

**FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HWY 401 HIGH FILL EMBANKMENT WIDENING FROM 0.25 KM
WEST OF CHOATE RD TO 0.15 KM EAST OF GANARASKA RIVER
NORTHUMBERLAND COUNTY – PORT HOPE, ONTARIO
ASSIGNMENT NO.: 4019-E-0021
GWP 4068-14-00**



THURBER ENGINEERING LTD.



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**SITE NO.
GEOCRES NO.: 30M16-079**

**Report
to
MCINTOSH PERRY | LEA JOINT VENTURE**

Latitude: 43.969733°
Longitude: -78.294973°

August 2023
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PART 1. FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual findings obtained from preliminary and detailed foundation investigations conducted by Thurber Engineering Ltd. (Thurber) for the proposed high fill widening of Highway 401 to the north of the existing alignment from approximately 0.25 km west of the Choate Road overpass to approximately 0.15 km east of the Ganaraska River, located within the Municipality of Port Hope in Northumberland County. Thurber carried out the preliminary foundation investigation as a subconsultant to the McIntosh Perry | LEA joint venture (MPLJV), under MTO Agreement Number 4017-E-0021, Assignment #13 and the detailed foundation investigations as a subconsultant to MPLJV under Agreement No. 4019-E-0021, Assignment No. 18.

A General Arrangement (GA) drawing and base plan mapping were provided by MPLJV for the preparation of this report.

The purpose of these investigations was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, records of boreholes, stratigraphic profiles, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction of the high fill embankment widening was developed in the course of the current investigation.

2. SITE DESCRIPTION

2.1 General

The location of the proposed high fill widening is on the north side of Highway 401 f from approximately 0.25 km west of the Choate Road overpass to approximately 0.15 km east of the



Ganaraska River. The location of the widening is shown on the inset Key Plan in Drawing No. 1 through 6 in Appendix A.

Highway 401 within the corridor of the proposed high fill widening has three lanes in the westbound direction and three lanes in the eastbound direction with paved shoulders. The traffic volume on this section of Highway 401 is understood to be 50,000 AADT (2016). It is noted that for project orientation purposes, Highway 401 will be assumed to be oriented east-west. Speedchange lanes for the on/off ramps to the County Rd 28/Ontario Street interchange are present within the eastern 150 m of the project limits. The eastbound and westbound lanes are separated by a paved median with a concrete barrier wall. The existing Ganaraska River Bridge and the Choate Road Overpass structures are both located within the limits of the proposed widening, dividing it into three separate sections:

- Choate Rd to 250 m west of Choate Rd
- Choate Rd to the Ganaraska River
- The Ganaraska River to 150 m east of the river

The profile of Highway 401 has a grade of approximately 3% from west to east across the Choate Road and Ganaraska River bridge structures.

The lands to the north of Highway 401 consist of undeveloped Ganaraska Region Conservation Authority (GRCA) conservation lands east of the Ganaraska River and GRCA lands and a gravel parking lot between Choate Rd and the Ganaraska River. Low-lying marshy areas are present near the shores of the Ganaraska River. West of the Choate Rd bridge, Choate Rd is parallel to Highway 401 and located near the toe of the Highway 401 embankment slope. Residential and agricultural lands are present on the north side of Choate Rd. Storm water drainage in the area is to existing ditches that drain to the Ganaraska River.

The existing Highway 401 embankment is up to approximately 12 m high with slopes that extend down at approximately 2H:1V (Horizontal:Vertical). The embankment slopes are vegetated with long grasses, shrubs, and occasional trees. No signs of instability of the existing embankments were noted during the field investigation although it is noted that a portion of the existing north side slope west of Choate Road has been lined with rip-rap slope protection.

Site photographs showing the general conditions at the site are presented in Appendix D.



2.2 Site Geology

The site is located within a physiographic region known as the Iroquois Plain. This area was formed by a body of water known as Lake Iroquois and is characterized by lacustrine deposits of sand, silts and clays. Along Highway 401, within the project limits, the principal overburden consists of till and clay with occasional drumlins (Chapman and Putnam, 1984). Ontario Geological Survey Bedrock Geology Mapping indicates the bedrock within the project area consists of limestone, dolostone, shale, arkose and sandstone of the Shadow Lake Formation.

