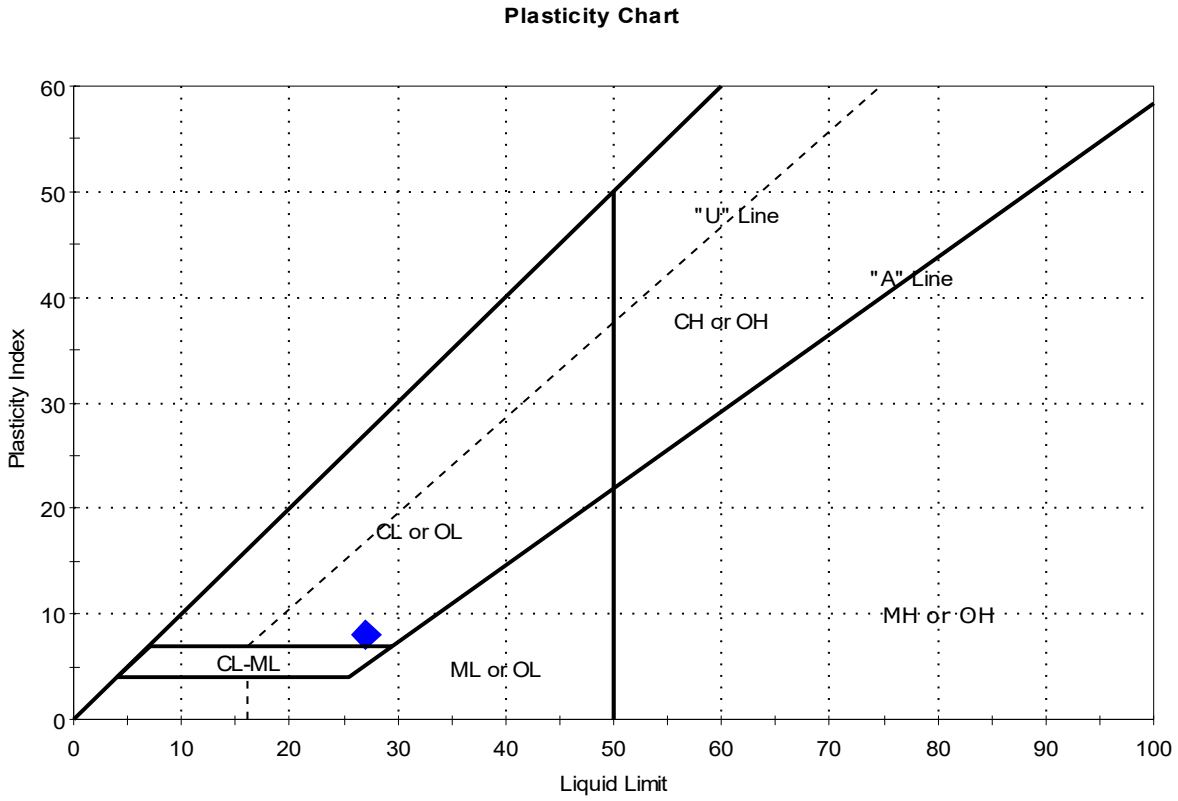


Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	ST-1	B-WHB-10	15-17 ft	49	41	20	21	1.4	Lean CLAY (CL)

Sample Prepared using the WET method
0% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilatancy: SLOW
Toughness: LOW

Client:	Nobis Engineering, Inc.				
Project:	Route 32 over Hook Brook				
Location:	Waldeboro, ME			Project No:	GTX-310368
Boring ID:	BB-WHB-105	Sample Type:	jar	Tested By:	cam
Sample ID:	S-2	Test Date:	08/05/19	Checked By:	bfs
Depth :	5-7 ft	Test Id:	516209		
Test Comment:	---				
Visual Description:	Moist, dark gray clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318

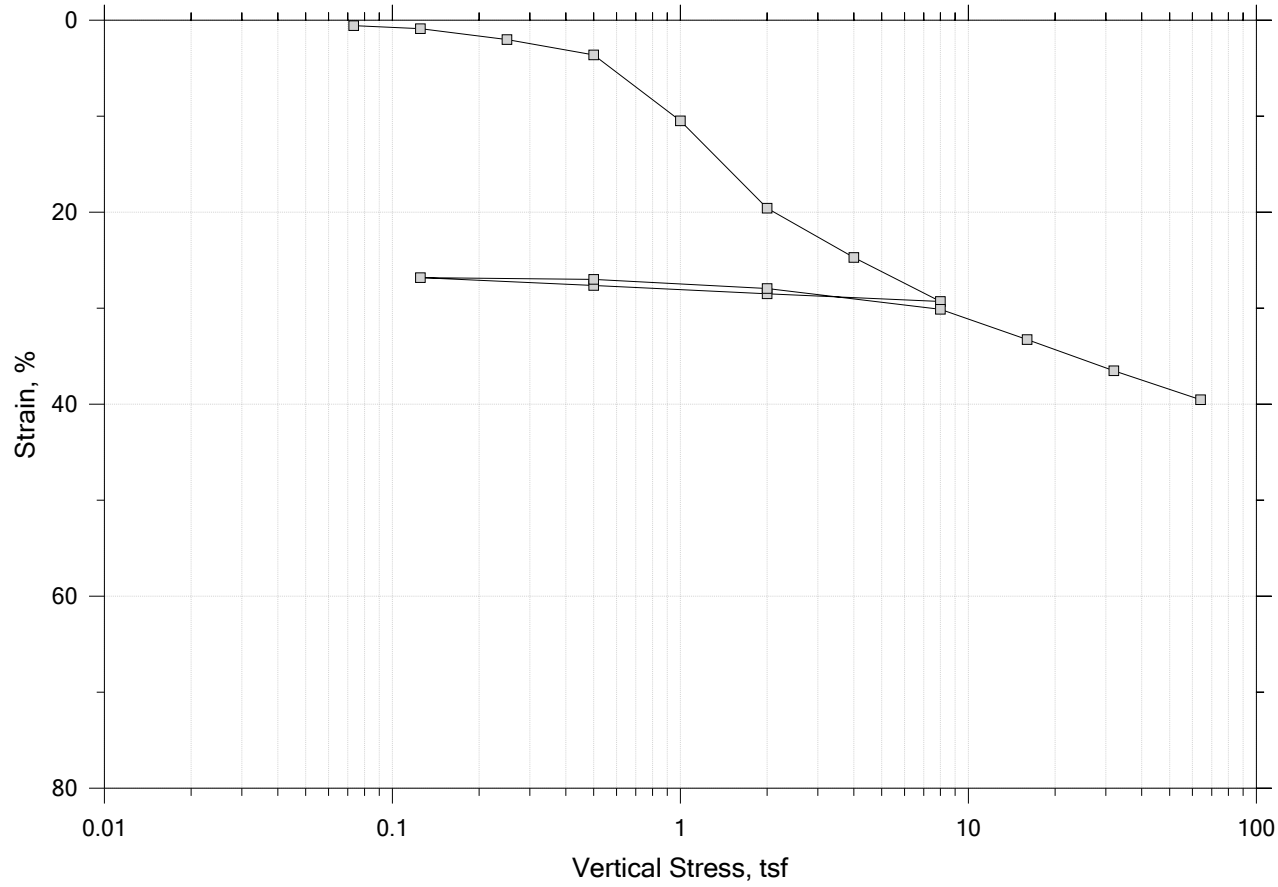


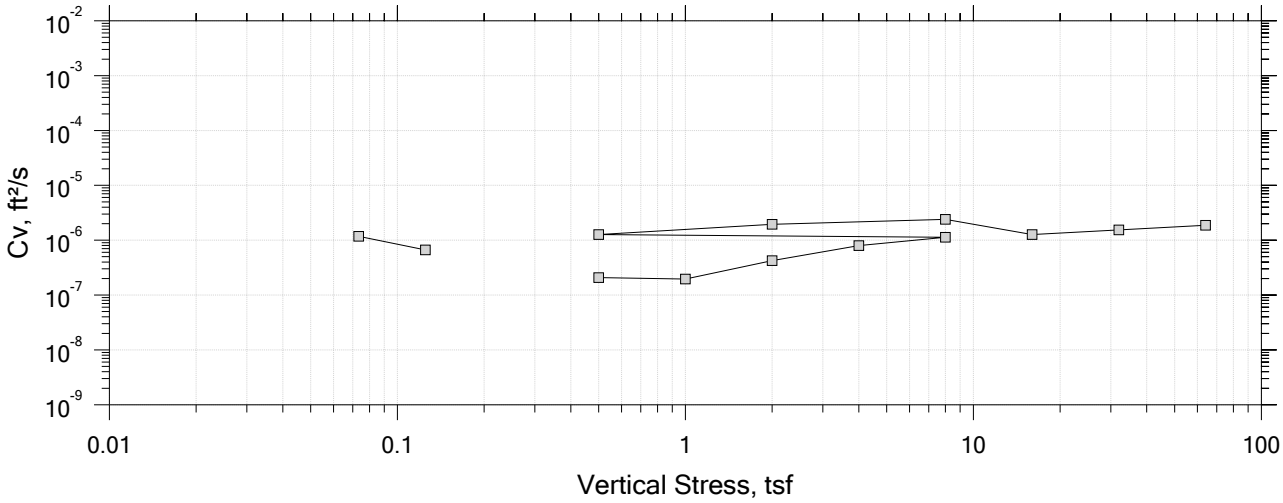
Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-2	B-WHB-10	5-7 ft	29	27	19	8	1.2	Lean CLAY (CL)

Sample Prepared using the WET method
2% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilatancy: RAPID
Toughness: LOW

One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report





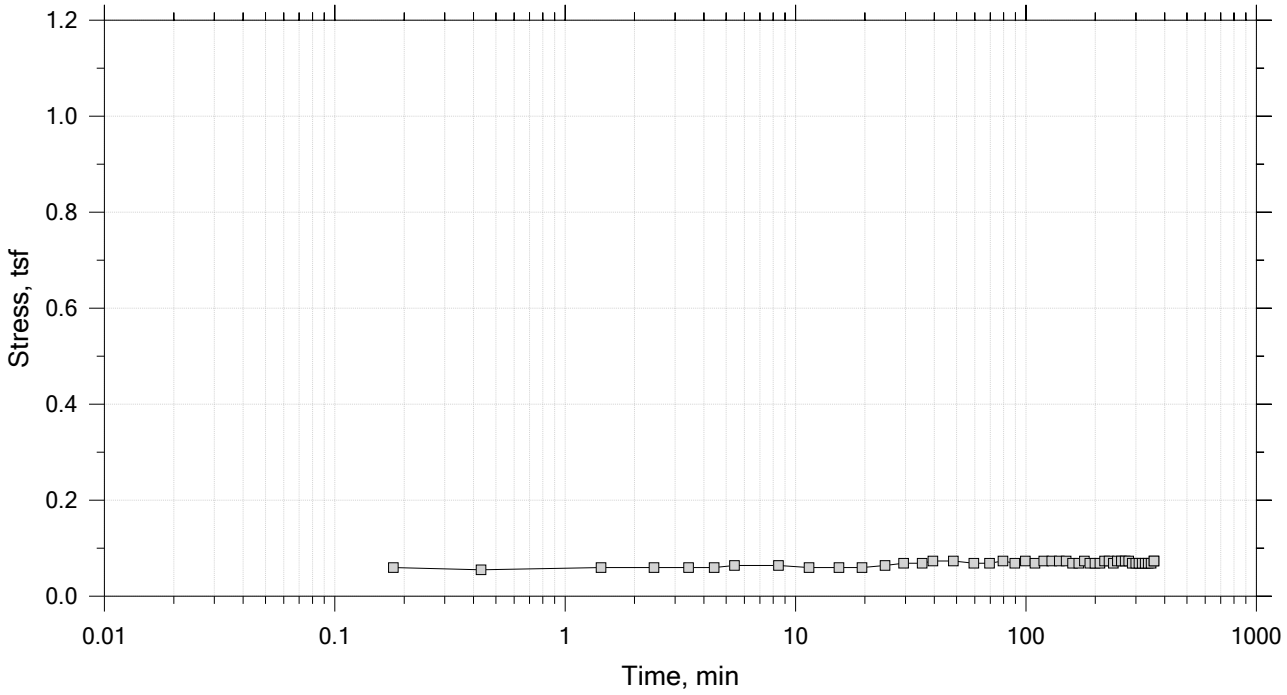
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		
	Displacement at End of Increment		

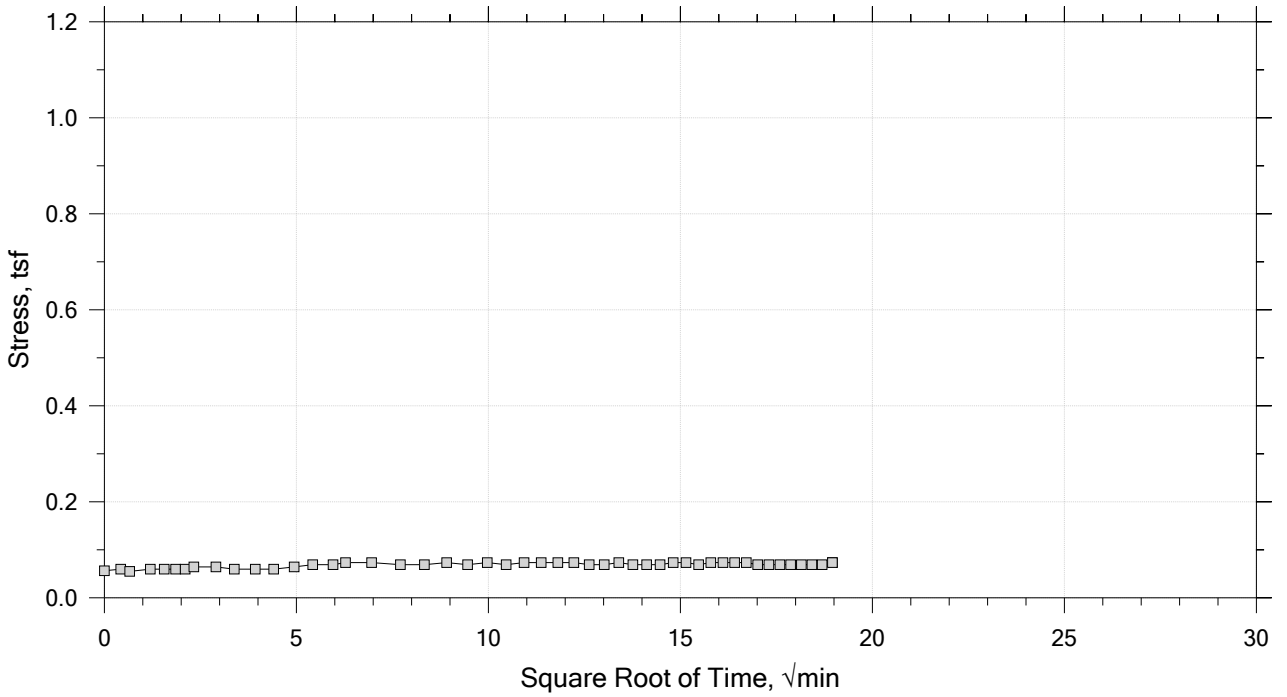
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 1 of 17

Constant Volume Step

Stress: 0.0734 tsf





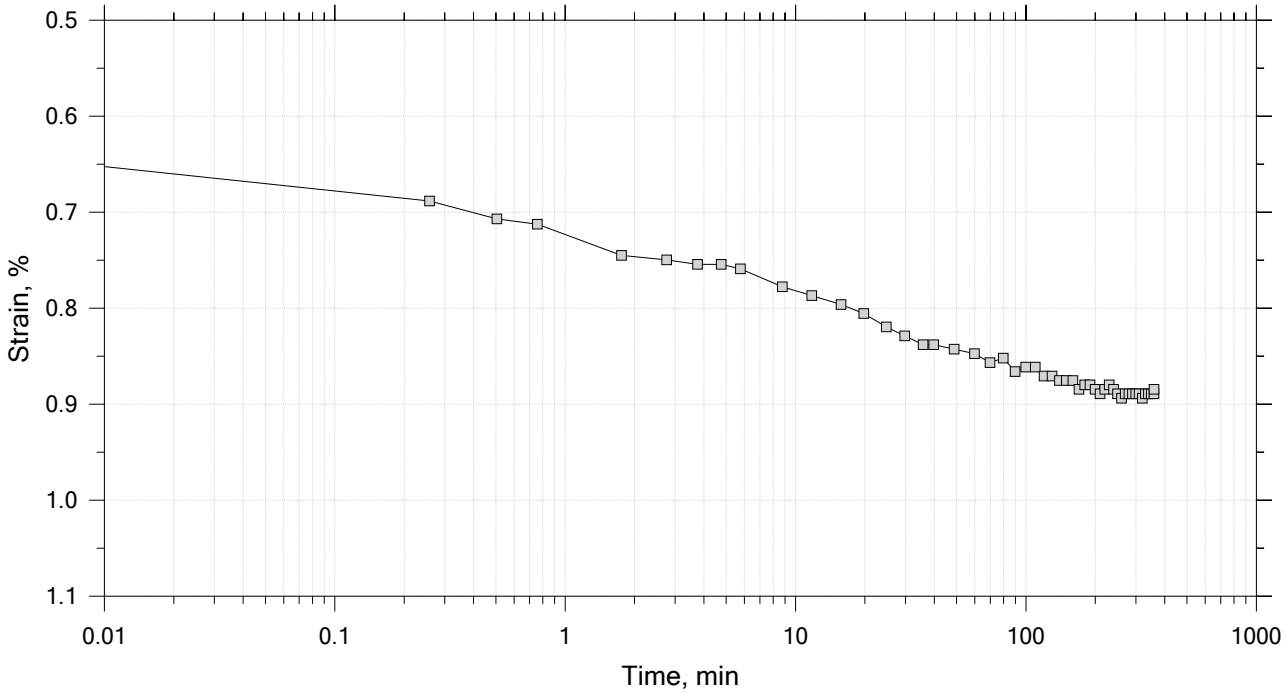
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

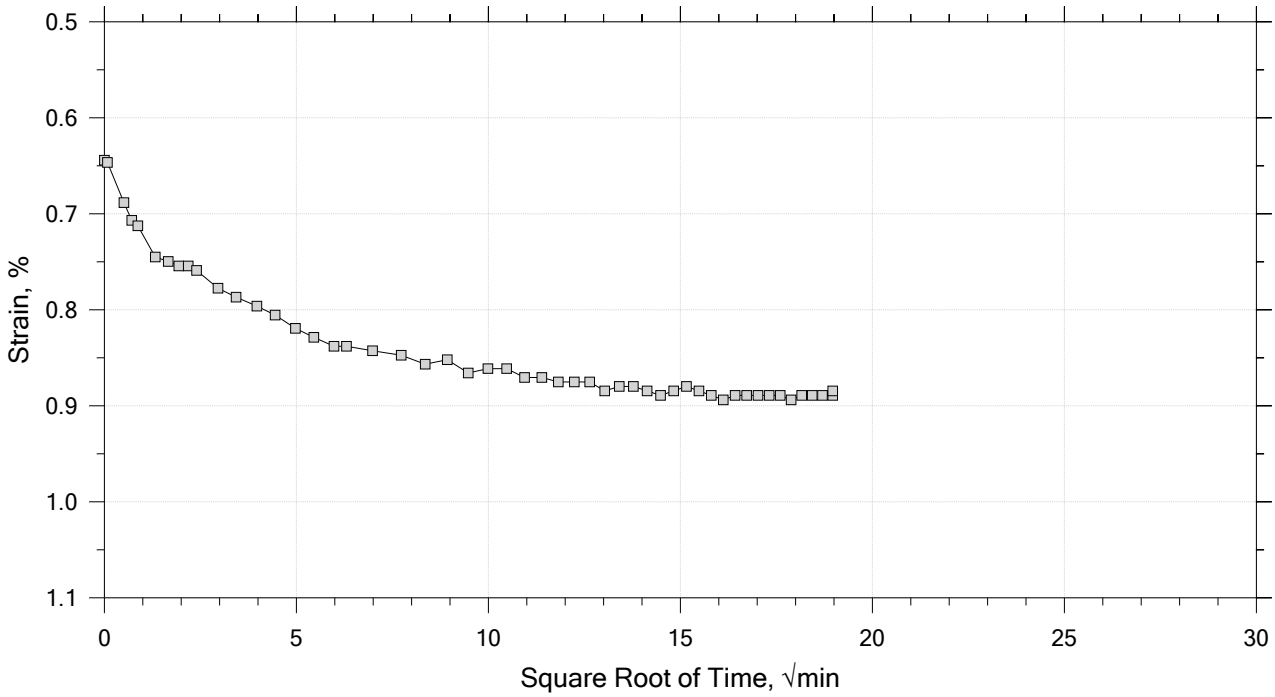
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 2 of 17

Constant Load Step

Stress: 0.125 tsf





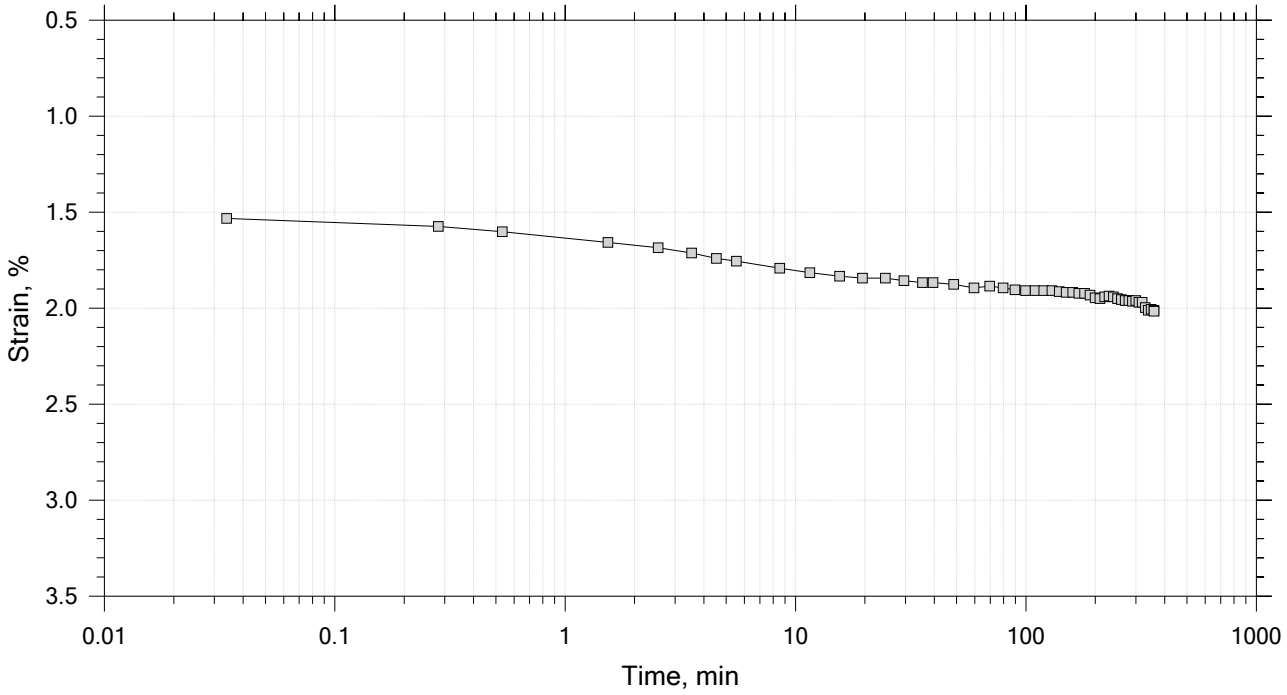
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