3. EXISTING INFORMATION

3.1 Ganaraska River Bridge

GEOCRES Report 30M16-078 presents the results of both a preliminary and a detailed foundation investigation carried out for the design and replacement of the existing bridge with a widened structure. The preliminary investigation was carried out by Thurber in 2016 and included advancing 4 boreholes (BHs 401 to 404) through the Highway 401 platform; one borehole behind the east and west abutments within both the eastbound and westbound lanes. The detailed investigation was carried out by Thurber in 2022 and included advancing 8 boreholes (GR22-01 to GR22-08) located below and to the north of the existing bridge structure near the proposed piers and abutments of the replacement bridge. Seven of the boreholes were advanced 3.0 m into the limestone bedrock and five of the boreholes were advanced to refusal on inferred bedrock. The stratigraphy through the embankments in the area of the Ganaraska River Bridge is generally described as an asphalt pavement underlain by embankment fill overlying native organic silt, overlying glacial till, and underlain by limestone bedrock. The upper portion of the embankment fill generally consisted of silty sand with gravel with occasional cobbles. The lower portion of the embankment fill was more variable and included clay, silty sand some gravel, sandy silt, sandy clay and silty sand. The bedrock surface ranges from elevation 87.1 m to 91.5 m in the boreholes where rock was cored. The depth to bedrock ranges from 6.1 m to 15.7 m at the locations of the boreholes. The relevant Borehole Records (BHs 401 to 404; GR22-01 to GR22-04, Appendix B) from the 2016 and 2022 investigations are included in Appendix B.

3.2 Choate Road Overpass

GEOCRES Report 30M16-075 presents the results of a preliminary and two detailed foundation investigations carried out for the design and replacement of the existing overpass with a widened structure. The preliminary investigation was carried out by Thurber in 2016 and included advancing 4 boreholes (BHs 301 to 304, Appendix B) through the Highway 401 platform; one borehole behind the east and west abutments within both the eastbound and westbound lanes.



The first detailed investigation was carried out by Thurber in 2019 and included advancing 13 boreholes (BHs 19-01 to 19-13, Appendix B) for the previously proposed structure and associated retaining walls. The second detailed investigation was carried out by Thurber in 2022 and included advancing 4 boreholes (CR22-01 to CR22-04, Appendix B) located below and to the north of the existing bridge structure near the proposed abutments of the currently proposed replacement bridge. Nineteen of the boreholes were advanced 3.0 m into the limestone bedrock and one of the boreholes was advanced to refusal on inferred bedrock. The stratigraphy through the embankments in the area of the Choate Road Overpass is generally described as an asphalt pavement overlying sand and gravel fill, overlying granular and cohesive embankment fill, overlying native clay and silty sand to silt, overlying glacial till. The overburden materials were underlain by a grey, fine grained limestone bedrock. The bedrock surface ranges from elevation 91.7 m to 93.4 m in the boreholes where rock was cored. The depth to bedrock ranges from 4.1 m to 18.5 m at the locations of the boreholes.

3.3 Highway 401 High Fill Widening

GEOCRE 30M16-074 presents the results of a preliminary foundation investigation for the proposed high fill widening of Highway 401 carried out by Thurber in 2020 under MTO Agreement Number 4017-E-0021, Assignment #13. The site investigation and field-testing program was carried out between July 6th and July 14th, 2020 and included advancing seven boreholes labelled 20-01 through 20-07. The results of the preliminary investigation boreholes have been included in the description of subsurface conditions that follows.

4. SITE INVESTIGATION AND FIELD TESTING

A detailed site investigation and field testing program was carried out between March 14th and July 27th, 2022, to supplement the 2020 preliminary investigation and included advancing nine boreholes labelled HF22-01 through HF22-09. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawings in Appendix A and are summarized in Table 4-1. The site is within MTM Zone 10. The as-drilled locations and elevations of all boreholes were surveyed using a Trimble Catalyst DA2 global positioning system antenna with centimeter accuracy. The elevations were surveyed relative to the first order vertical benchmark tablet number PBM 61-69 set in the south face of the west abutment of the Choate Road Overpass which has a geodetic elevation of 109.880 m.