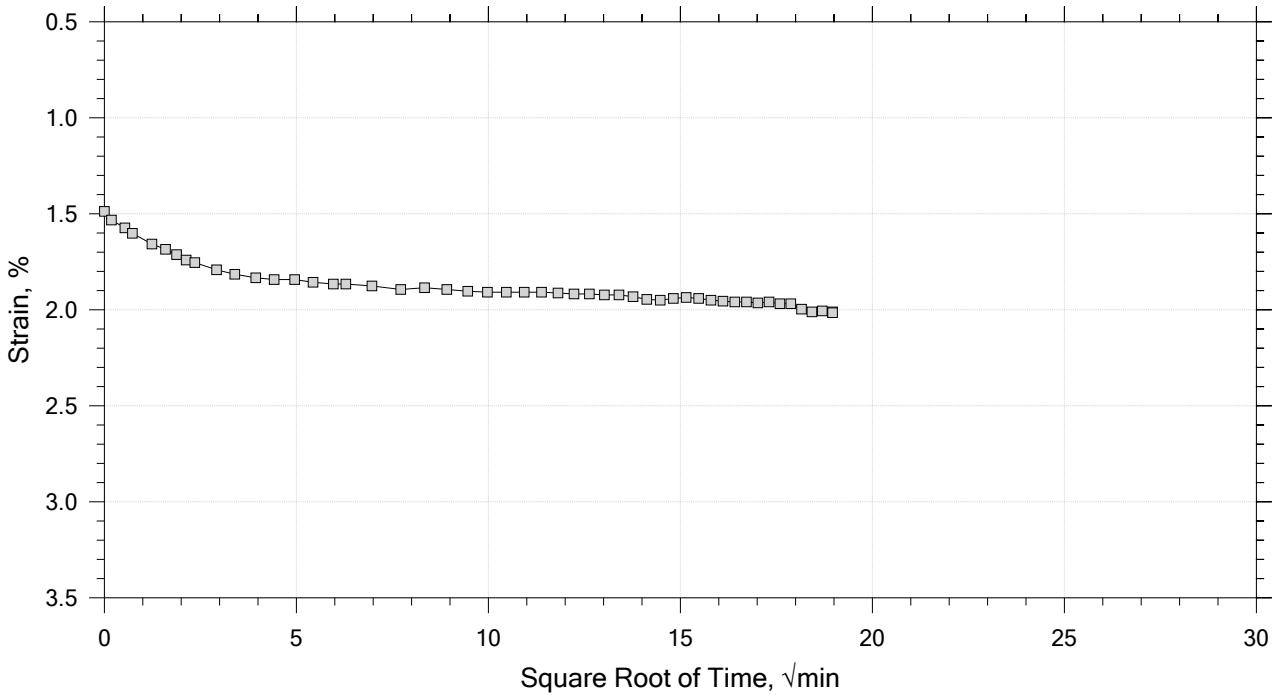
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 3 of 17

Constant Load Step

Stress: 0.25 tsf





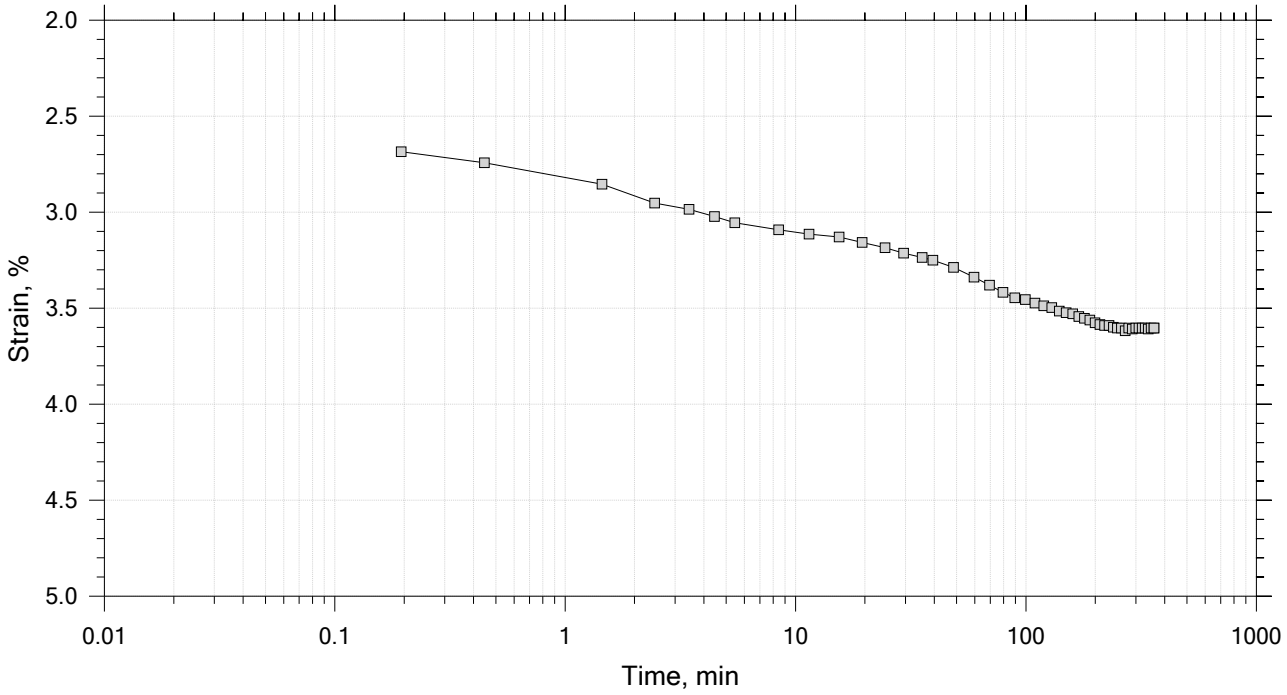
Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
Test No.: IP-1	Sample Type: Tube	Elevation: ---
Description: Wet, dark gray clay		
Remarks: System V, Swell Pressure = 0.0734 tsf		

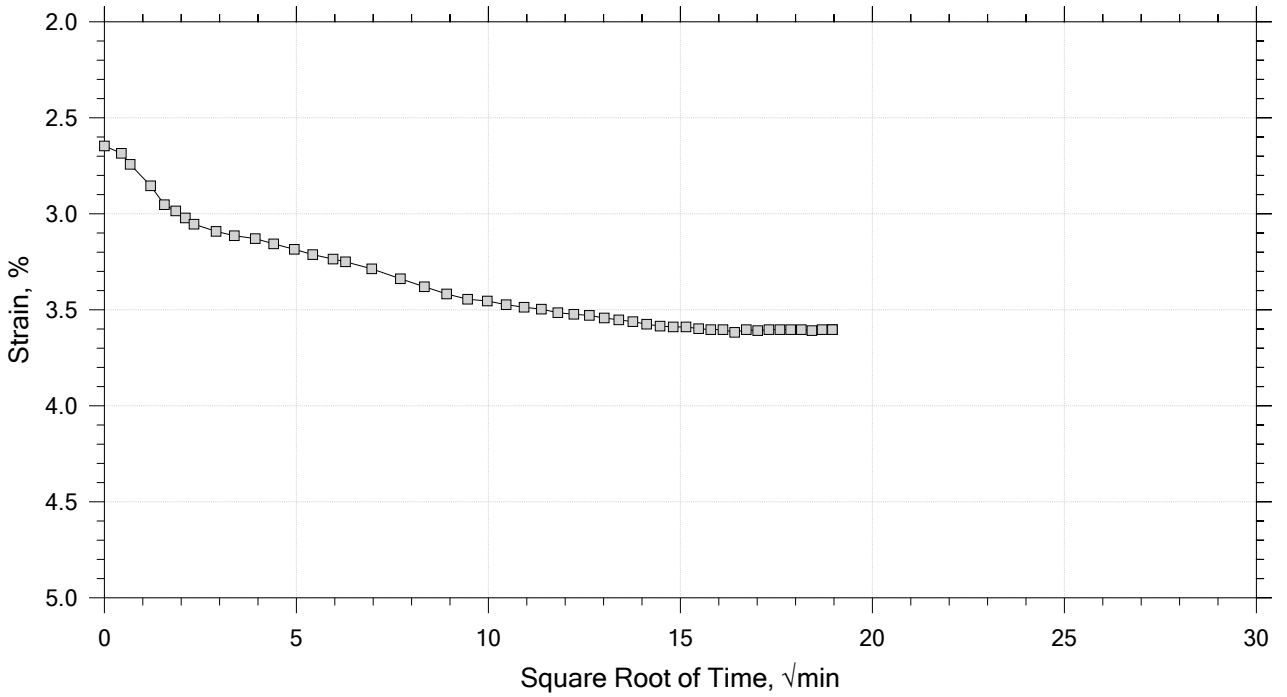
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 4 of 17

Constant Load Step

Stress: 0.5 tsf





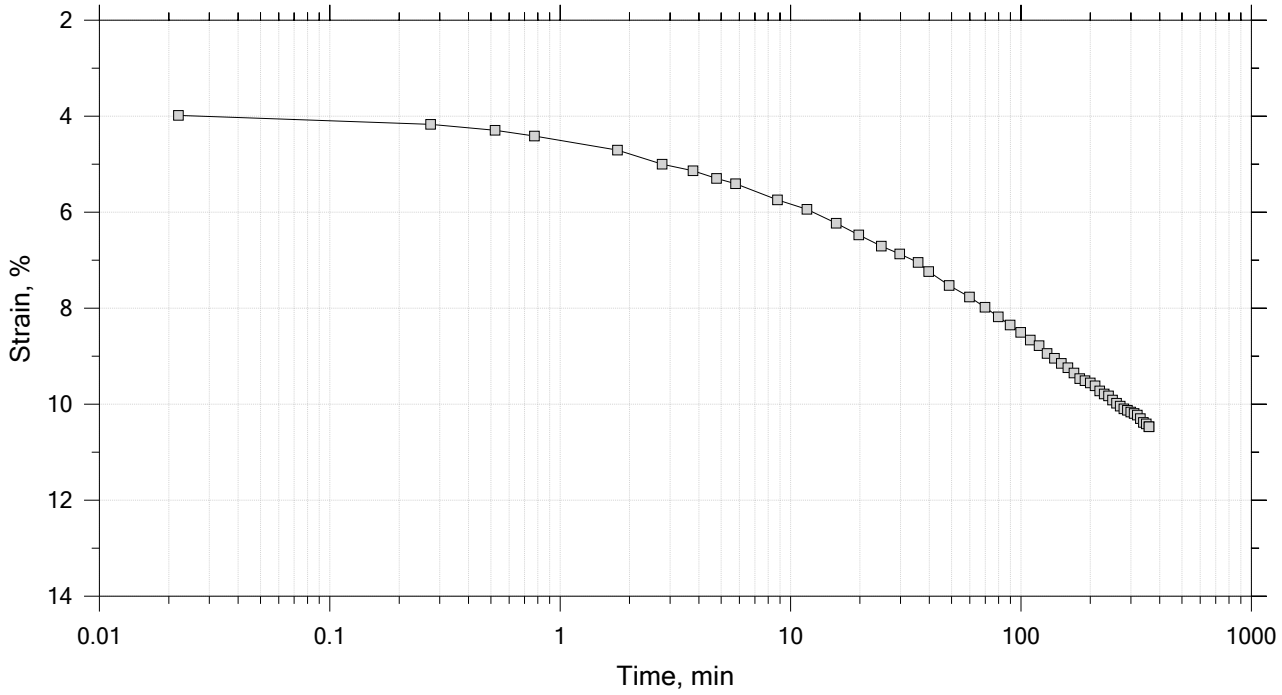
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

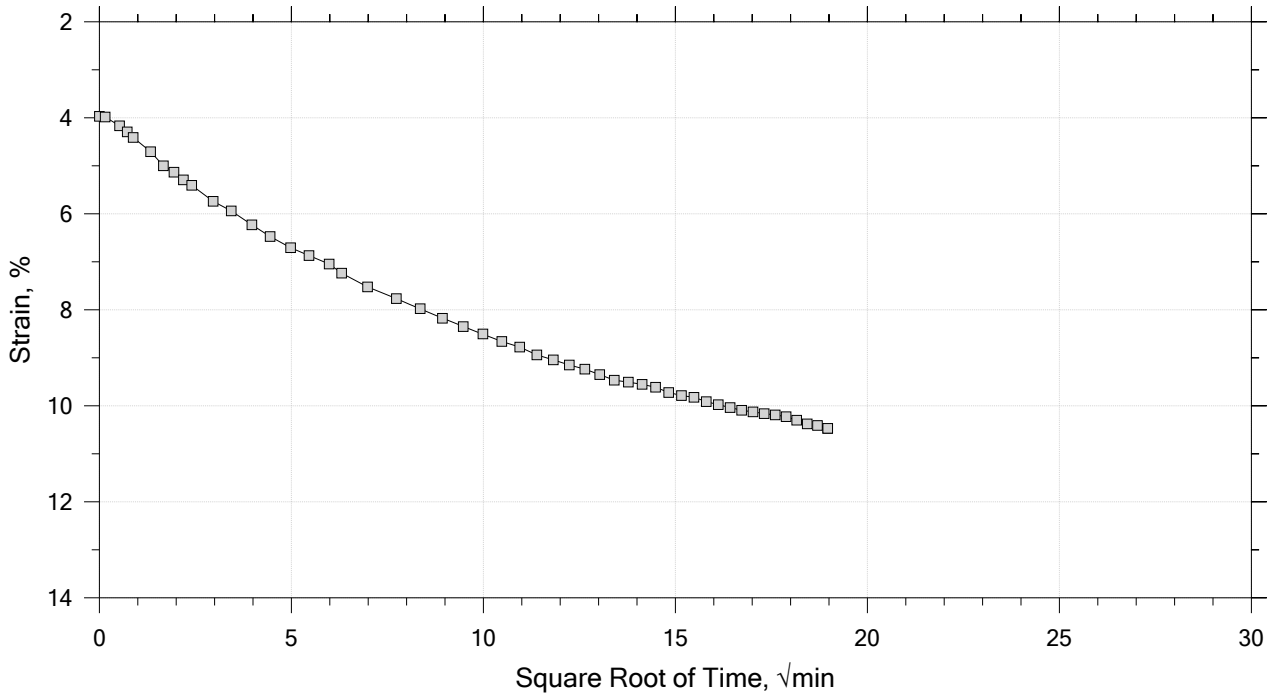
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 5 of 17

Constant Load Step

Stress: 1 tsf





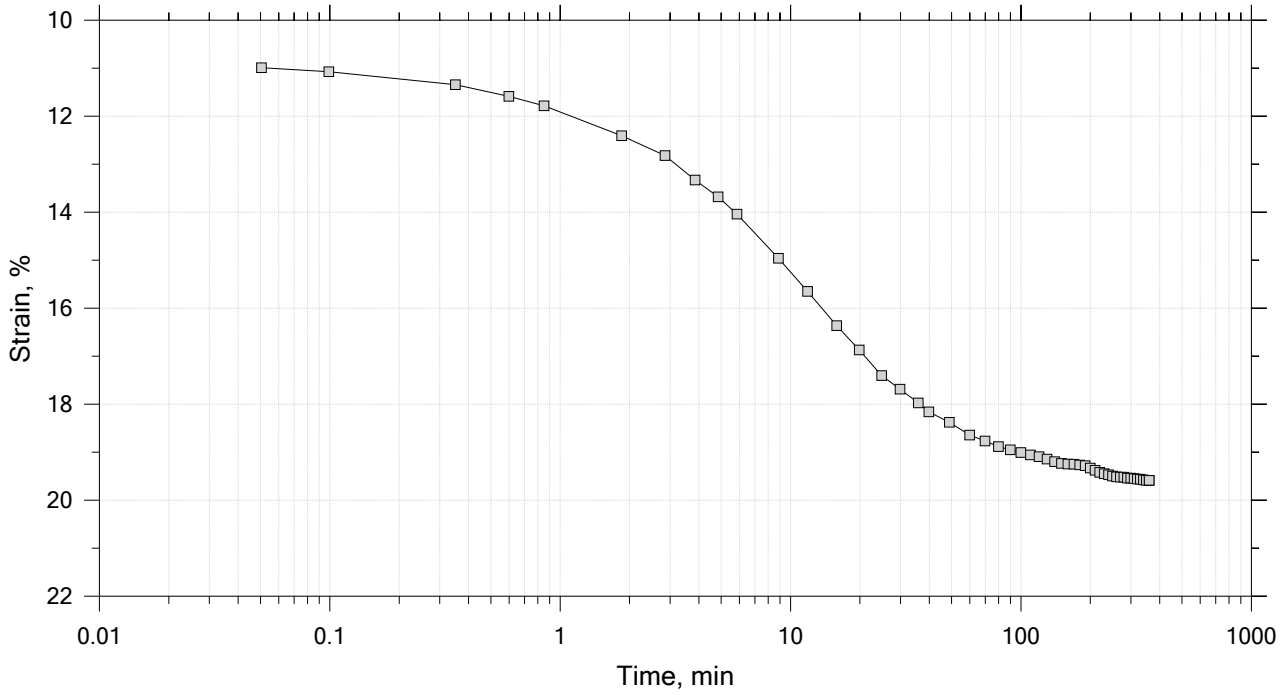
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

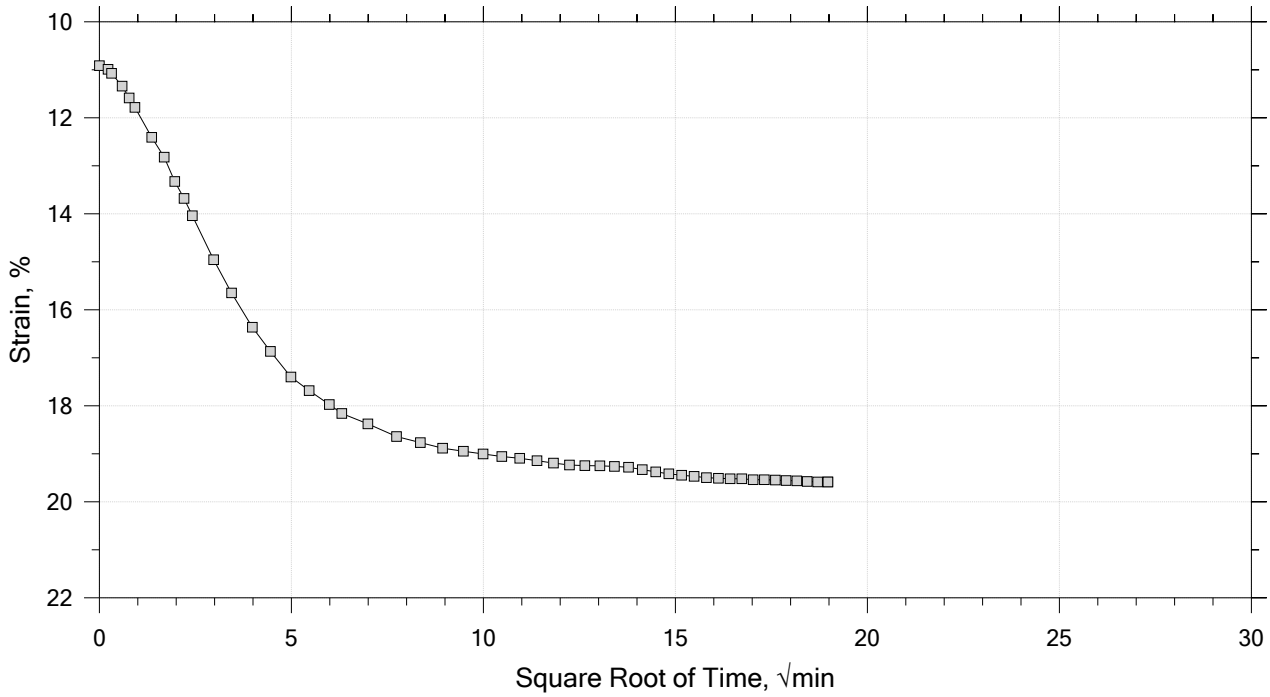
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 6 of 17

Constant Load Step

Stress: 2 tsf





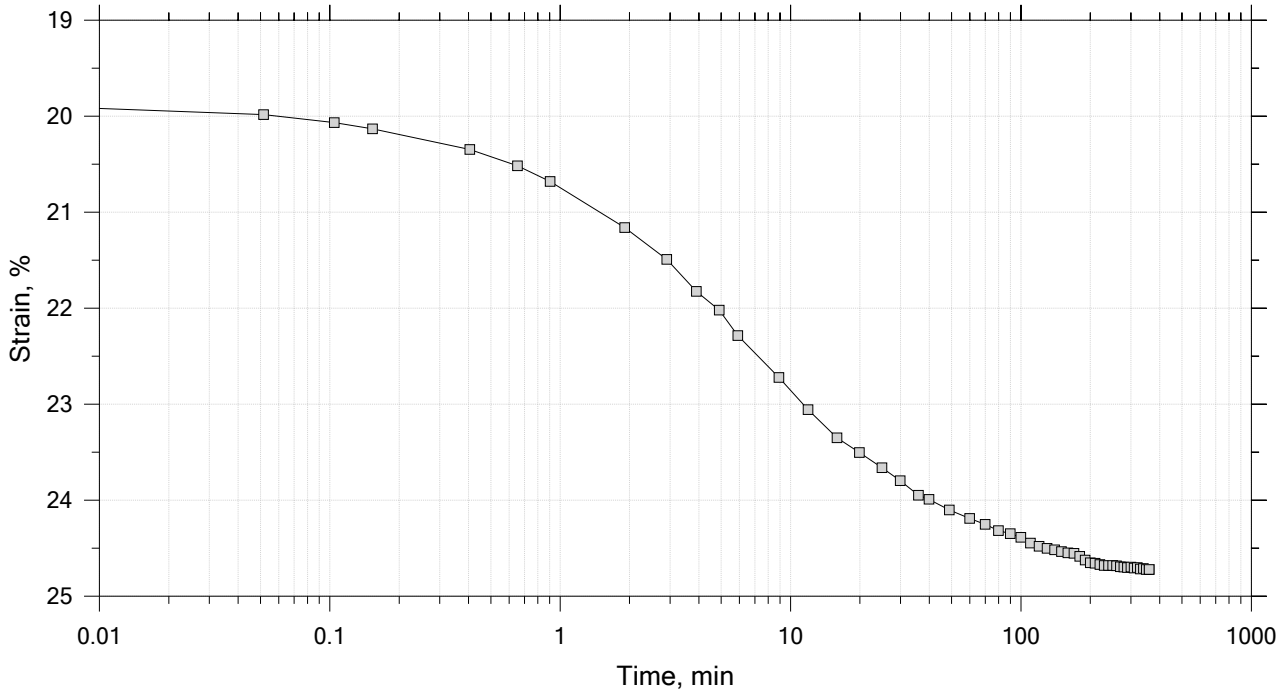
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

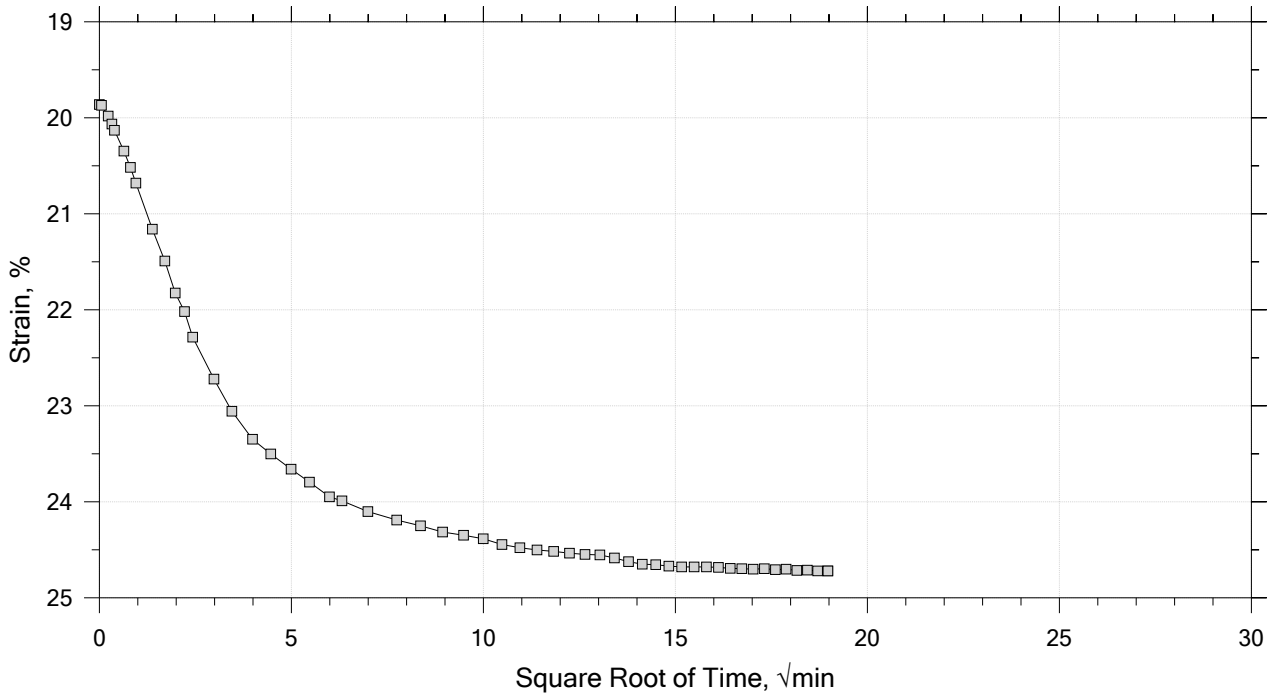
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 7 of 17

Constant Load Step

Stress: 4 tsf





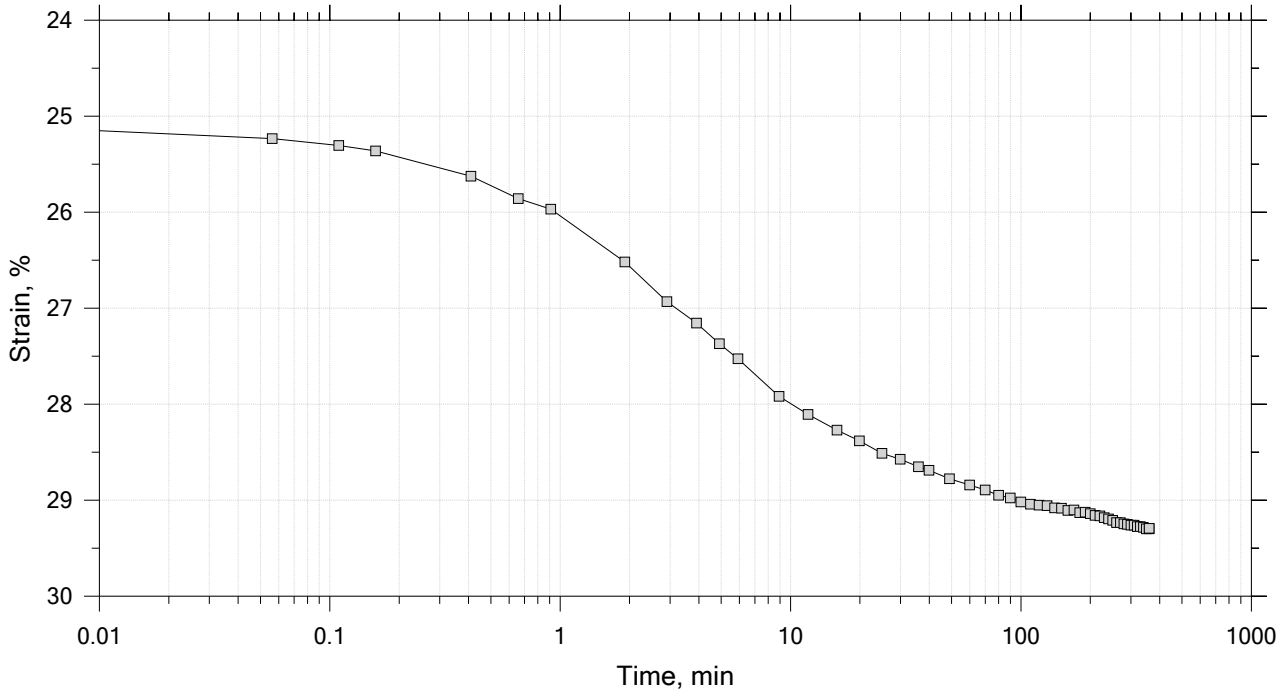
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

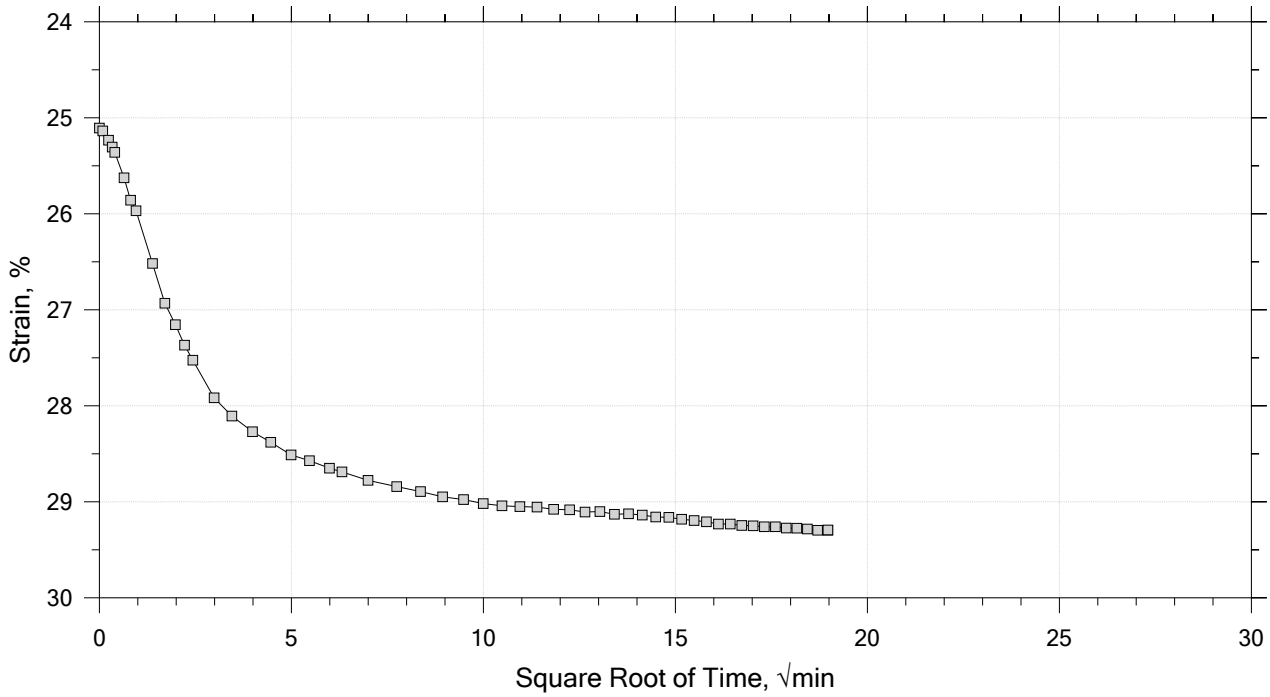
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 8 of 17

Constant Load Step

Stress: 8 tsf





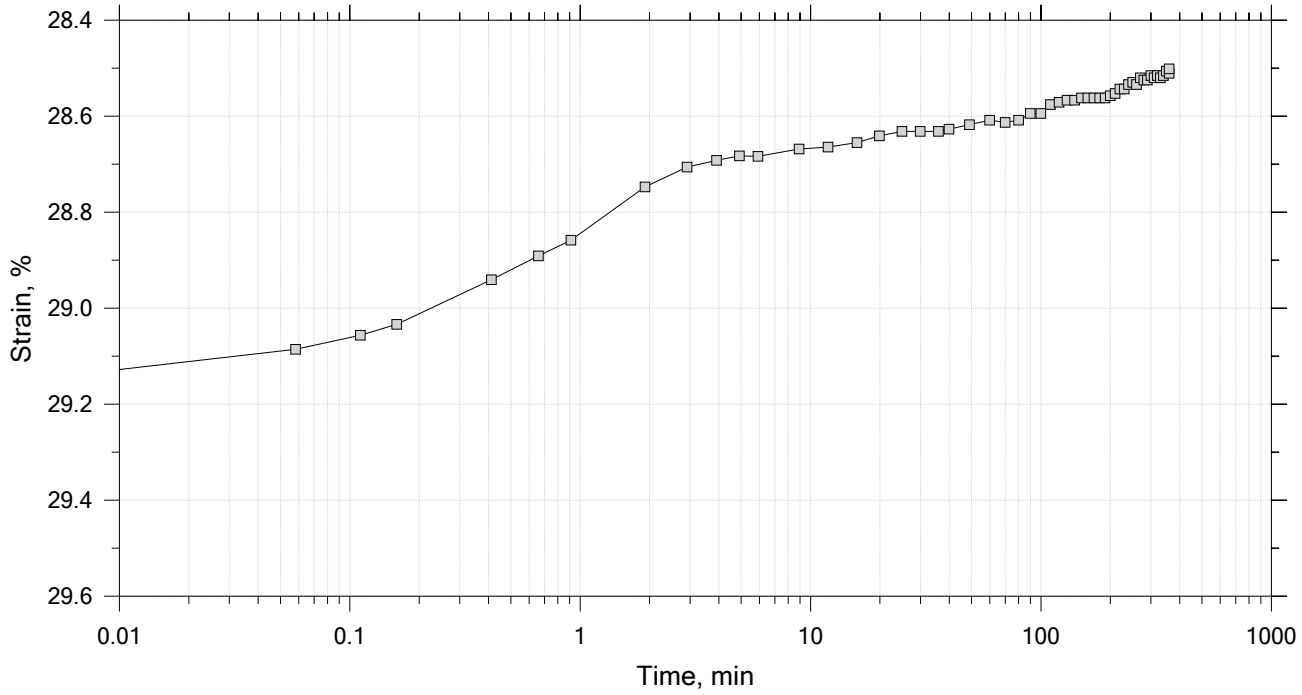
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

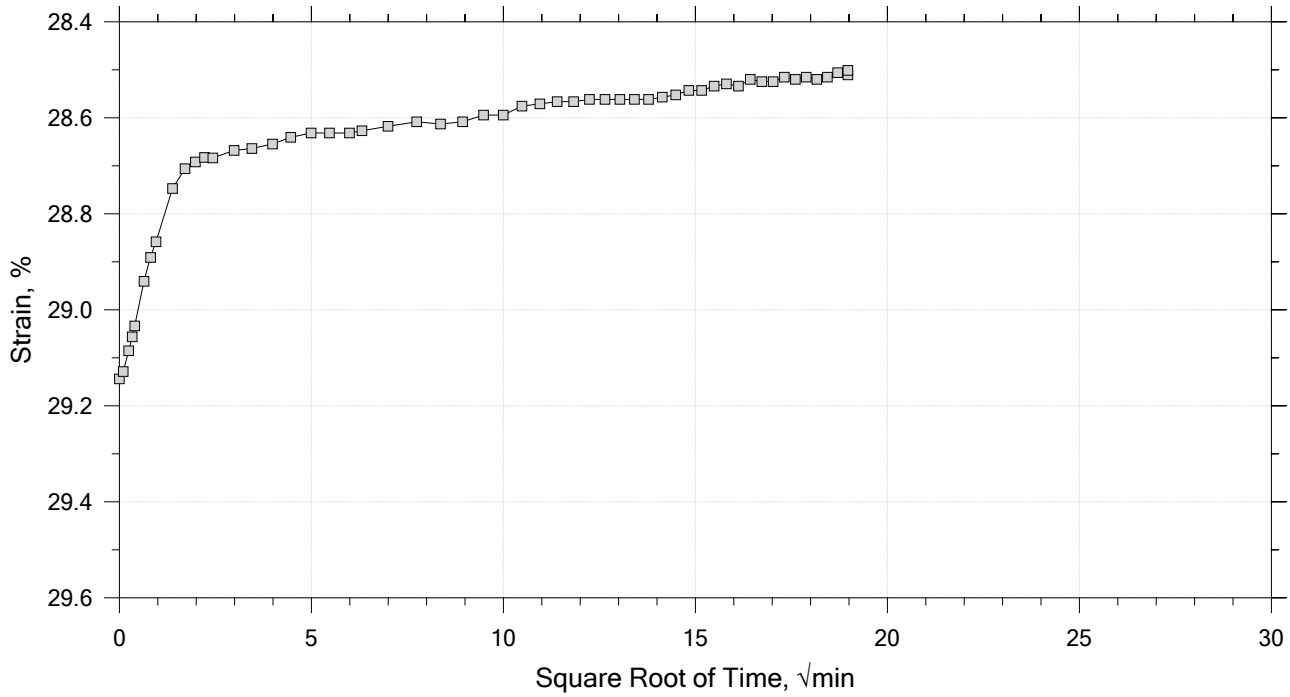
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 17

Constant Load Step

Stress: 2 tsf

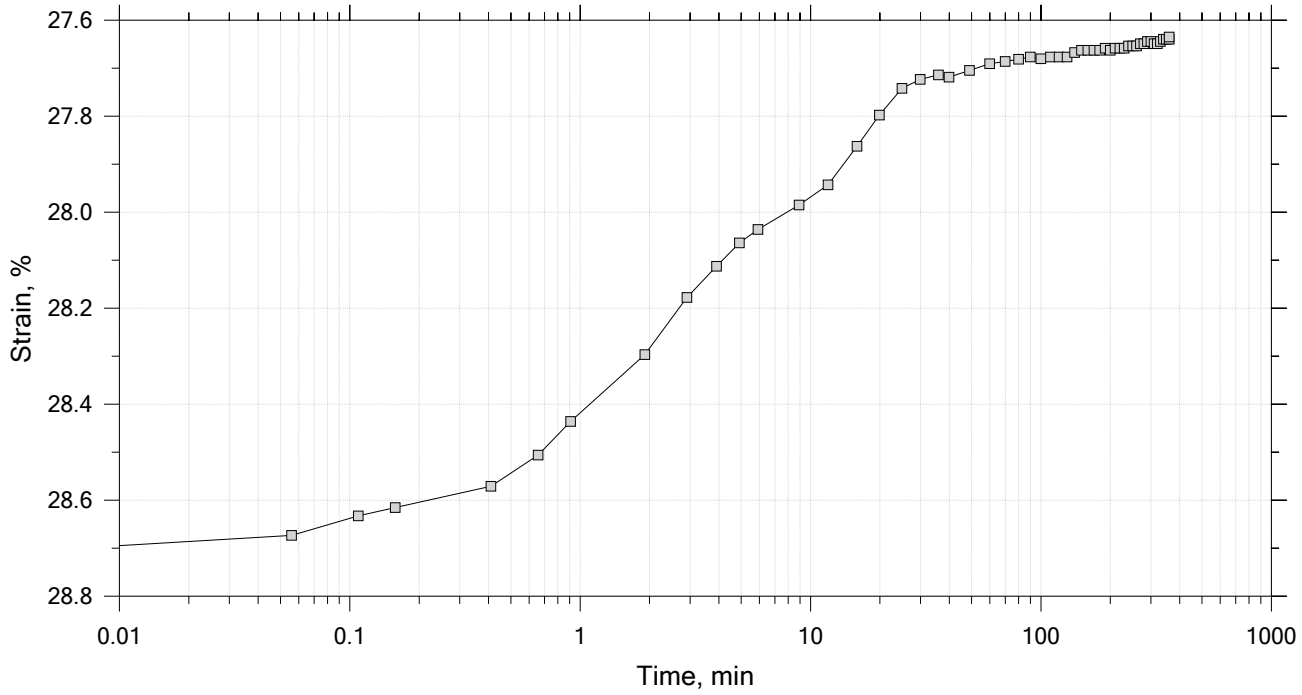


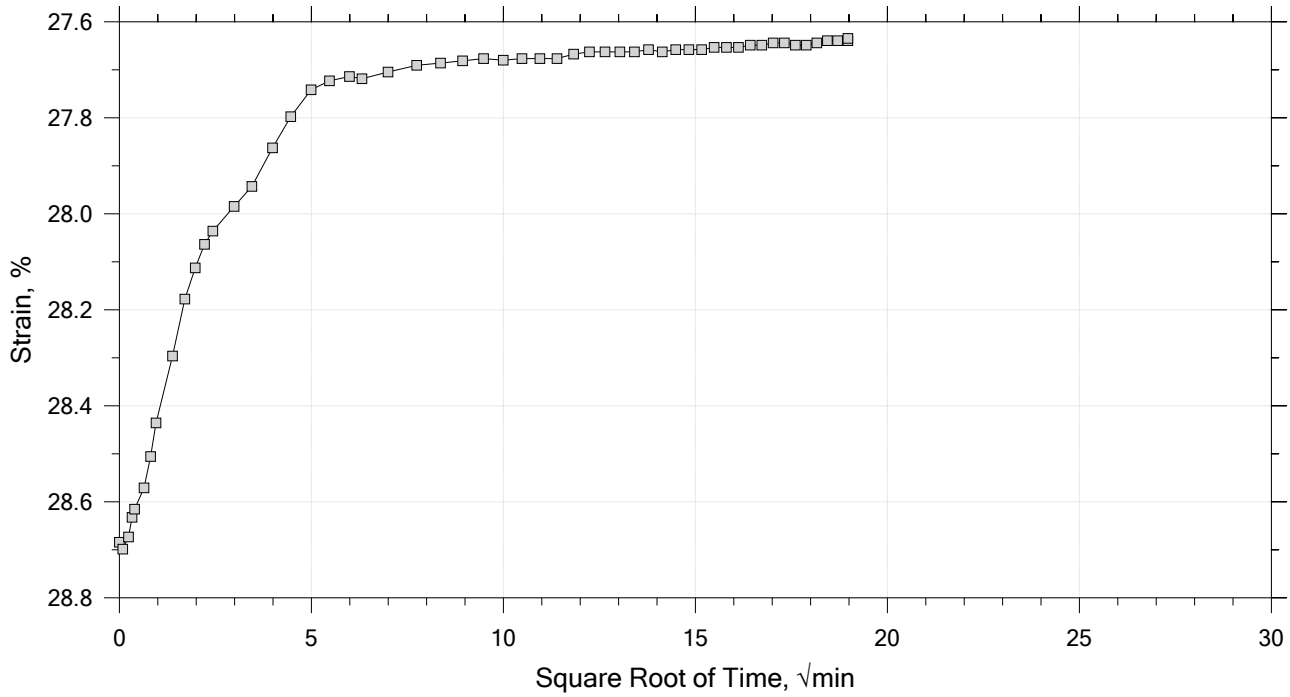


GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 17
Constant Load Step
Stress: 0.5 tsf