Table 4-1: Borehole Summary

Section	Borehole No.	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
West of Choate Road Overpass	20-01	4 870 657.3	401 290.1	103.8	13.6
	20-02	4 870 669.4	401 361.5	99.8	10.1
	HF22-01	4 870 635.2	401 181.6	110.3	6.3
	HF22-02	4 870 645.0	401 239.6	107.4	10.5
	HF22-03	4 870 651.5	401 278.7	104.3	14.4
	HF22-04	4 870 654.2	401 328.4	105.0	15.5
	HF22-07	4 870 612.9	401 201.2	115.3	14.3
	HF22-08	4 870 626.0	401 302.2	112.2	19.7
Choate Road Overpass to Ganaraska River	20-03	4 870 678.4	401 453.0	97.0	7.8
	20-04	4 870 681.6	401 482.9	96.0	7.7
	20-05	4 870 689.0	401 520.1	94.8	7.5
East of Ganaraska River	20-06	4 870 699.7	401 610.7	94.6	6.7
	20-07	4 870 700.7	401 633.1	94.5	6.8
	HF22-05	4 870 706.3	401 658.7	95.0	8.2
	HF22-06	4 870 710.0	401 681.5	95.7	10.7
	HF22-09	4 870 683.7	401 680.0	102.1	15.4

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locates/clearances in the vicinity of the intended borehole locations. In addition, MTO traffic operations was contacted to obtain ATMS Fibre utility locates and RW Electric was contacted to obtain MTO electric locates for the project limits.

Boreholes 20-01 through 20-05 were advanced using a track mounted CME45 drill rig equipped with Hollow Stem Augurs, NW casing, and NQ coring equipment. Boreholes HF22-03 and HF22-04 were advanced using a track mounted D50 Turbo drill rig equipped with NW casing equipment, NQ coring equipment and wash boring. Boreholes HF22-07 through HF22-09 were advanced using a truck mounted CME55 drill rig equipped with Hollow Stem Augurs. Boreholes 20-06 and 20-07 were advanced using a portable tri-pod setup with NW casing and a full-weight hammer. Boreholes HF22-01, HF22-02, HF22-05 and HF22-06 were advanced using portable



drilling equipment with NW casing equipment, NQ coring equipment, a half-weight hammer and wash boring.

The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes via the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. In-situ shear vane testing was carried out within the cohesive strata where possible using an MTO 'N' sized vane following the methods described in ASTM Standard D2573-18. Thin-wall (Shelby) Tube samples of the cohesive soil were retrieved to obtain relatively undisturbed soil samples for further laboratory testing. All soil samples recovered from split spoons were placed in moisture-proof containers and the samples were transported to Thurber's Ottawa or Pickering geotechnical laboratory for further examination and testing. Where bedrock was cored, the procedure followed ASTM Standard D6032-08. NQ size coring equipment was used in all cored boreholes. Bedrock core samples were stored in wood core boxes for transport.

A 38 mm diameter PVC standpipe piezometer was installed in Borehole HF22-06 and 19 mm standpipe piezometers consisting of PVC pipe were installed in Boreholes 20-01, 20-05, 20-07, HF22-01 and HF22-04 to allow for measurement of the groundwater level at the site. The piezometer construction details are illustrated on the corresponding Record of Borehole sheets provided in Appendix B. The 2020 piezometers were decommissioned in general accordance with Ontario MOE Regulation 903 on August 20th, 2020, after final water level readings were taken. The piezometers in Boreholes HF22-01, HF22-04 and HF22-06 were decommissioned in accordance with Ontario MOE Regulation 903 on June 22, 2023.

The boreholes without piezometer installations were backfilled with a low-permeability combination of soil cuttings and bentonite pellets in general accordance with Ontario MOE Regulation 903 as amended. All boreholes through Highway 401 were capped with 150 mm of cold patch asphalt, the cold patch was underlain by 150 mm layer of concrete.

5. LABORATORY TESTING

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. More than 25% of the recovered soil samples were tested for grain size distribution and, where appropriate, Organic Content, Atterberg Limits and Consolidation in accordance with MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Selected samples of the rock core were submitted for unconfined compressive



strength (UCS) testing. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate, sulphide and chloride concentrations was carried out on select soil samples.