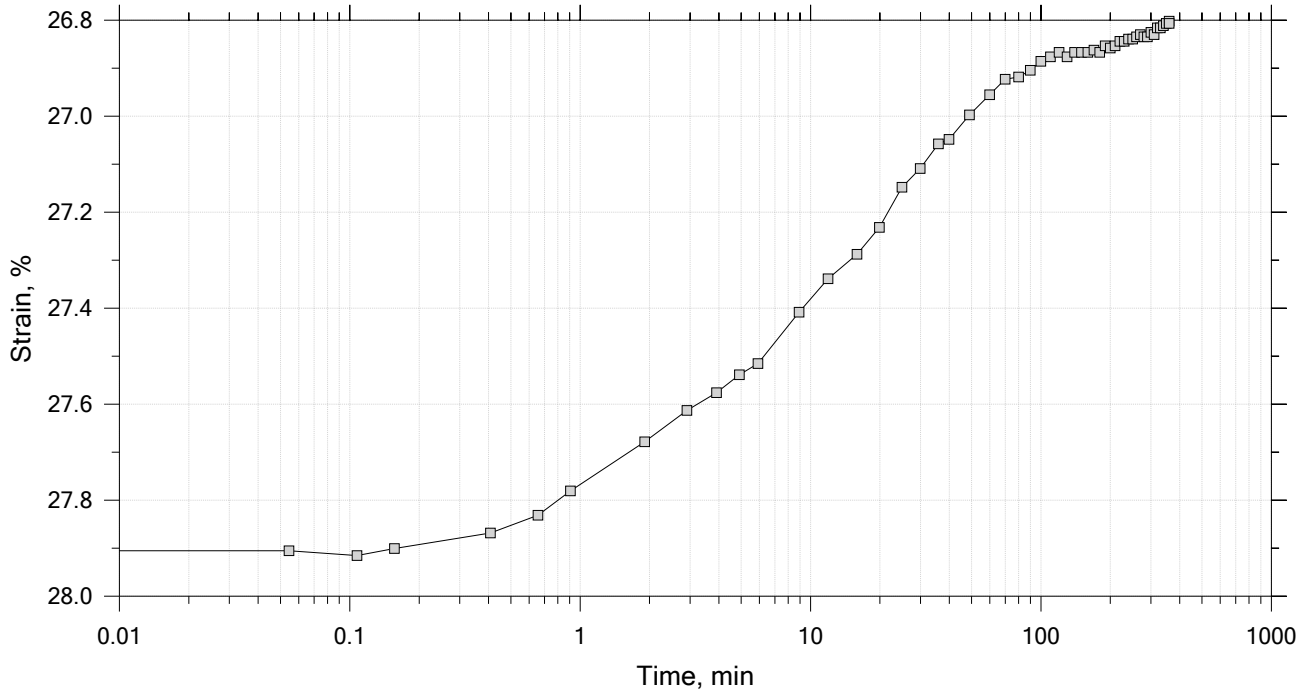


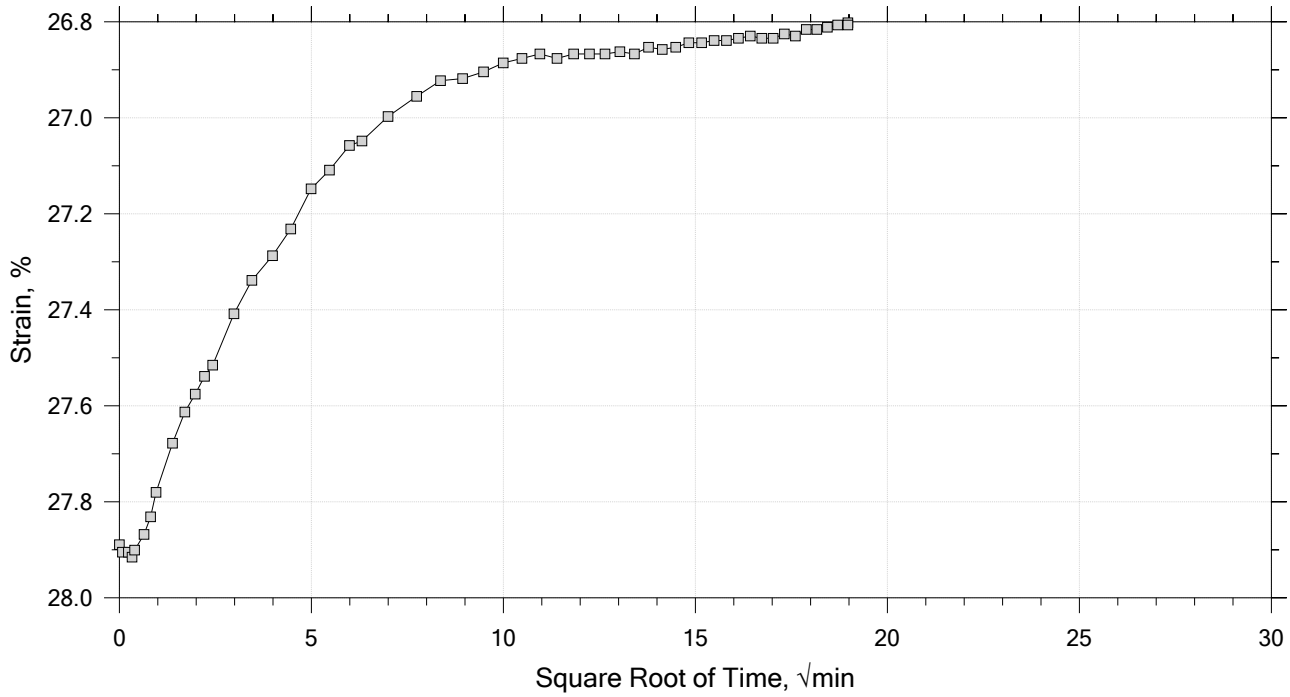


Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
Test No.: IP-1	Sample Type: Tube	Elevation: ---
Description: Wet, dark gray clay		
Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 17
Constant Load Step
Stress: 0.125 tsf

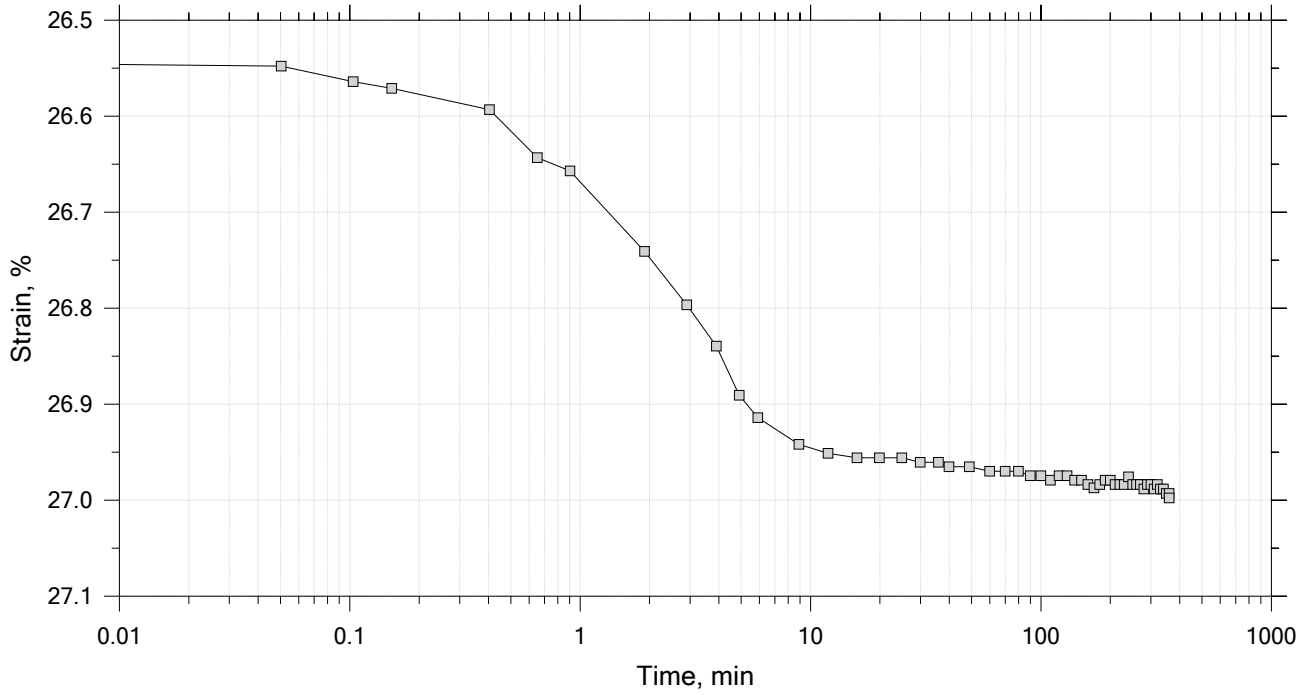


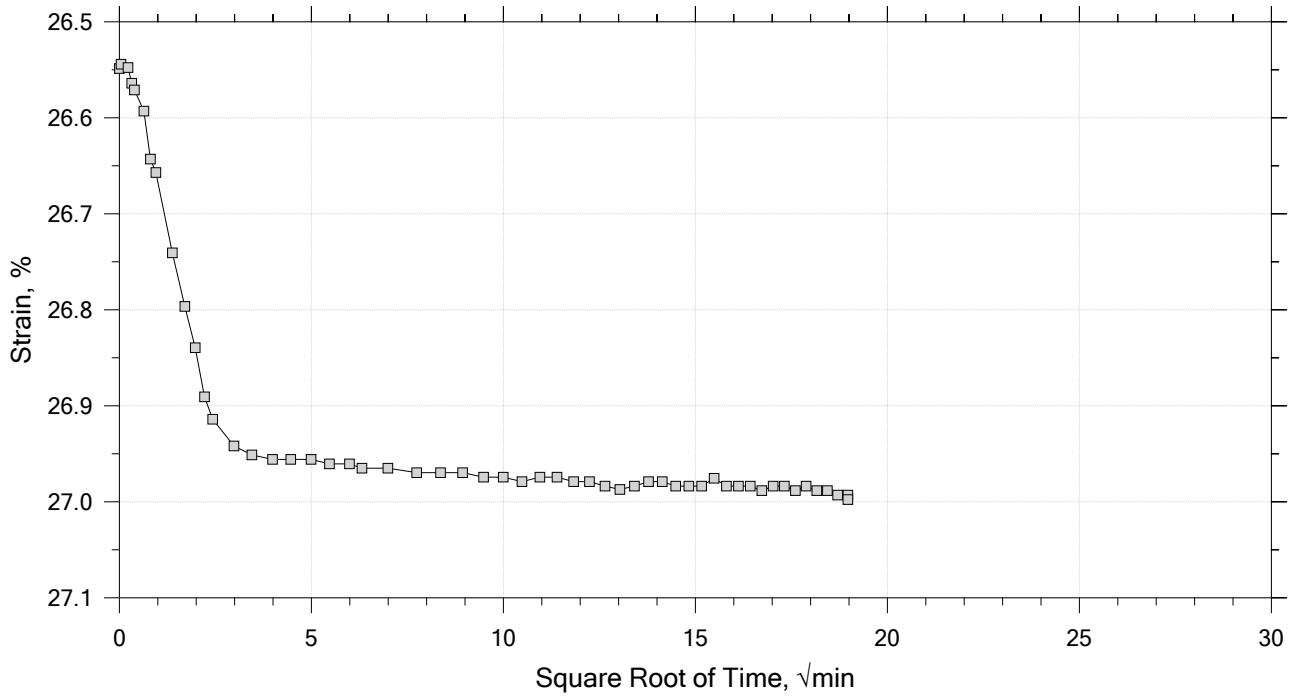


GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 17
Constant Load Step
Stress: 0.5 tsf

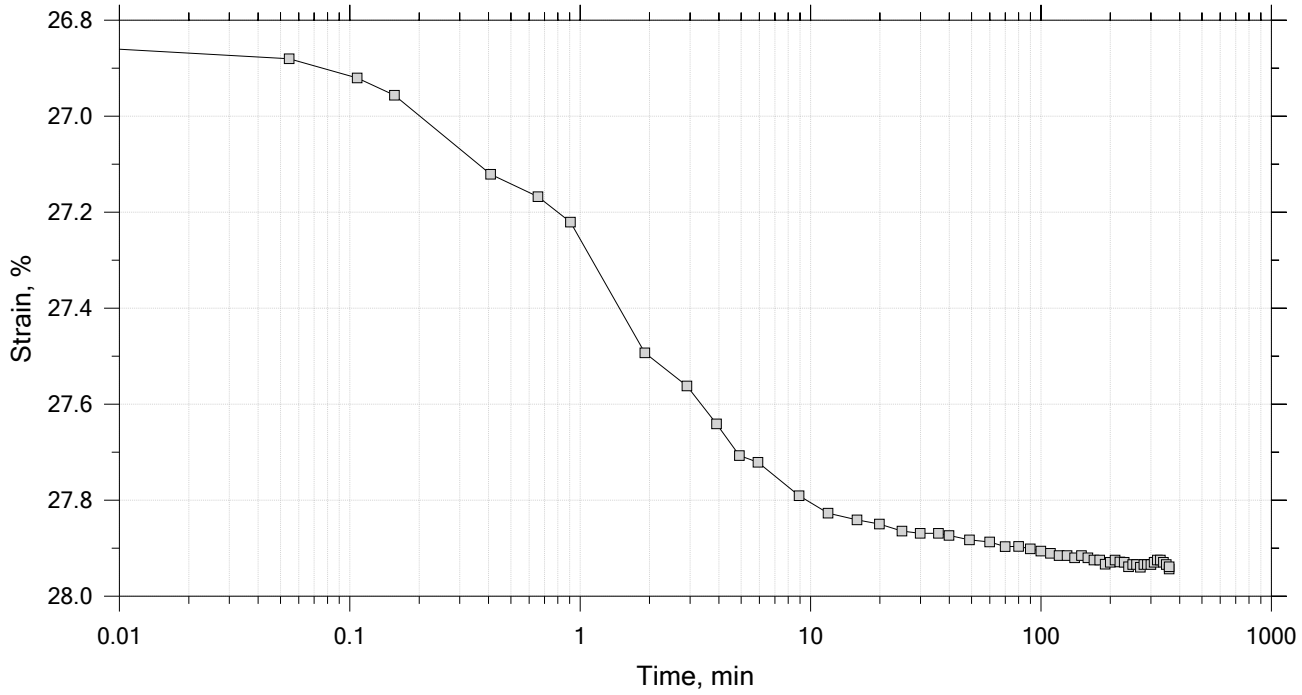


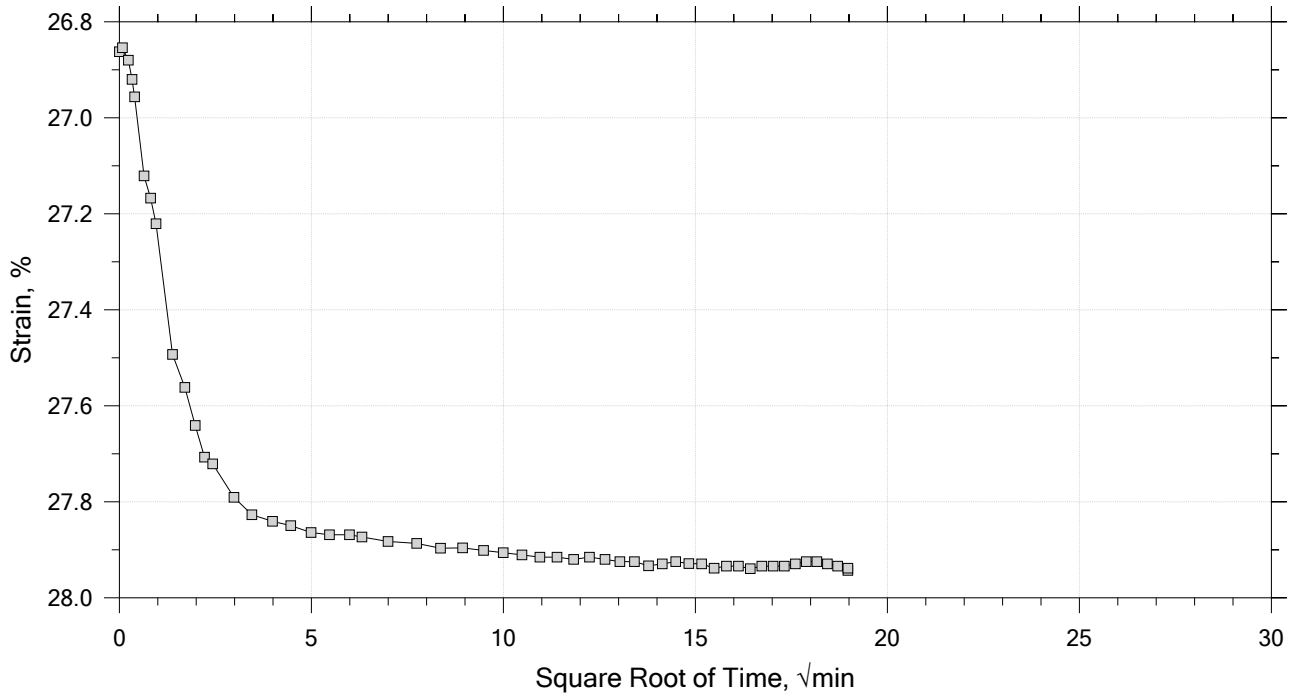


GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 17
Constant Load Step
Stress: 2 tsf

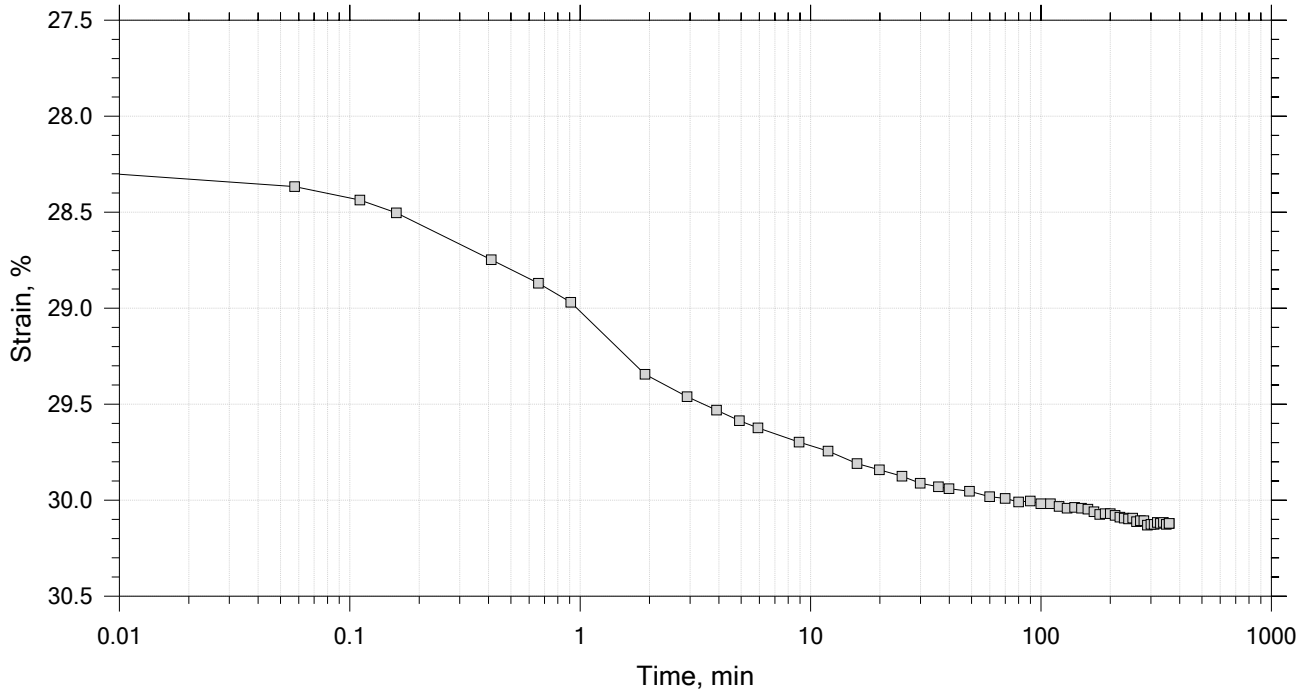


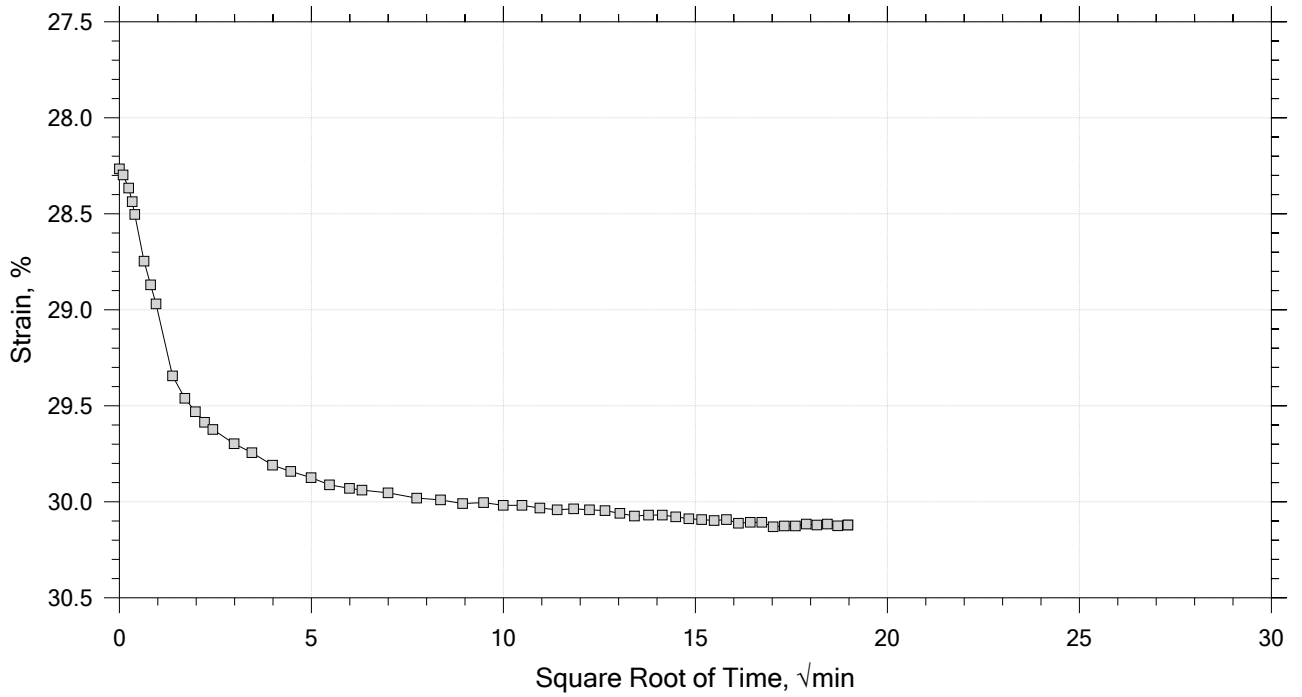


GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 17
Constant Load Step
Stress: 8 tsf

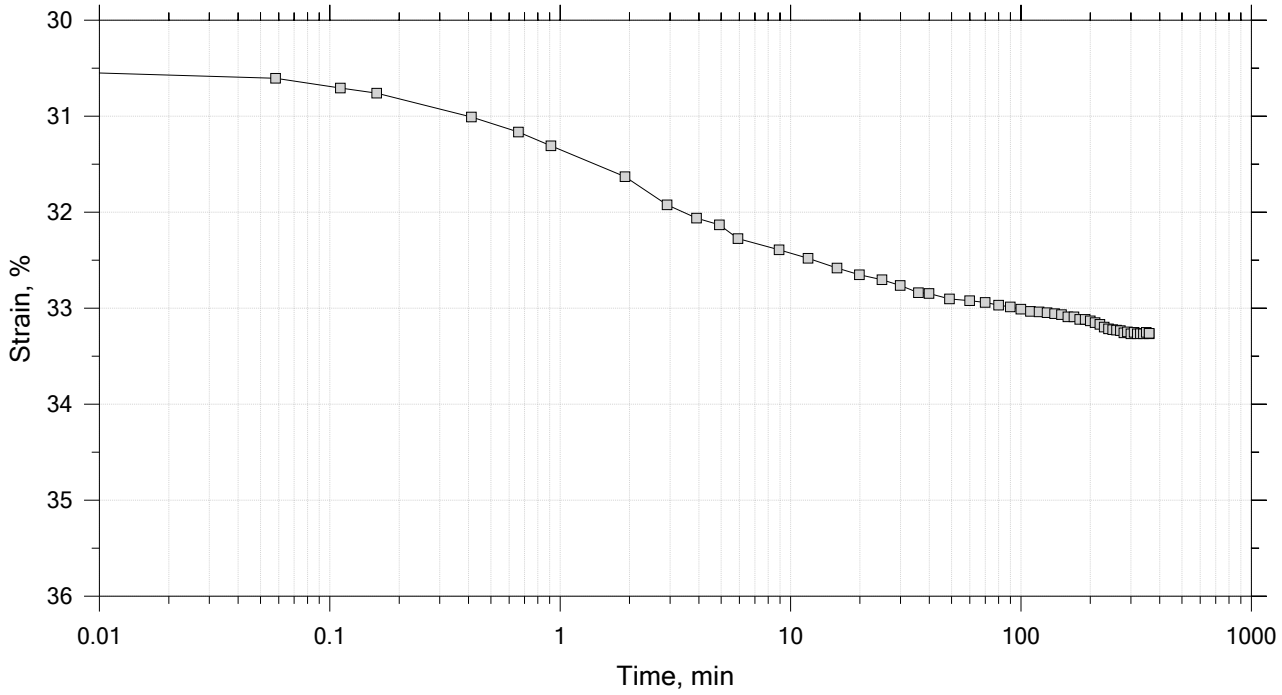


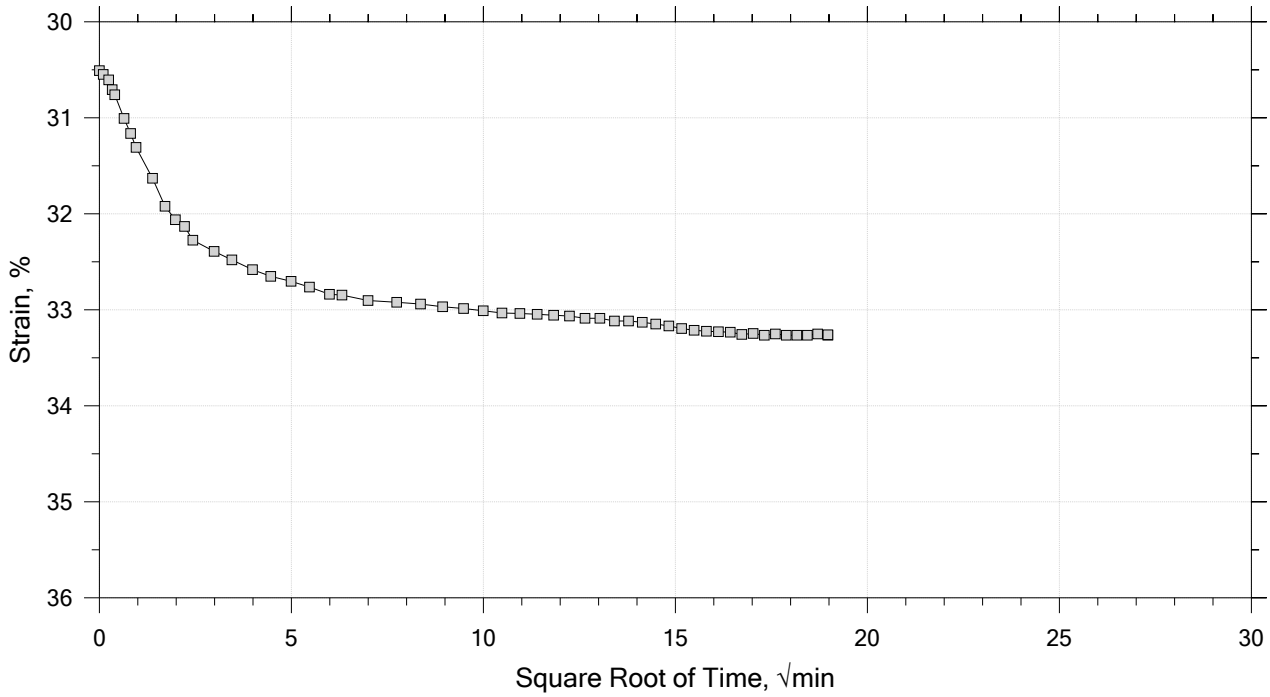


GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 17
Constant Load Step
Stress: 16 tsf





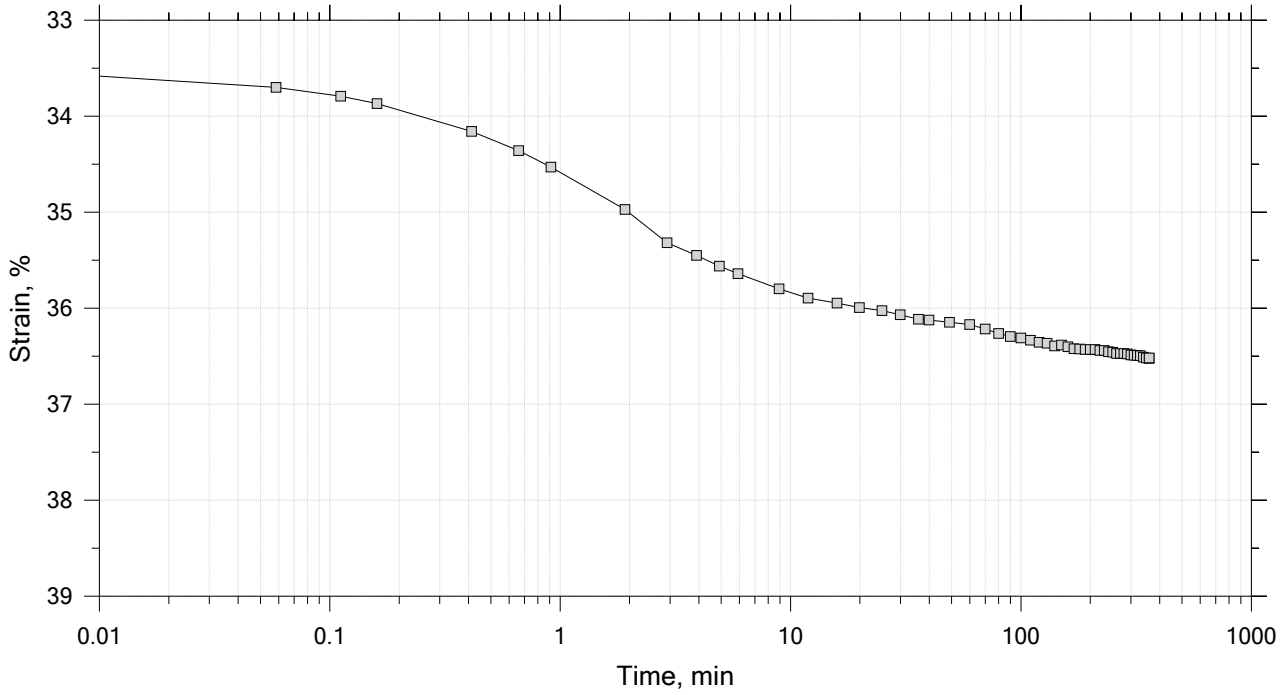
GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

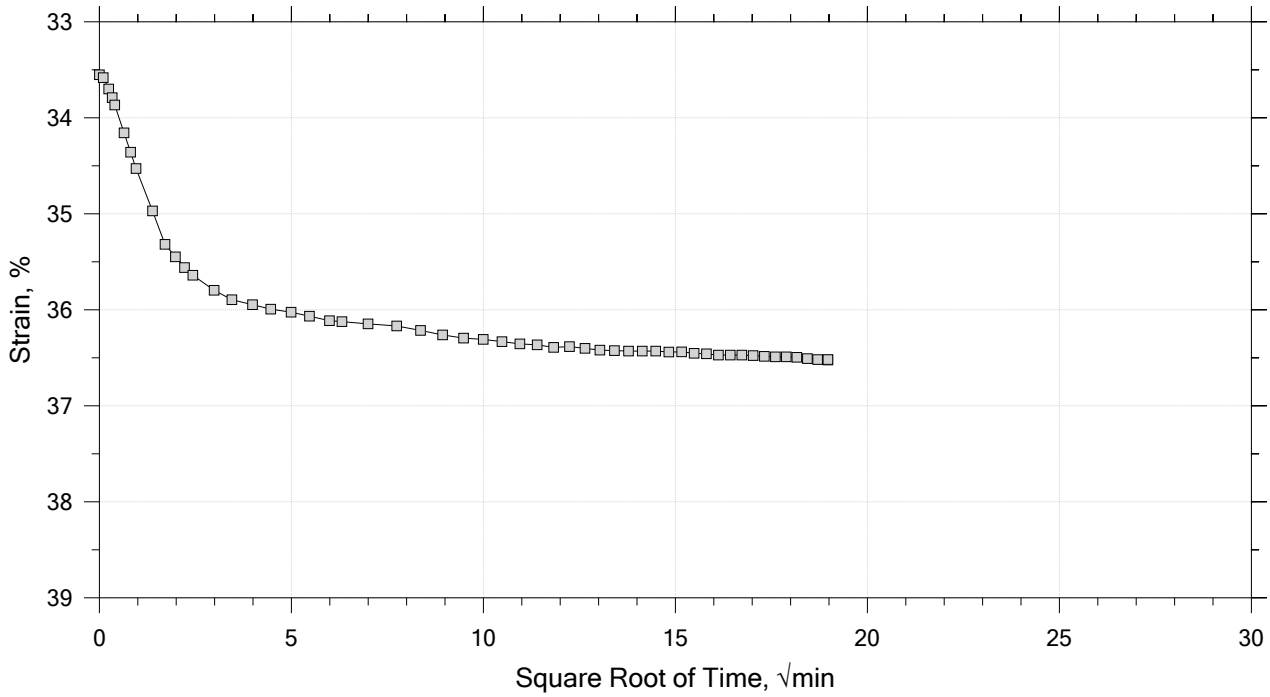
One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 16 of 17

Constant Load Step

Stress: 32 tsf

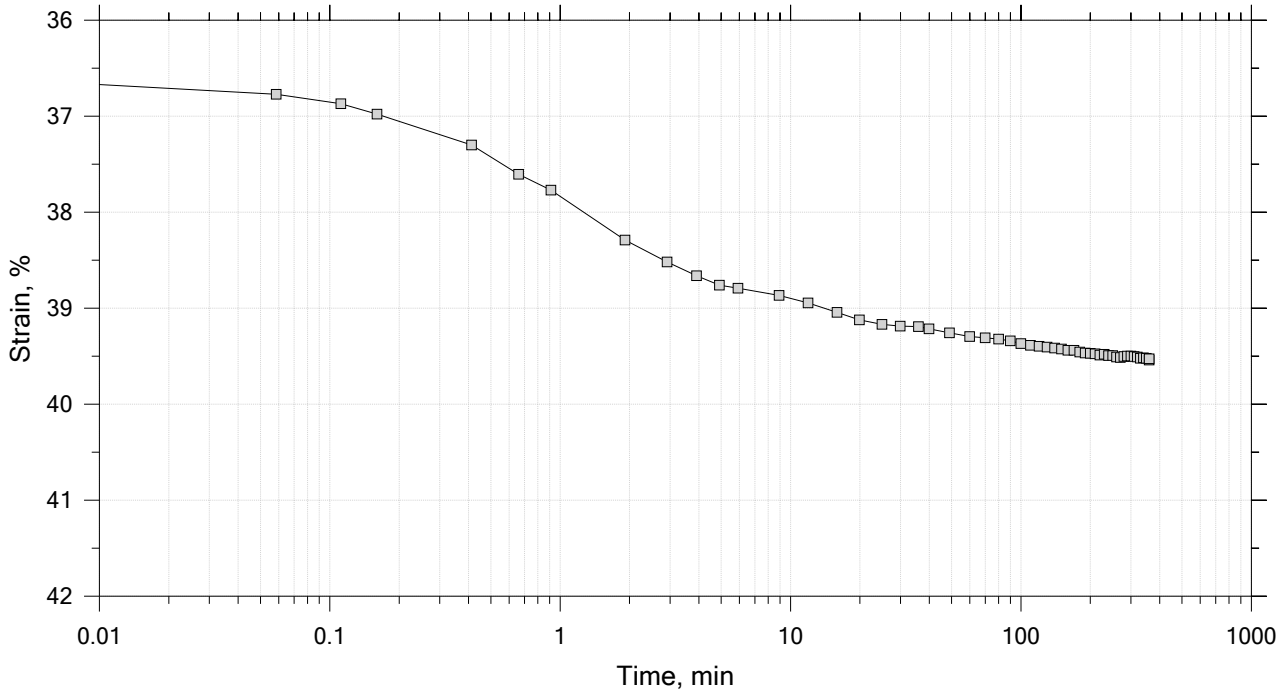


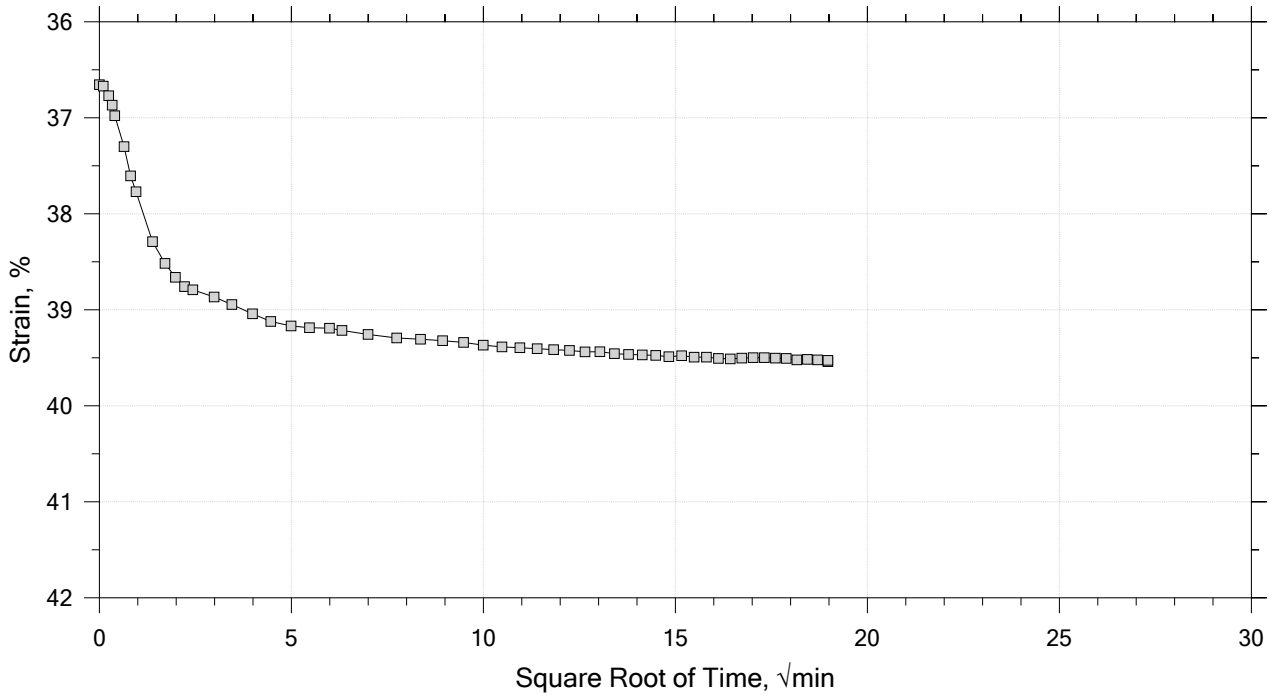


GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 17 of 17
Constant Load Step
Stress: 64 tsf





GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.75	Liquid Limit: 41
Initial Height: 1.00 in	Initial Void Ratio: 1.34	Plastic Limit: 20
Final Height: 0.65 in	Final Void Ratio: 0.518	Plasticity Index: 21

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	D-2251	RING		C-2263
Mass Container, gm	8.46	111.18	111.18	9.28
Mass Container + Wet Soil, gm	149.75	251.29	223.65	122
Mass Container + Dry Soil, gm	103.17	205.8	205.8	104.11
Mass Dry Soil, gm	94.71	94.62	94.62	94.83
Water Content, %	49.18	48.08	18.87	18.87
Void Ratio	---	1.34	0.52	---
Degree of Saturation, %	---	98.88	100.00	---
Dry Unit Weight, pcf	---	73.433	112.97	---

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test. Therefore, values may not represent actual values for the specimen.

GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		

One-Dimensional Consolidation by ASTM D2435 - Method B

Log of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Log T50 min	Cv ft²/s	Mv 1/tsf	k ft/day	Ca %
1	0.0734	0.005677	1.32	0.568	0.000	0.00e+00	7.74e-02	0.00e+00	0.00e+00
2	0.125	0.008845	1.32	0.885	0.000	0.00e+00	6.13e-02	0.00e+00	0.00e+00
3	0.250	0.02015	1.29	2.02	0.000	0.00e+00	9.05e-02	0.00e+00	0.00e+00
4	0.500	0.03603	1.25	3.60	0.000	0.00e+00	6.35e-02	0.00e+00	0.00e+00
5	1.00	0.1047	1.09	10.5	0.000	0.00e+00	1.37e-01	0.00e+00	0.00e+00
6	2.00	0.1959	0.878	19.6	9.755	4.22e-07	9.11e-02	1.04e-04	0.00e+00
7	4.00	0.2472	0.758	24.7	4.299	8.04e-07	2.57e-02	5.56e-05	0.00e+00
8	8.00	0.2929	0.652	29.3	2.659	1.14e-06	1.14e-02	3.52e-05	0.00e+00
9	2.00	0.2850	0.670	28.5	0.000	0.00e+00	1.32e-03	0.00e+00	0.00e+00
10	0.500	0.2763	0.690	27.6	2.288	1.29e-06	5.78e-03	2.01e-05	0.00e+00
11	0.125	0.2681	0.710	26.8	10.700	2.82e-07	2.21e-02	1.68e-05	0.00e+00
12	0.500	0.2700	0.705	27.0	0.000	0.00e+00	5.10e-03	0.00e+00	0.00e+00
13	2.00	0.2794	0.683	27.9	0.000	0.00e+00	6.27e-03	0.00e+00	0.00e+00
14	8.00	0.3012	0.632	30.1	1.247	2.30e-06	3.64e-03	2.26e-05	0.00e+00
15	16.0	0.3326	0.559	33.3	1.909	1.39e-06	3.93e-03	1.48e-05	0.00e+00
16	32.0	0.3652	0.483	36.5	1.742	1.39e-06	2.04e-03	7.62e-06	0.00e+00
17	64.0	0.3953	0.413	39.5	1.246	1.76e-06	9.40e-04	4.45e-06	0.00e+00

GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Square Root of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Sq.Rt. T90 min	Cv ft²/s	Mv 1/tsf	k ft/day
1	0.0734	0.005677	1.32	0.568	23.501	1.04e-06	7.74e-02	2.17e-04
2	0.125	0.008845	1.32	0.885	35.754	6.76e-07	6.13e-02	1.12e-04
3	0.250	0.02015	1.29	2.02	0.000	0.00e+00	9.05e-02	0.00e+00
4	0.500	0.03603	1.25	3.60	95.001	2.44e-07	6.35e-02	4.18e-05
5	1.00	0.1047	1.09	10.5	111.565	1.90e-07	1.37e-01	7.04e-05
6	2.00	0.1959	0.878	19.6	45.648	3.88e-07	9.11e-02	9.54e-05
7	4.00	0.2472	0.758	24.7	20.729	7.17e-07	2.57e-02	4.97e-05
8	8.00	0.2929	0.652	29.3	14.165	9.23e-07	1.14e-02	2.84e-05
9	2.00	0.2850	0.670	28.5	4.125	3.01e-06	1.32e-03	1.07e-05
10	0.500	0.2763	0.690	27.6	12.560	1.01e-06	5.78e-03	1.57e-05
11	0.125	0.2681	0.710	26.8	39.560	3.29e-07	2.21e-02	1.96e-05
12	0.500	0.2700	0.705	27.0	11.805	1.11e-06	5.10e-03	1.53e-05
13	2.00	0.2794	0.683	27.9	8.960	1.44e-06	6.27e-03	2.44e-05
14	8.00	0.3012	0.632	30.1	6.385	1.94e-06	3.64e-03	1.90e-05
15	16.0	0.3326	0.559	33.3	12.386	9.24e-07	3.93e-03	9.79e-06
16	32.0	0.3652	0.483	36.5	7.041	1.48e-06	2.04e-03	8.11e-06
17	64.0	0.3953	0.413	39.5	6.278	1.50e-06	9.40e-04	3.81e-06

GeoTesting EXPRESS	Project: Route 32 over Hook Brook	Location: Waldeboro, ME	Project No.: GTX-310368
	Boring No.: BB-WHB-103	Tested By: md	Checked By: njh
	Sample No.: ST-1	Test Date: 07/29/19	Depth: 15-17 ft
	Test No.: IP-1	Sample Type: Tube	Elevation: ---
	Description: Wet, dark gray clay		
	Remarks: System V, Swell Pressure = 0.0734 tsf		
	Displacement at End of Increment		

APPENDIX F.1 Calculations – Bearing Resistance & Settlement Calculations

Bearing Resistance and Settlement Calculations for Wagner (#02) Bridge at Route 32 over Hook Brook.

Objective: Develop a graph for a range of effective footing sizes that can be used to evaluate bearing resistance and settlement based on effective footing width for the closed box culvert foundation supported by Presumpscot Formation.

References:
1) AASHTO LRFD Bridge Design Specifications: 2014 Edition.
2) Borings BB-WBH-101 and 102 performed by NEBC on December 5 to December 6, 2017.
3) Drawing provided by CLD | Fuss & O'Neill on 12/15/2017.

Assumptions:
1) Boring BB-WHB-101 is the worst case subsurface condition. Groundwater El. 65 +/-
2) Analysis was performed for the south half of the closed box culvert

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	90	pcf	Andrews Paper, 1987.
Unit Weight of Soil Above Footing (γ):	125	pcf	Assumed
Cohesion of Bearing Soil (c):	250	psf	Assumed
Friction Angle of Bearing Soil (ϕ'):	0	degrees	Assumed

Soil Description: Footing overlying presumpscot formation, approximately 7.4 feet thick. Grey-olive, Silt & Clay.

Footing Elevation:	57.75	ft, NAVD-88	Reference No. 3
Ground Surface (GS) Elevation:	72.5	ft, NAVD-88	Reference No. 3 (Roadway EL)
Groundwater Elevation:	65	ft, NAVD-88	Reference No. 2

Strip Footing Geometry

Minimum Footing Depth (D_f):	14.75	ft	Reference No. 3
Groundwater Depth Below GS:	7.5	ft	Reference No. 2
Width (B):	8	ft	Reference No. 3
Length (L):	80	ft	Reference No. 3
Width Eccentricity (e_B):	0.0	ft	Reference No. 3/Assumed
Length Eccentricity (e_L):	0	ft	Reference No. 3/Assumed
Effective Width (B'):	8.0	ft	
Effective Length (L'):	80	ft	

Notes: 1) See Geotechnical Report for details on subgrade preparation for footings.

Example Bearing Resistance Calculation

Factored Bearing Resistance: $q_R = q_n * \phi_b$			Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =		0.45	Tb. 10.5.5.2.2-1
Nominal Resistance (q_n) =			
$q_n = c*N_{cm} + \gamma*D_f*N_m*C_{wq} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma}$			Eq. 10.6.3.1.2a-1
$N_{qm} = N_q*s_q*d_q*i_q$			Eq. 10.6.3.1.2a-3
Bearing Capacity Factor (N_q)		1	Tb. 10.6.3.1.2a-1 or Eq 10.6.3.1.2c-1
Shape Correction Factor (s_q)		1.00	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_q)		1.00	Assumed or Tb. 10.6.3.1.2a-7
Depth Correction Factor (d_q)		1.0	Tb. 10.6.3.1.2a-4
	N_{qm}=	1.00	
$N_{cm} = N_c*s_c*i_c$			Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)		5.14	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)		1.02	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)		1.00	Assumed or Calculated
	N_{cm} =	5.24	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$			Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ or $N_{\gamma q}$)		0	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)		1.00	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)		1.00	Assumed or Calculated
	$N_{\gamma m}$=	0.00	
Groundwater Coefficients			Tb. 10.6.3.1.2a-2
	(C_{wq})	0.75	
	($C_{w\gamma}$)	0.50	
	q_n=	**2.7 ksf**	
	q_R=	**1.2 ksf**	

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JOB 94140.00 Route 32 over Hoosic Brook
SHEET NO. 5 OF 8
CALCULATED BY KAK DATE 1/2/2018
CHECKED BY KT DATE 1/3/2018
SCALE

Settlement Calculations - Proposed Strip Footing of 4-sided Closed Box Culvert

Given: 1) Borings BB-WHB-101 & BB-WHB-102
2) Bottom Footing Elevation: 57.75' (assuming full box frame)
3) Approximately 15-feet of embedment required for the footing footprint.

Assumptions: 1) Evaluate conditions at BB-WHB-101 (most conservative); Groundwater @ EL. 65' +/-
2) Assume a compression index (C_c) of 0.40, from Reference 1, showing typical values of C_c for Presumpscot Formation and $e_o \approx 1.1$; $\gamma = 90$ pcf
3) Assume full service load (1.4 ksf) applied to each side. (conservative)

References: 1) David W. Andrews, The Engineering Aspects of The Presumpscot Formation, 1987.
2) Boring logs, performed by NEBC on December 5 to 6, 2017.

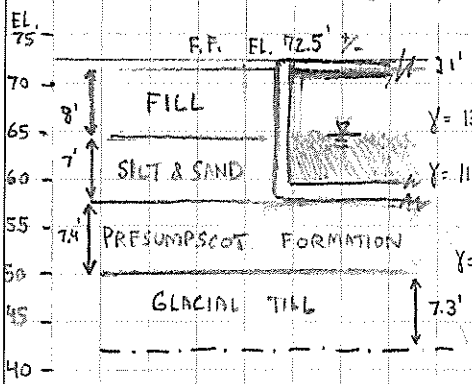


Figure 1. Strata Diagram for BB-WHB-101

Analyze Settlement @ Boring BB-WHB-101

- Initial effective stress = $\bar{\sigma}_{vo}$ @ MIDPOINT of clay

$\bar{\sigma}_{vo} = (135\ pcf)\cdot 7.5' + (135\ pcf - 62.4\ pcf)\cdot 0.5' + (110\ pcf - 62.4\ pcf)\cdot 7' + \ldots$
$\ldots + (90\ pcf - 62.4\ pcf)\cdot 3.6' = 1{,}481.36\ psf = \bar{\sigma}'_{vo}$

- $\Delta\bar{\sigma}'_v$ @ MIDPOINT of clay

Based on assumption 3, use full service load @ FOOTING [D.m. ≈ 8.0ft × 80 ft] ☆
Contact stress (q_o) = 1,400 psf = $\Delta\bar{\sigma}'_v$

- Consolidation Settlement = S_c @ BB-WHB-101

$$S_c = C_c \cdot \left(\frac{H_o}{1+e_o}\right) \cdot \log\left(\frac{\bar{\sigma}'_{vo} + \Delta\bar{\sigma}'_v}{\bar{\sigma}'_{vo}}\right)$$

$$S_c = 0.4 \cdot \left(\frac{7.4'}{1+1.1}\right) \cdot \log\left(\frac{1481.36\ psf + 1400\ psf}{1481.36\ psf}\right) = 1.41 \cdot \log(1.97) = 0.41\ ft \text{ or } \boxed{5\ inches}$$

approximately

Calculated by: KAK Date: 8/14/2019
Checked by: RAC Date: 8/16/2019
Revision: 1

Bearing Resistance Calculations for Wagner No. 2 Bridge at Route 32 over Hoch Brook.

Objective: Evaluate bearing resistance and settlement based on effective footing width for the full-box culvert foundation supported by Compacted Structural Fill, over-excavating Glaciomarine deposits.

References:
1) AASHTO LRFD Bridge Design Specifications: 2017 Edition.
2) Test borings performed by NEBC and observed by Nobis in December, 2017 and July, 2019.
3) Drawing provided by Fuss & O'Neill on 8/15/2019.

Assumptions:
1) Boring BB-WHB-101 is the worst case subsurface condition located near proposed culvert. Groundwater El. 65 +/-
2) Analysis was performed for the southern-portion of the full-box culvert.

Solution:

Bearing Soil Properties/Subsurface Information

Unit Weight of Bearing Soil (γ):	130	pcf	Andrews Paper, 1987.
Unit Weight of Soil Above Footing (γ):	110	pcf	Assumed
Cohesion of Bearing Soil (c):	0	psf	Assumed
Friction Angle of Bearing Soil (ϕ'):	35	degrees	Assumed

Soil Description: Footing overlying compacted structural fill, (over-excavating Glaciomarine deposits), approximately 7.4 feet thick, overlying Glacial Till.

Footing Elevation:	59.5	ft, NAVD-88	Reference No. 3
Ground Surface (GS) Elevation:	74.5	ft, NAVD-88	Reference No. 3 (Roadway EL)
Groundwater Elevation:	74.5	ft, NAVD-88	Reference No. 2

Strip Footing Geometry

Minimum Footing Depth (D_f):	15	ft	Reference No. 3
Groundwater Depth Below GS:	0	ft	Reference No. 2
Width (B):	20	ft	Reference No. 3
Length (L):	75	ft	Reference No. 3
Width Eccentricity (e_B):	6.7	ft	Assumed
Length Eccentricity (e_L):	0	ft	Assumed
Effective Width (B'):	6.7	ft	
Effective Length (L'):	75	ft	

Notes: 1) See Geotechnical Report for details on subgrade preparation for the full-box culvert.

Example Bearing Resistance Calculation

Factored Bearing Resistance: $q_R = q_n * \phi_b$		Eq. 10.6.3.1.1-1
Resistance Factor (ϕ_b) =	0.45	Tb. 10.5.5.2.2-1
Nominal Resistance (q_n) =		
$q_n = c*N_{cm} + \gamma*D_f*N_m*C_{wq} + 0.5*\gamma*B'*N_{\gamma m}*C_{w\gamma}$		Eq. 10.6.3.1.2a-1
$N_{qm} = N_q*s_q*d_q*i_q$		Eq. 10.6.3.1.2a-3
Bearing Capacity Factor (N_q)	33.3	Tb. 10.6.3.1.2a-1 or Eq 10.6.3.1.2c-1
Shape Correction Factor (s_q)	1.06	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_q)	1.00	Assumed or Tb. 10.6.3.1.2a-7
Depth Correction Factor (d_q)	1.0	Tb. 10.6.3.1.2a-4
N_{qm}=	35.37	
$N_{cm} = N_c*s_c*i_c$		Eq. 10.6.3.1.2a-2
Bearing Capacity Factor (N_c)	46.1	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_c)	1.06	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_c)	1.00	Assumed or Calculated
N_{cm} =	49.06	
$N_{\gamma m} = N_\gamma*s_\gamma*i_\gamma$		Eq. 10.6.3.1.2a-4
Bearing Capacity Factor (N_γ or $N_{\gamma q}$)	48	Tb. 10.6.3.1.2a-1
Shape Correction Factor (s_γ)	0.96	Tb. 10.6.3.1.2a-3
Load Inclination Factor (i_γ)	1.00	Assumed or Calculated
$N_{\gamma m}$=	46.29	
Groundwater Coefficients		Tb. 10.6.3.1.2a-2
(C_{wq})	0.50	
($C_{w\gamma}$)	0.50	
q_n=	**39.2 ksf**	
q_R=	**17.6 ksf**	

Example Settlement (Elastic) Calculation using Elastic Half-Space Method

$$S_e = \frac{(q_o(1-\nu^2)\sqrt{A})}{144*E_s*\beta_z}$$ Eq. 10.6.2.4.2-1

Poisson's Ratio (v)	0.35		Tb. C10.4.6.3-1
Young's modulus of elasticity (E_s)	11	ksi	Tb. C10.4.6.3-1
Flexible or Rigid	Rigid		
Shape Factor (β_z)	1.18		Tb. 10.6.2.4.2-1
Width (B)	20.0	ft	
Area of Footing (A)	1500	ft^2	B * L

Assumed Settlement, S_e (in)	Applied Vertical Stress, q_o (ksf)
1.0	4.6
2.0	9.2
3.0	13.8
4.0	18.4
5.0	22.9
6.0	27.5

Route 32 over Hoch Brook Wagner No. 2 Bridge

Proposed Culvert Replacement

Waldoboro, Maine

Discipline: Geotechnical

Title: Settlement Analysis for South Approach Embankment located at STA 15+00.

WIN No. 18230.00

Design Basis/Assumptions:

Purpose: Evaluate settlement for the proposed south approach embankment along the southern portion of the site at STA 15+00.

Assumptions:

1) Groundwater conditions the same or similar to those observed during the subsurface explorations by Nobis (see test boring BB-WHB-105).
2) Surcharge loading is assumed to be of proposed fill, with unit weight of 0.125 kips/ft^3.
3) Nobis understands the proposed roadway and embankment grade are to be raised approximately 2 feet and up to 5 feet, respectively.

Approach:

Use the computer settlement analysis software Settle3D 4.0, by RocScience, Inc., to perform settlement analyses on the south approach embankment due to proposed fill placement. STA 15+00 was analyzed.

References:

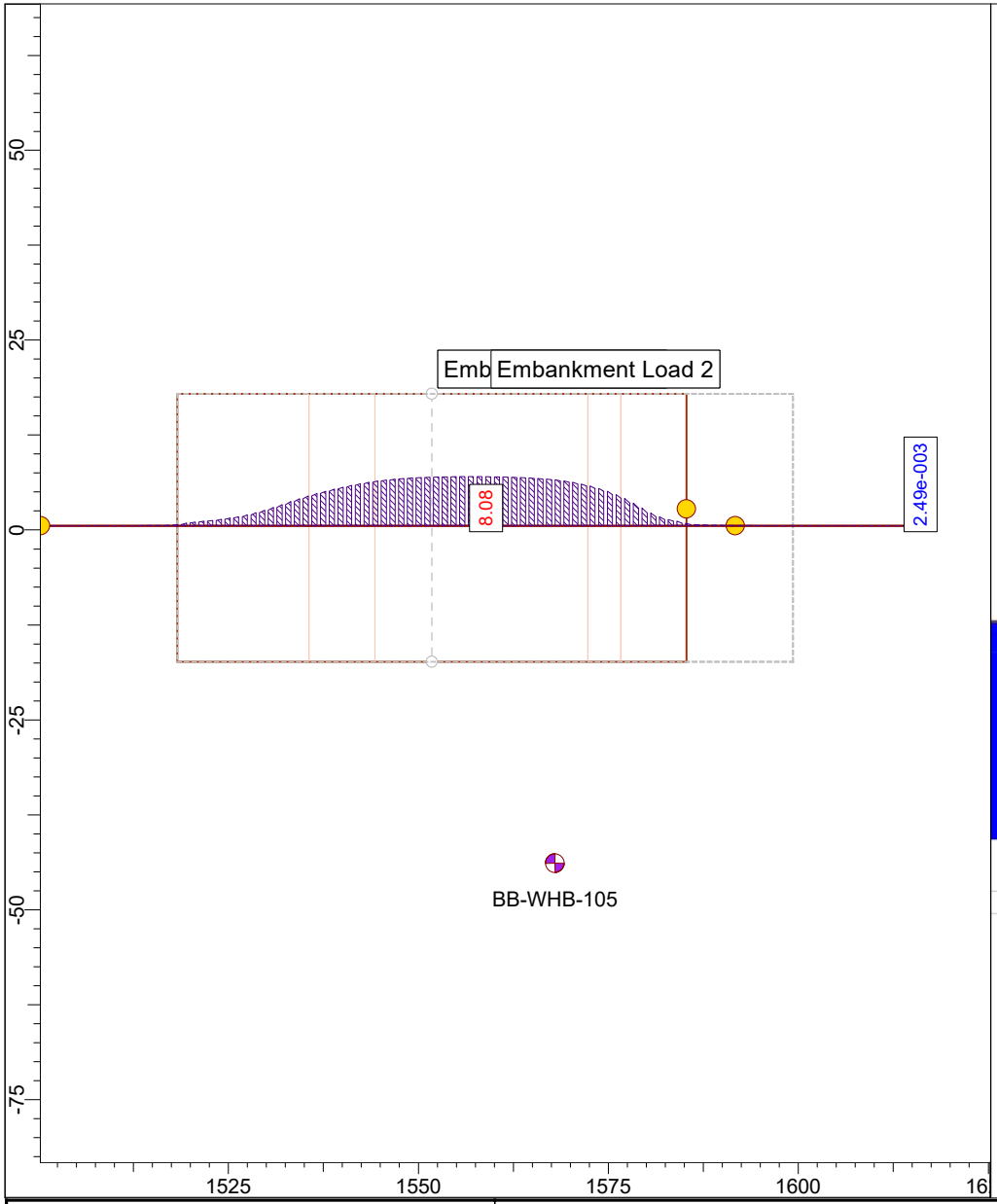
1) Concept Plan drawings provided by Fuss & O'Neill in August, 2019.
2) Subsurface explorations and laboratory tests performed by Nobis.
3) AASHTO LRFD Bridge Design Specifications, 8th Edition 2017.

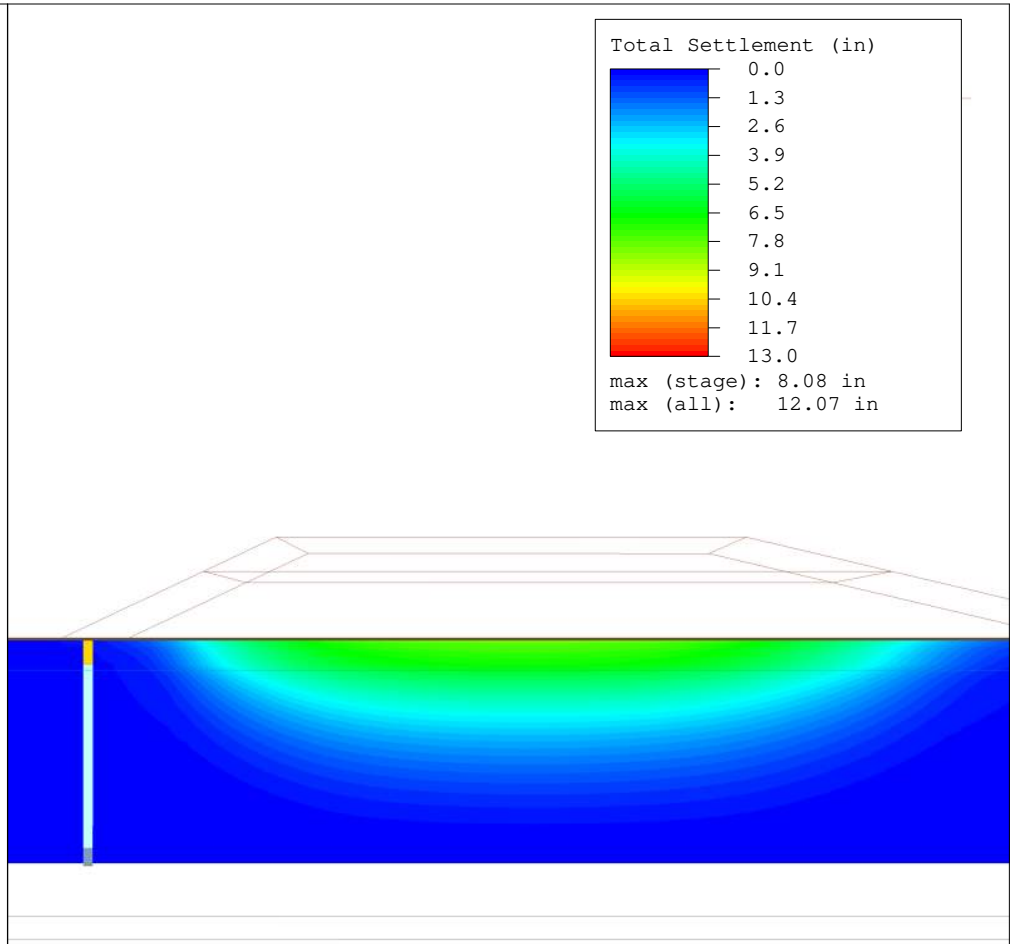
Remarks/Conclusions:

The total settlement due to the placement of proposed fill at Route 32 over Hoch Brook for the approach embankments critical section nof STA 15+00 will result in approximately 0.7-inches of settlement settlement on roadway grade and up to approximately 4 inches of settlement at the approach embankment slopes, within 30 days of additional fill placement. In addition, 3.3 inches of consolidation settlement could occur within 50 years after construction.

Originated By: Kamil A. Kocia, Staff Engineer Date: 08/13/2019

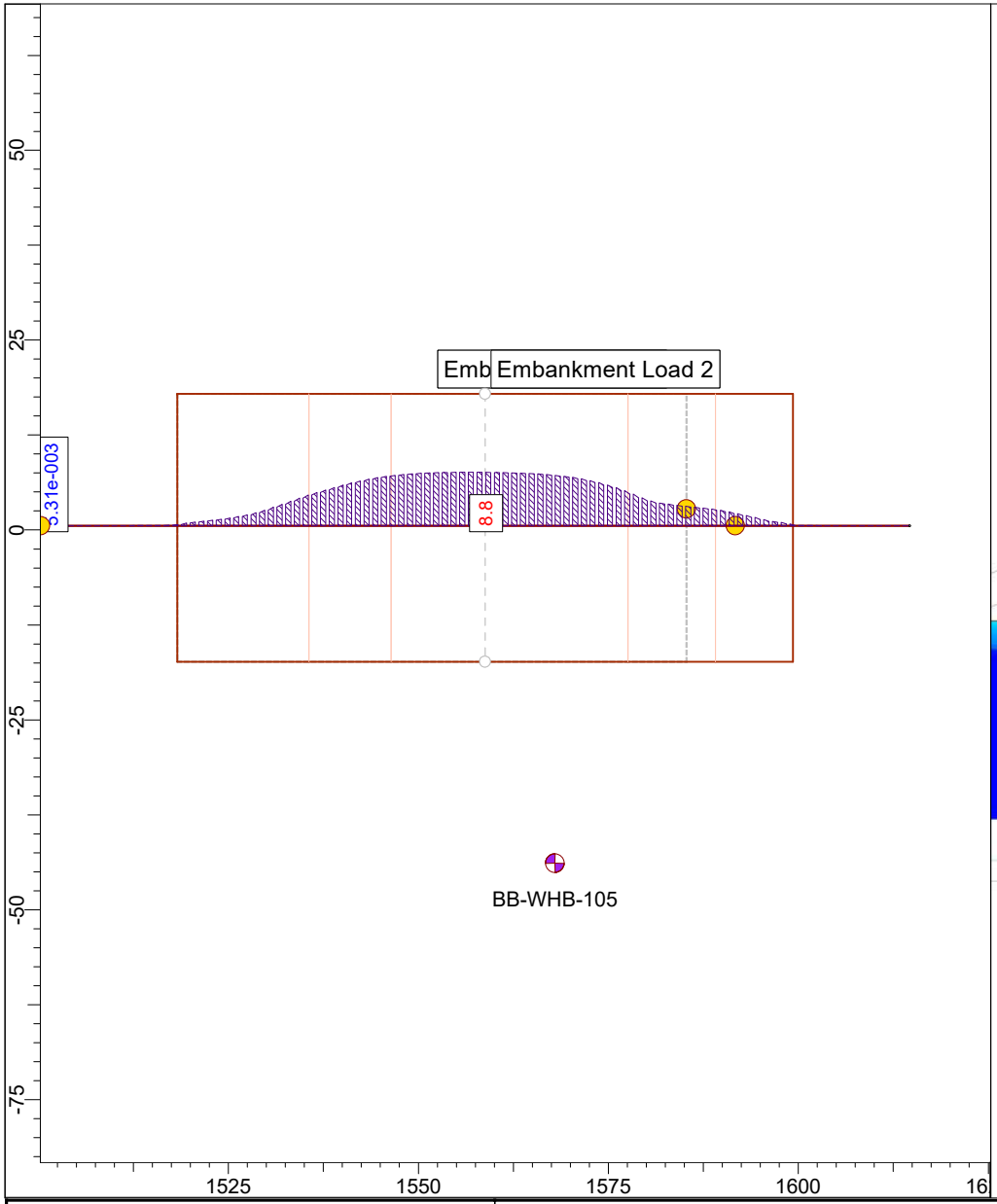
Approved By: Brien Waterman, PE / Kurt Jelinek, PE Date: 08/29/2019

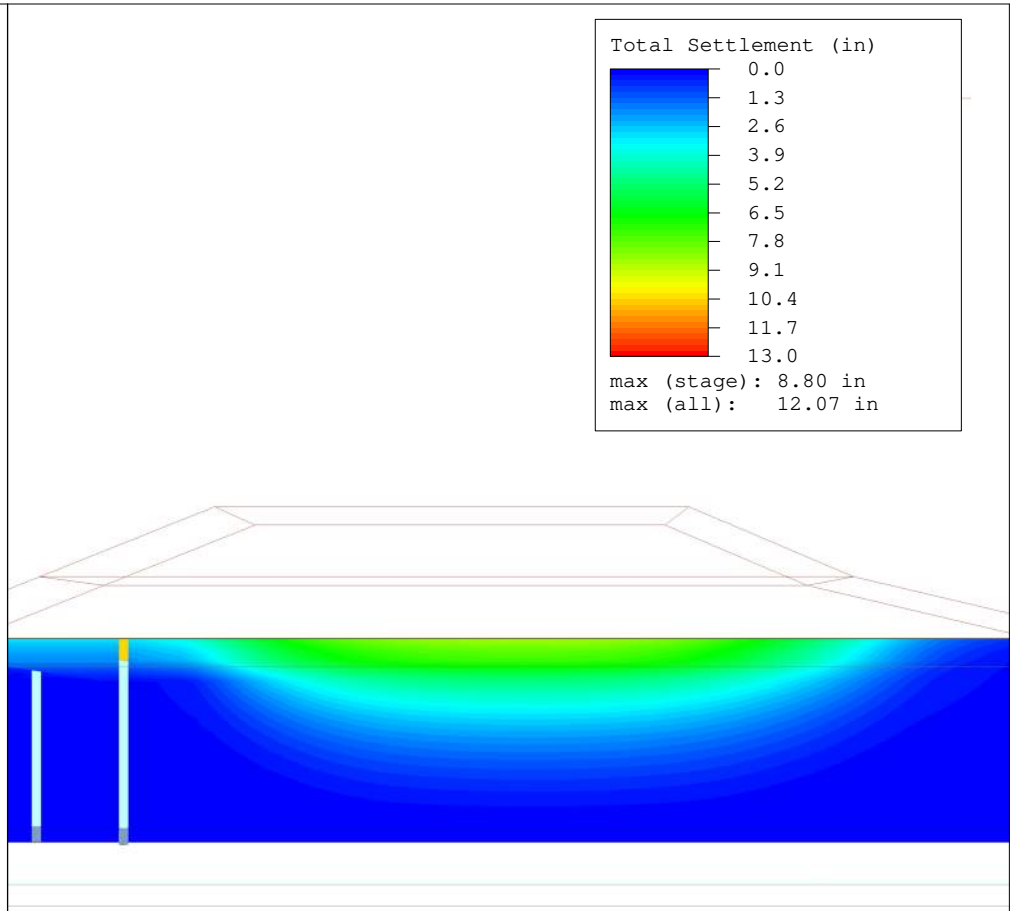




Stage 2 - Present Day

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By KAK Checked by: BTW	*Company*	Nobis Engineering, Inc.
SETTLE3D 4.017	*Date* 8/13/2019	*File Name*	94140.00 - model - emb - updated.s3z

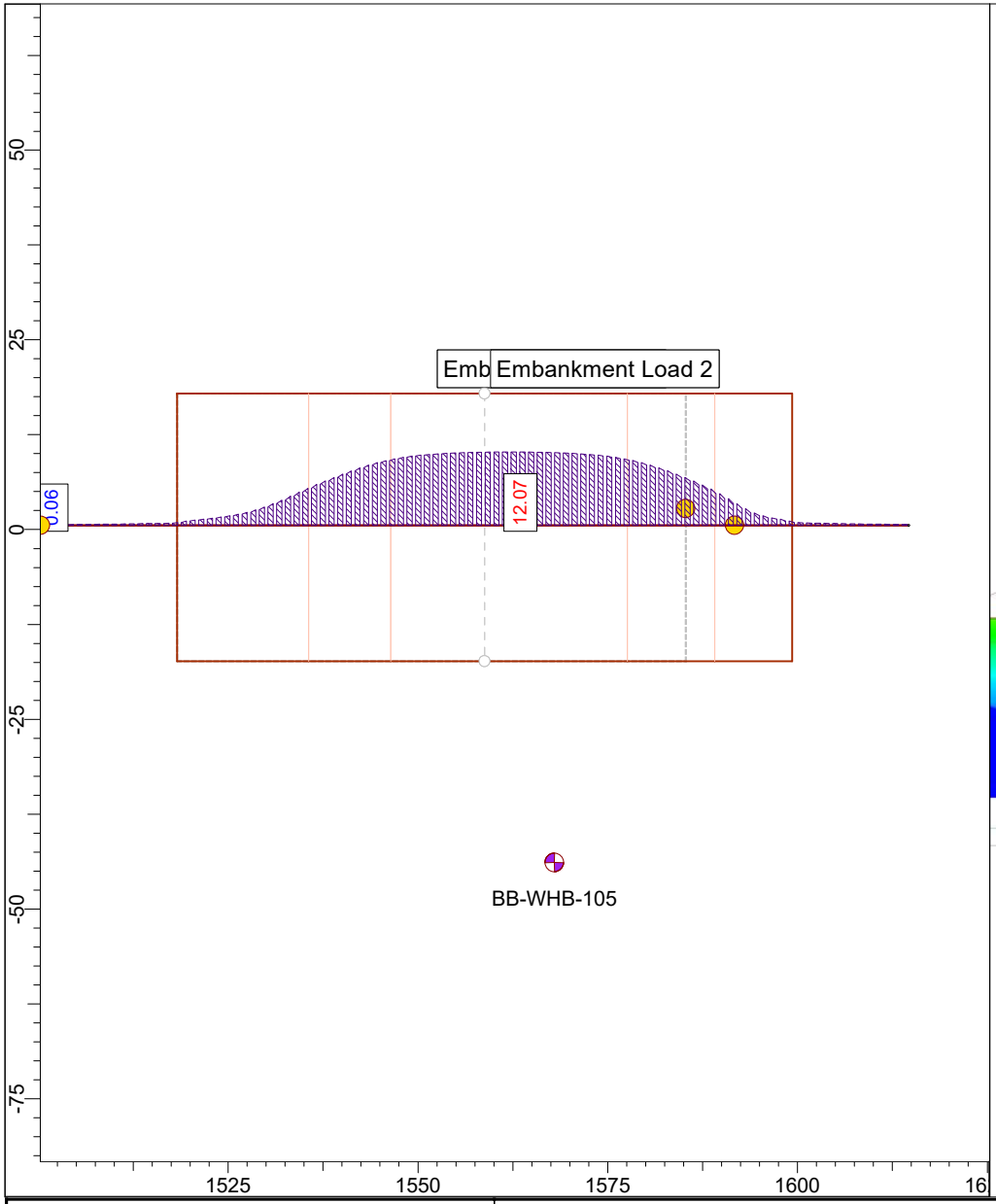


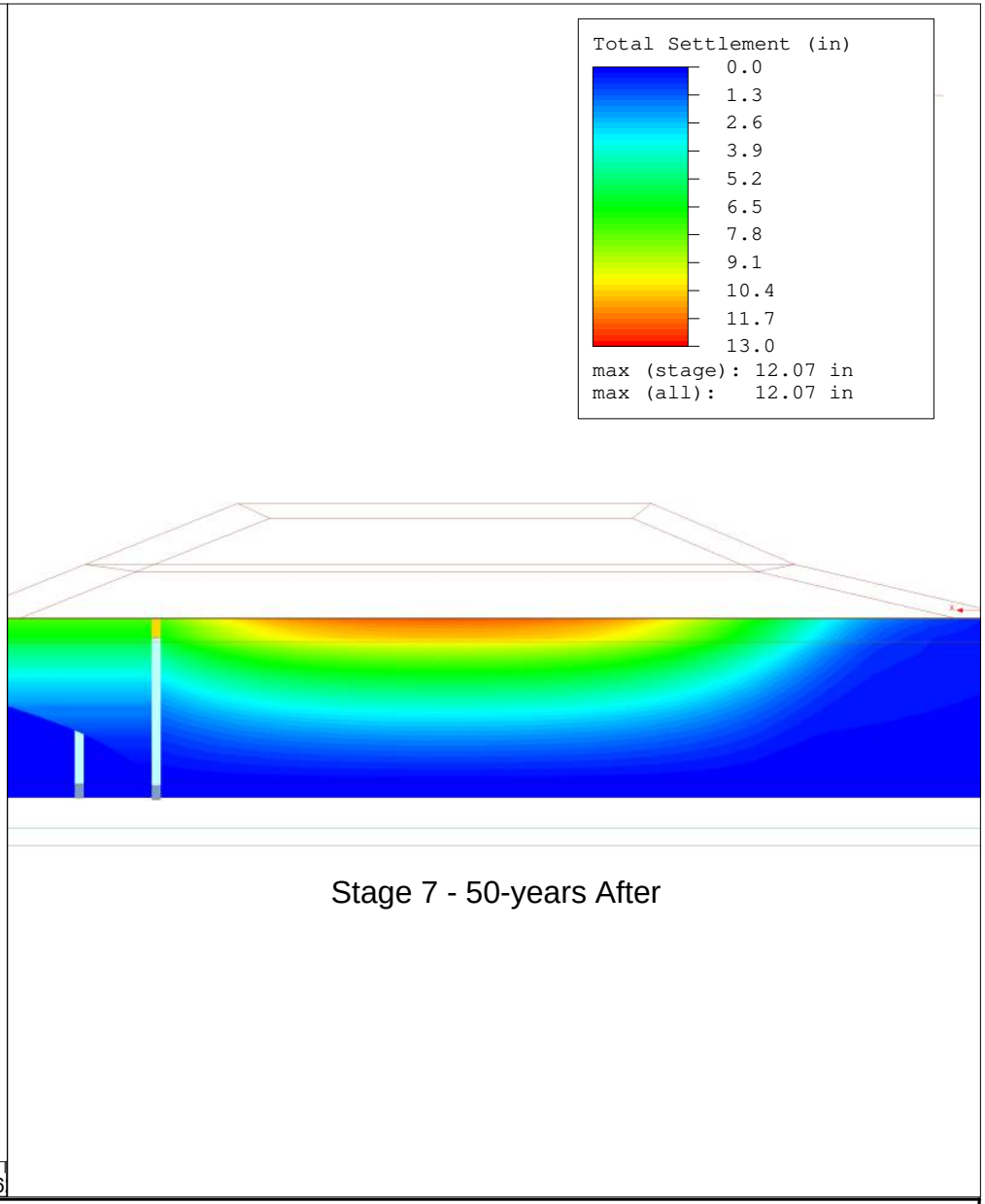


Stage 3 - New Grade (Post Construction)

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By KAK	Checked by: BTW	*Company* Nobis Engineering, Inc.
	Date 8/13/2019		*File Name* 94140.00 - model - emb - updated.s3z

SETTLE3D 4.017



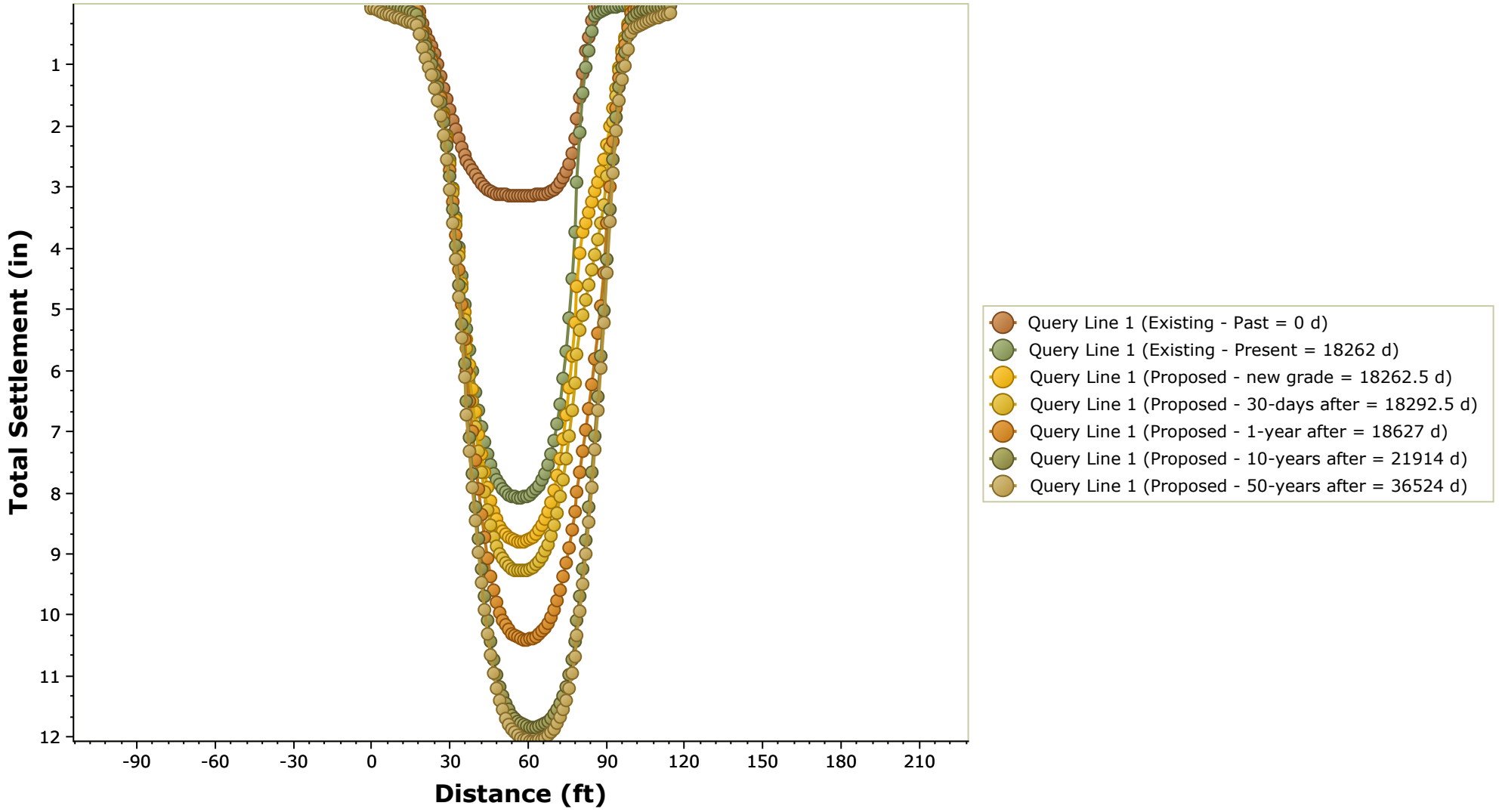


Stage 7 - 50-years After

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By KAK Checked by: BTW	*Company*	Nobis Engineering, Inc.
	Date 8/13/2019	*File Name*	94140.00 - model - emb - updated.s3z

SETTLE3D 4.017

Distance vs. Total Settlement

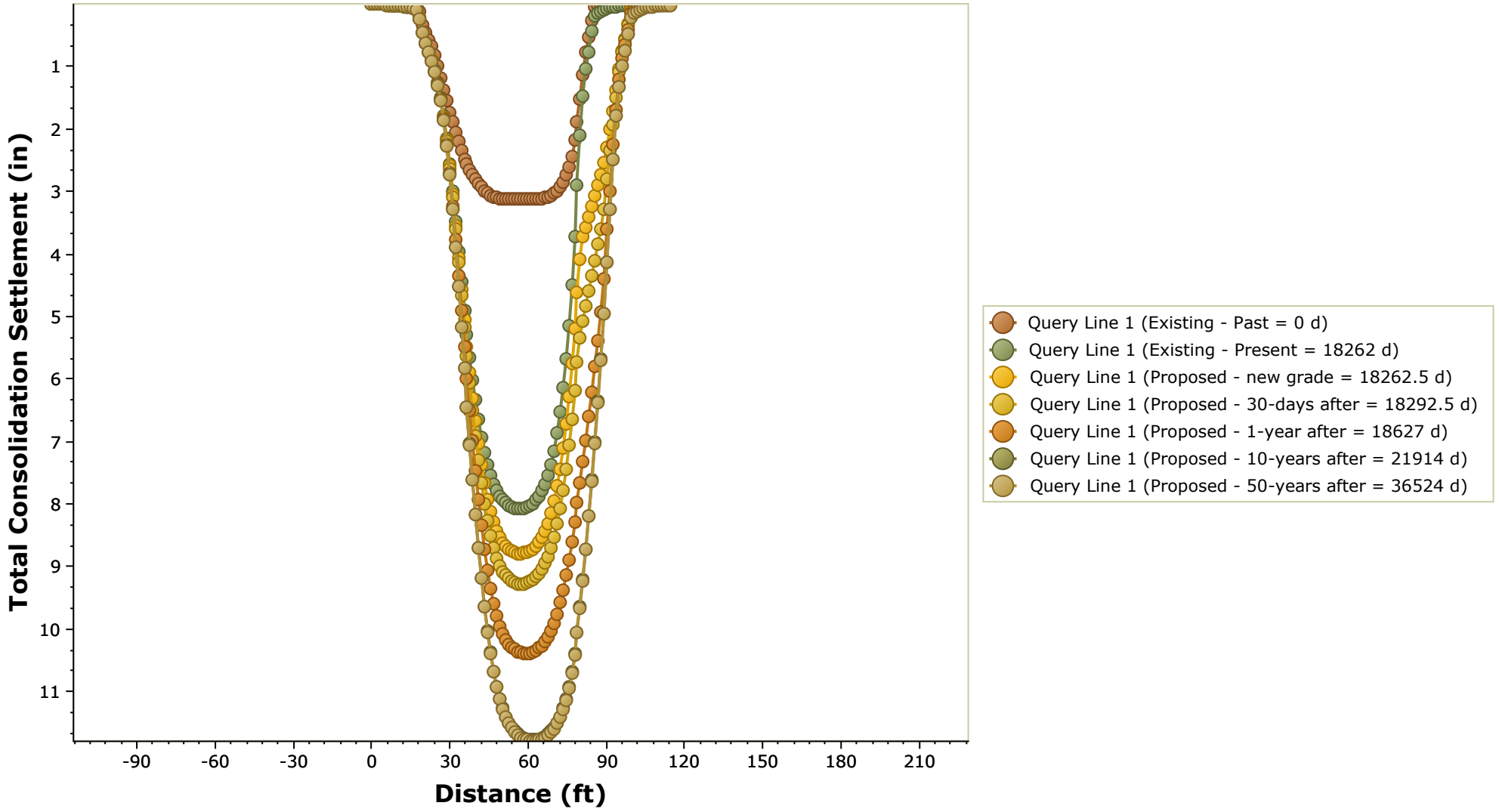


Reference Stage: None
Total Settlement at Depth = -67 ft

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By KAK Checked by: BTW	*Company*	Nobis Engineering, Inc.
	Date 8/13/2019	*File Name*	94140.00 - model - emb - updated.s3z

SETTLE3D 4.017

Distance vs. Total Consolidation Settlement

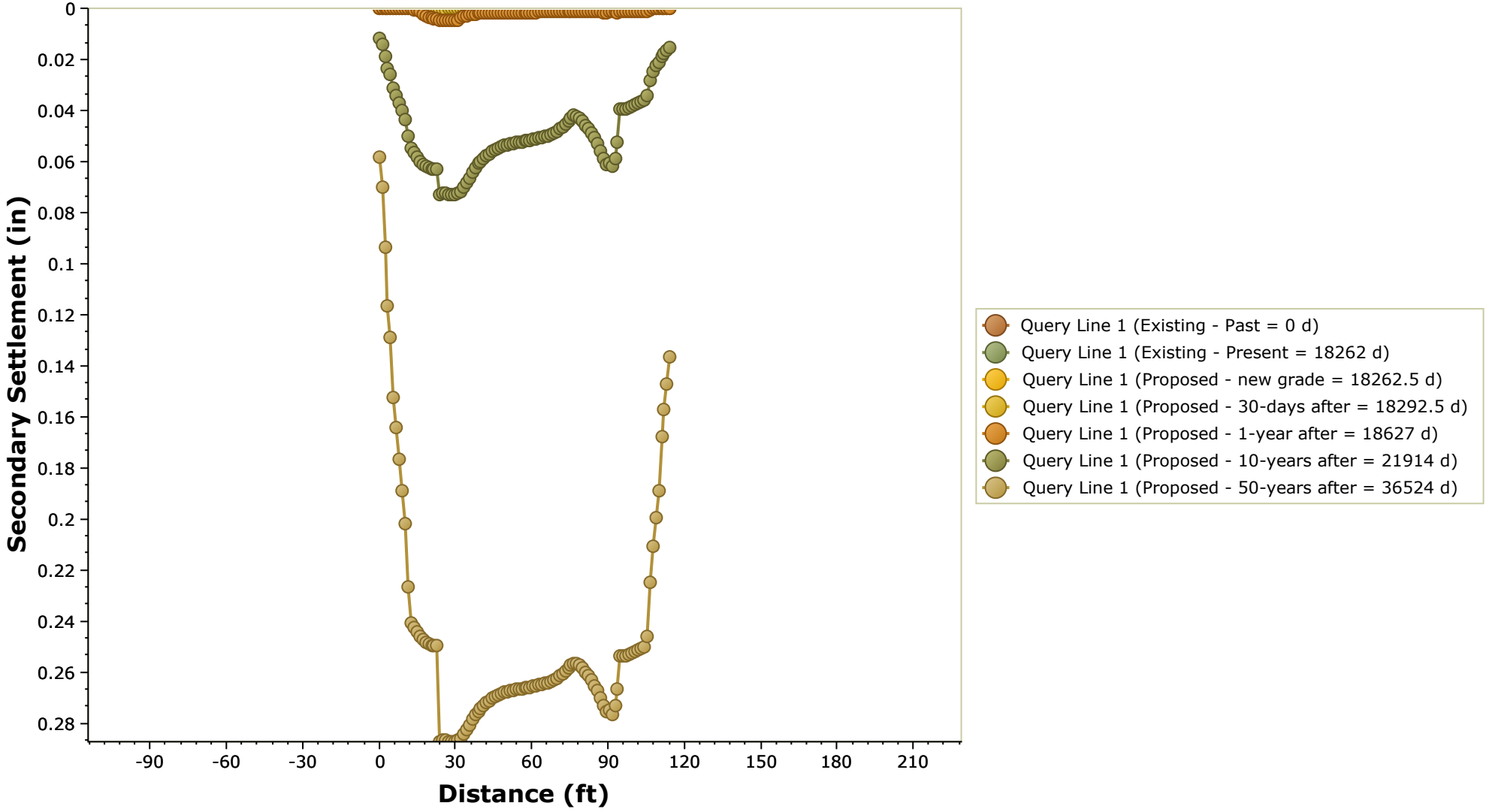


Reference Stage: None
Total Consolidation Settlement at Depth = -67 ft

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By	KAK Checked by: BTW	*Company* Nobis Engineering, Inc.
	Date	8/13/2019	*File Name* 94140.00 - model - emb - updated.s3z

SETTLE3D 4.017

Distance vs. Secondary Settlement

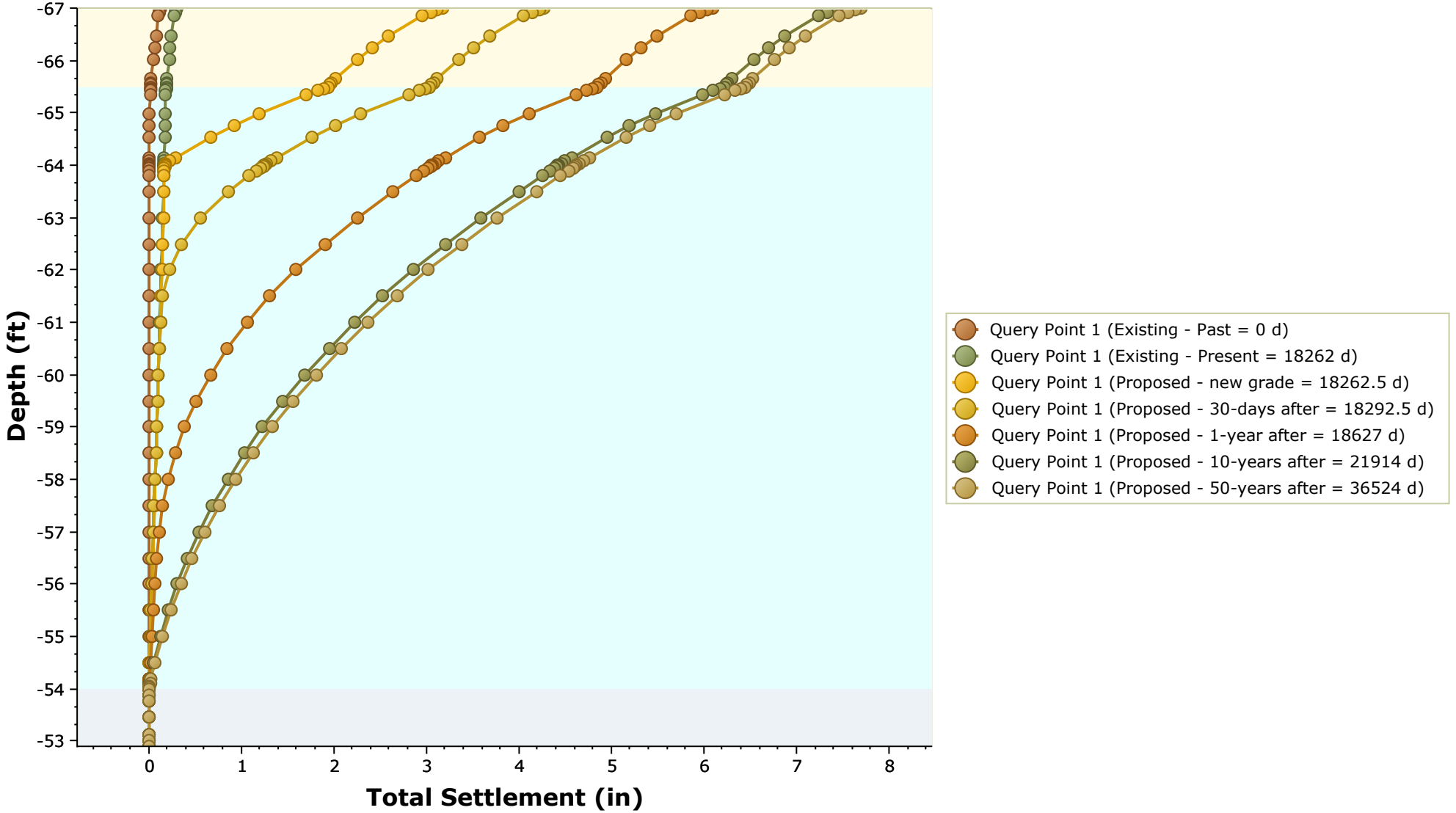


Reference Stage: None
Secondary Settlement at Depth = -67 ft

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By KAK Checked by: BTW	*Company*	Nobis Engineering, Inc.
	Date 8/13/2019	*File Name*	94140.00 - model - emb - updated.s3z

SETTLE3D 4.017

Total Settlement vs. Depth



Reference Stage: None

rocscience	*Project*	Route 32 over Hoch Brook, Waldoboro, Maine	
	Analysis Description	Settlement Analysis - Southern Approach Embankment	
	Drawn By	KAK Checked by: BTW	*Company* Nobis Engineering, Inc.
	Date	8/13/2019	*File Name* 94140.00 - model - emb - updated.s3z

SETTLE3D 4.017

APPENDIX F.2 Caculations – Lateral Earth pressure Calculation

Calculated by: BTW Date: 11.30.2018
Checked by: KJ Date: 08.27.2019

Objective: Calculate lateral earth pressure coefficient for the proposed concrete culvert.

Approach: Determine at-rest earth pressure coefficient in accordance with MaineDOT Bridge Design Manual.

References:
1. MaineDOT Bridge Design Guide, 2003, with revisions through 2014.
2. AASHTO Bridge Design Specifications, 2017 Edition.

At-Rest Earth Pressure

$K_o = 1 - \sin(\phi)$

K_o = 0.47 Effective friction angle of soil: $\phi = 32°$

ϕ = soil friction angle

We recommend that the proposed concrete culvert be designed for lateral earth pressures using backfill material properties for Soil Type 4 (MaineDOT Bridge Design Guide Section 3.6.1). In accordance with the MaineDOT Bridge Manual Soil Type 4 has a friction angle of 32 degrees.

Table 3-3 Material Classification

Soil Type	Soil Description	Internal Angle of Friction of Soil, ϕ	Soil Total Unit Weight (pcf)	Coeff. of Friction, tan δ, Concrete to Soil	Interface Friction, Angle, Concrete to Soil δ
1	Very loose to loose silty sand and gravel Very loose to loose sand Very loose to medium density sandy silt Stiff to very stiff clay or clayey silt	29°*	100	0.35	19°
2	Medium density silty sand and gravel Medium density to dense sand Dense to very dense sandy silt	33°	120	0.40	22°
3	Dense to very dense silty sand and gravel Very dense sand	36°	130	0.45	24°
4	Granular underwater backfill Granular borrow	32°	125	0.45	24°
5	Gravel Borrow	36°	135	0.50	27°

* The value given for the internal angle of friction (ϕ) for stiff to very stiff silty clay or clayey silt should be used with caution due to the large possible variation with different moisture contents.

APPENDIX F.3 Caculations – Global Slope Stability Calculation

Route 32 over Hoch Brook Wagner No. 2 Bridge
South Approach Embankment Cross Section @ STA 15+00
Waldoboro, Maine

Discipline: Geotechnical

Title: Global Slope Stability Analysis for Proposed South Approach Embankment in Lateral Direction at STA 15+00

WIN #: 18230.00

Design Basis/Assumptions:

Purpose: Perform global stability analyses at proposed south approach embankment.

Assumptions:

1) Engineering properties for existing fill and the native soils encountered in boring BB-WHB-105 estimated based on standard penetration test (SPT) data and engineering judgment based on visual classification.
2) Existing Fill: Unit Weight = 120 pcf, Angle of Internal Friction = 35°.
3) Proposed Granular Fill: Unit Weight = 130 pcf, Angle of Internal Friction = 37°.
3) Wetland Deposit: Unit Weight = 110 pcf, Angle of Internal Friction = 29°.
3) Glaciomarine: Unit Weight = 100 pcf, Cohesion = 250 psf.
4) Groundwater conditions the same or similar to those observed in the subsurface explorations by Nobis. Groundwater table modeled at approximately EL. 65 feet, based on test boring information.
5) Surcharge loading of 250 psf.

Approach:

Use the computer slope stability analysis software Slide 6.0, by RocScience, Inc., to perform global stability analyses based at the proposed approach embankment located at STA 15+00.

References:

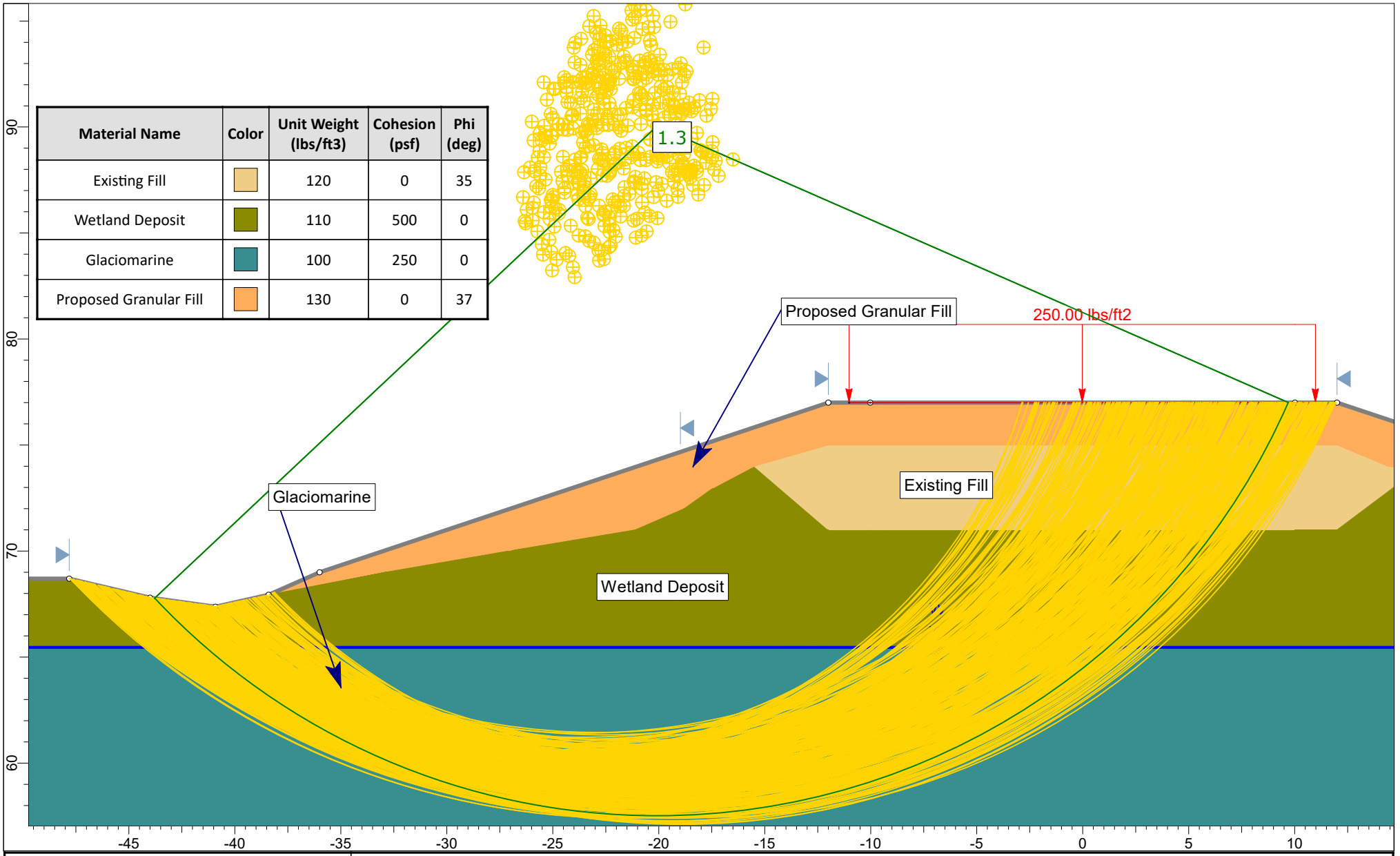
1) CAD drawings provided by Fuss & O'Neill, sent on August 15, 2019.
2) SPT data and field classifications by Nobis at borings performed nearest to proposed slopes (BB-WHB-105).

Remarks/Conclusions:

The minimum factor of safety against global slope failure is 1.3, which meets the acceptable minimum factor of safety of 1.3.

Originated By: Kamil Kocia, Staff Engineer Date: 8/14/2019

Approved By: Rob Clopper, Project Engineer Date: 8/19/2019



Project	94140.00 - Route 32 over Hoch Brook		
Analysis Description	Global Slope Stability Analysis - STA 15+00		
Drawn By: K. Kocia ; chk: R. Clopper	Scale: 1:75	Company: Nobis Engineering	
Date: 8/14/2019		File Name: 94140.00 Embankment STA 15+00.slim	

SLIDEINTERPRET 8.013

APPENDIX F.4 Calculations – Seismic Site Class Calculation

Seismic site classification for the Wagner Bridge over Hoch Brook

Objective: Evaluate seismic site classification for the above mentioned project site.

References:

1) AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017.
2) Borings Observed by Nobis Engineering in December, 2017 and July, 2019.
3) MaineDOT Bridge Design Manual, 2003, with revisions through March, 2014.

Solution:

AASHTO Section 3.10 was used to determine the seismic site classification for the Wagner Bridge project site, as follows:

Step 1: Check for the three categories of Site Class F as described in Table 3.10.3.1-1 - Site Classification Definitions, as follows:

1. Peats or highly organic clays (H>10 ft of peat or highly organic clay where H = thickness of soil).
2. Very high plasticity clays (H>25 ft with PI >75).
3. Very thick soft/medium stiff clays (H > 120 ft).

Soil conditions for Site Class F were not shown on the Nobis Boring Logs.

Step 2: Check for existence of a soft layer with total thickness >10 ft, where soft layer is defined by su<0.5 ksf, w>40%, and PI>20. If these criteria are met, classify site as Site Class E.

Based on step 3, soil conditions for Site Class E were encountered.

Step 3: Categorize the site using one of three methods (i.e. A, B, or C).

Method B (N-bar Method) was used to determine the average Standard Penetration Test (SPT) blow count (blows/ft) for the upper 100 ft of the soil profile using the 2017 and 2019 borings. See attached Table 3.10.3.1-1. The test borings were performed in general accordance with ASTM D1586. The samples were obtained using a 1-3/8" diameter sampler driven with a 140-lb safety hammer dropping a distance of 30 inches.

Conclusion:

The average Standard Penetration Resistance, N-bar, for the site was 4 to 50 bpf. The seismic site classification for the project site is **Site Class E.** The calculated values for the borings are summarized in the following table. See attached tables presenting the value of SPT-N vs. depth for the respective borings.

Sample Calculation: Consider Boring BB-WHB-101

Determine N-bar: Use the average N value of each layer, N_i, for each layer provided in the table toward the end of this report.

$$\overline{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

$$\overline{N} = \frac{8' + 7' + 7.4' + 7.3' + 70.3'}{\frac{8'}{14} + \frac{7'}{7} + \frac{7.4'}{1} + \frac{7.3'}{16} + \frac{70.3'}{100} +} = 10\ bpf$$

Determine the site class for this boring using the Site Class Definitions, attached (Table 3.10.3.1-1, Reference 1)

An N-bar of 10 bpf does not meet the criteria for Site Class D. Boring BB-WHB-101 is classified as **Site Class E** as its standard penetration resistance of 10 bpf is less than 15 bpf. Below, summary tables provide general information for all of the borings considered in this analysis.

Table: Summary of Seismic Site Classification from Borings Performed by Nobis Engineering

Boring No.	N-bar (bpf)	Site Class	Comments
BB-WHB-101	**10**	Site Class E	Boring terminated at 34.7 feet bgs
BB-WHB-102	**50**	Site Class C / D	Boring terminated at 27.7 feet bgs
BB-WHB-103	**5**	Site Class E	Boring terminated at 27.5 feet bgs
BB-WHB-105	**4**	Site Class E	Boring terminated at 23.1 feet bgs
BB-WHB-107	**7**	Site Class E	Boring terminated at 23.1 feet bgs

Notes

1. The SPT-N values were corrected to N60 values assuming the automatic hammer. Please see the attached Calibration reports regarding the automatic hammer.
2. Boring BB-WHB-104 was excluded from the analysis due to located at the culvert and as a result would give an unrepresentative N-value for the site.

Data from Boring BB-WHB-101 (performed December, 2017)

Layer	Depth Range		Thickness (d_i)	N_i	d_i/N_i	Comments
	Start [ft]	End [ft]	[ft]	blows/ft		
1	0	8	8	20	0.400	Fill
2	8	15	7	7	1.000	Wetland Deposit
3	15	22.4	7.4	1	7.400	Glaciomarine
4	22.4	29.7	7.3	23	0.317	Glacial Till
5	29.7	100	70.3	100	0.703	Bedrock
SUM			**100**		**9.820**	

N-bar	**10**	**Site Class E**

Data from Boring BB-WHB-102 (performed December, 2017)

Layer	Depth Range		Thickness (d_i)	N_i	d_i/N_i	Comments
	Start [ft]	End [ft]	[ft]	blows/ft		
1	0	9	9	31	0.290	Fill
2	9	16	7	10	0.700	Wetland Deposit
3	16	18.5	2.5	13	0.192	Glacial Till
4	18.5	22.7	4.2	100	0.042	Inferred Cobbles & Boulders in Glacial Till
5	22.7	100	77.3	100	0.773	Bedrock
SUM			**100**		**1.998**	

N-bar	**50**	**Site Class C - Very Dense Soil & Soft Rock**

Data from Boring BB-WHB-103 (performed July, 2019)

Layer	Depth Range		Thickness (d_i)	N_i	d_i/N_i	Comments
	Start [ft]	End [ft]	[ft]	blows/ft		
1	0	7.8	7.8	17	0.459	Fill
2	7.8	12.3	4.5	1	4.500	Wetland Deposit
3	12.3	20	7.7	1	15.400	Glaciomarine
4	20	27.5	7.5	41	0.183	Glacial Till
5	27.5	100	72.5	100	0.725	Inferred Bedrock
SUM			**100**		**21.267**	

N-bar	**5**	**Site Class E**

Calculated by: KAK Date: 8/14/2019
Checked by: BTW/ JV Date: 8/14/2019
Revision: 1

Data from Boring BB-WHB-105 (performed July, 2019)

Layer	Depth Range		Thickness (d_i)	N_i	d_i/N_i	Comments
	Start [ft]	End [ft]	[ft]	blows/ft		
1	0	4	4	48	0.083	Fill
2	4	9.5	5.5	5	1.100	Wetland Deposit
3	9.5	22	12.5	5	25.000	Glaciomarine
4	22	23.1	1.1	100	0.011	Glacial Till
5	23.1	100	76.9	100	0.769	Inferred Bedrock
SUM			**100**		**26.963**	

N-bar	**4**	**Site Class E**

Data from Boring BB-WHB-107 (performed July, 2019)

Layer	Depth Range		Thickness (d_i)	N_i	d_i/N_i	Comments
	Start [ft]	End [ft]	[ft]	blows/ft		
1	0	9	9	24	0.375	Fill
2	9	12	3	2	1.500	Wetland Deposit
3	12	18.2	6.2	1	12.400	Glaciomarine
4	18.2	23.1	4.9	41	0.120	Glacial Till
5	23.1	100	76.9	100	0.769	Inferred Bedrock
SUM			**100**		**15.164**	

N-bar	**7**	**Site Class E**

Design Maps Summary Report

User–Specified Input

Report Title Route 32 over Hook Brook
Thu January 18, 2018 19:10:09 UTC

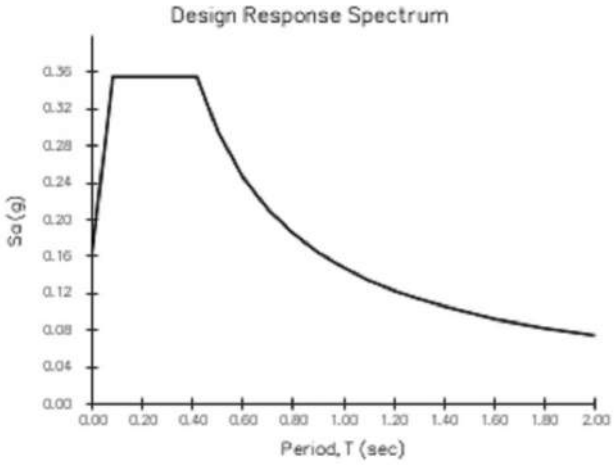
Building Code Reference Document 2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design
(which utilizes USGS hazard data available in 2002)

Site Coordinates 44.14113°N, 69.41707°W

Site Soil Classification Site Class E – "Soft Clay Soil"

USGS–Provided Output

PGA =	0.066 g	**A_s =**	0.165 g
S_s =	0.142 g	**S_{DS} =**	0.355 g
S_1 =	0.042 g	**S_{D1} =**	0.148 g



Design Maps Detailed Report

2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design (44.14113°N, 69.41707°W)

Site Class E – “Soft Clay Soil”

Article 3.4.1 — Design Spectra Based on General Procedure

Note: Maps in the 2009 AASHTO Specifications are provided by AASHTO for Site Class B. Adjustments for other Site Classes are made, as needed, in Article 3.4.2.3.

From Figure 3.4.1-2 [1]	PGA = 0.066 g
From Figure 3.4.1-3 [2]	S_S = 0.142 g
From Figure 3.4.1-4 [3]	S_1 = 0.042 g

Article 3.4.2.1 — Site Class Definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class E, based on the site soil properties in accordance with Article 3.4.2.

Table 3.4.2.1–1 Site Class Definitions

SITE CLASS	SOIL PROFILE NAME	Soil shear wave velocity, $\overline{v}_s$, (ft/s)	Standard penetration resistance, $\overline{N}$	Soil undrained shear strength, $\overline{s}_u$, (psf)
A	Hard rock	$\overline{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \overline{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \overline{v}_s \leq 2{,}500$	$\overline{N} > 50$	>2,000 psf
D	Stiff soil profile	$600 \leq \overline{v}_s < 1{,}200$	$15 \leq \overline{N} \leq 50$	1,000 to 2,000 psf
E	Stiff soil profile	$\overline{v}_s < 600$	$\overline{N} < 15$	<1,000 psf
E	—	Any profile with more than 10 ft of soil having the characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\overline{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Article 3.4.2.3 — Site Coefficients

Table 3.4.2.3-1 (for F_{pga})—Values of F_{pga} as a Function of Site Class and Mapped Peak Ground Acceleration Coefficient

Site Class	Mapped Peak Ground Acceleration				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = E and PGA = 0.066 g, F_{PGA} = 2.500

Table 3.4.2.3-1 (for F_a)—Values of F_a as a Function of Site Class and Mapped Short-Period Spectral Acceleration Coefficient

Site Class	Spectral Response Acceleration Parameter at Short Periods				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = E and S_S = 0.142 g, F_a = 2.500

Table 3.4.2.3-2—Values of F_v as a Function of Site Class and Mapped 1-sec Period Spectral Acceleration Coefficient

Site Class	Mapped Spectral Response Acceleration Coefficient at 1-sec Periods				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_1

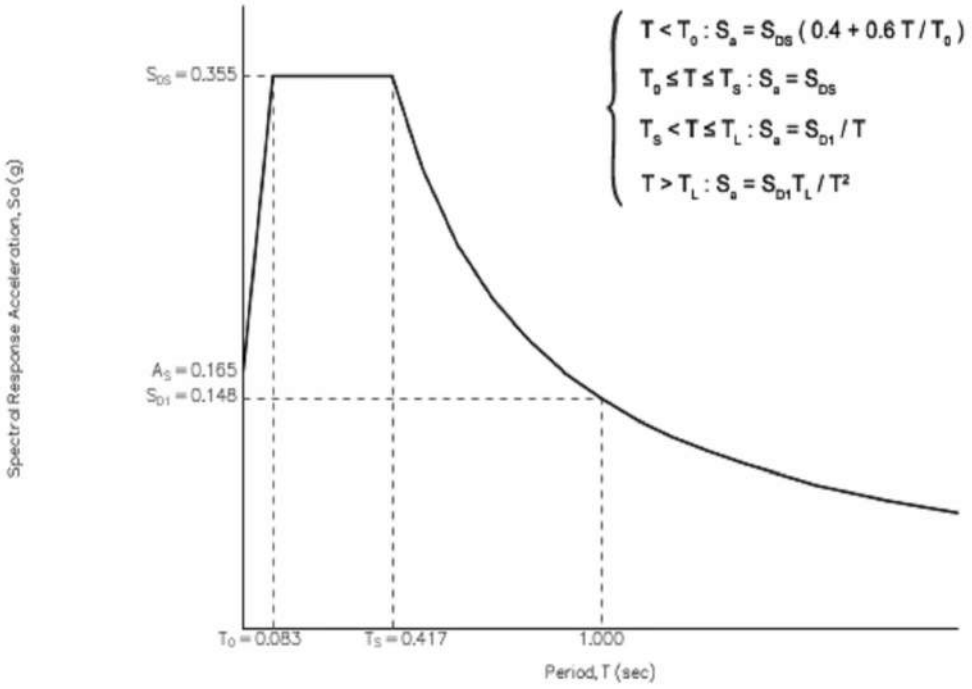
For Site Class = E and S_1 = 0.042 g, F_v = 3.500

Equation (3.4.1-1): $A_S = F_{PGA}\ PGA = 2.500 \times 0.066 = 0.165$ g

Equation (3.4.1-2): $S_{DS} = F_a\ S_S = 2.500 \times 0.142 = 0.355$ g

Equation (3.4.1-3): $S_{D1} = F_v\ S_1 = 3.500 \times 0.042 = 0.148$ g

Figure 3.4.1-1: Design Response Spectrum



Article 3.5 - Selection of Seismic Design Category (SDC)

Table 3.5-1—Partitions for Seismic Design Categories A, B, C, and D

VALUE OF S_{D1}	SDC
$S_{D1} < 0.15g$	A
$0.15g \le S_{D1} < 0.30g$	B
$0.30g \le S_{D1} < 0.50g$	C
$0.50g \le S_{D1}$	D

For S_{D1} = 0.148 g, Seismic Design Category = A

Seismic Design Category ≡ "the design category in accordance with Table 3.5-1" = A

References

1. *Figure 3.4.1-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-2.pdf
2. *Figure 3.4.1-3*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-3.pdf
3. *Figure 3.4.1-4*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-4.pdf

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