The results of geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and laboratory results are presented on the figures included in Appendix C.

6. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are described separately for each of the three embankment sections: 1) West of the Choate Rd Overpass; 2) East of the Choate Road Overpass to the Ganaraska River; and 3) East of the Ganaraska River.

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A for illustrative purposes. Soil classification is in accordance with ASTM D2487 with cohesive soils described as per current MTO Guidelines for Foundation Engineering Services. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions.

6.1 West of Choate Road Overpass

6.1.1 Overview / General

The Borehole Location and Soil Strata Drawing showing West of the Choate Road Overpass is shown in Drawing 1 provided in Appendix A. The stratigraphy encountered in Boreholes 20-01, 20-02, HF22-01 through HF22-04, advanced north of the existing Highway 401 embankment toe west of the Choate Road Overpass is generally characterized by silty clay and/or clayey silt overlying a glacial till containing frequent cobbles and boulders, overlying limestone bedrock.

The stratigraphy encountered in Boreholes HF22-07 and HF22-08, advanced on the north shoulder of the existing Highway 401 embankment west of the Choate Road Overpass, consists of asphalt overlying embankment fill overlying silty clay and/or clayey silt and underlain by glacial till.

More detailed descriptions of the individual strata are presented below.

6.1.2 Asphalt

A 100 mm thick layer of asphalt was encountered from ground surface in Boreholes HF22-07 and HF22-08.

6.1.3 Upper Embankment Fill

An upper embankment fill layer consisting of silty sand with gravel fill was encountered directly below the asphalt surface in Boreholes HF22-07 and HF22-08. The thickness of this fill layer was 1.3 m (underside elevation 110.8 m to 113.9 m). The SPT 'N' values ranged from 81 to 93 blows for 0.3 m of penetration, indicating a very dense condition.

The moisture content of the samples tested ranged from 2% to 5%. The results of grain size analysis conducted on two samples of this material are summarized in Table 6-1 and are illustrated in Figure C1 in Appendix C.

Table 6-1: Gradation Results for the Upper Embankment Fill

Soil Particle	Percentage (%)
Gravel	26 – 32
Sand	51 – 54
Silt & Clay	14 – 23

6.1.4 Lower Embankment Fill

A lower embankment fill layer ranging in composition from silty clayey sand to sandy clayey silt was encountered below the upper embankment fill in Boreholes HF22-07 and HF22-08. The thickness of the lower embankment fill layer ranged from 5.5 to 7.6 m (underside elevation 108.4 m to 103.2 m). The SPT 'N' values ranged from 12 blows for 0.3 m of penetration to 100 blows for 100 mm of penetration, indicating a compact to very dense condition.

The moisture content of the samples tested ranged from 3% to 20%. The results of grain size analysis conducted on five samples of this material are summarized in Table 6-2 and are illustrated in Figure C2 in Appendix C.

Table 6-2: Gradation Results for the Lower Embankment Fill

Soil Particle	Percentage (%)
Gravel	1 – 12
Sand	39 – 62
Silt	15 – 33
Clay	11 – 25

Atterberg Limits testing was completed on three samples of the silty clayey sand to sandy clayey silt fill (minus the coarse sand fraction). The samples were found to be of low plasticity (ML to CL), the results are summarized in Table 6-3 and are illustrated on Figure C10 in Appendix C.

Table 6-3: Atterberg Limit Results for the Lower Embankment Fill

Parameter	Moisture Content (%)
Liquid Limit	14 – 20
Plastic Limit	12 – 15
Plasticity Index	1 – 8

6.1.5 Silty Clayey Sand Fill

A surficial fill layer consisting of silty clayey sand with varying amounts of gravel was encountered from ground surface in Boreholes HF22-01 and HF22-03. The thickness of this fill layer ranged from 1.4 m to 2.3 m (underside elevation 102.0 m to 108.9 m). The SPT 'N' values ranged from 1 to 28 blows for 0.3 m of penetration, indicating a very loose to compact condition. Occasional cobbles were noted within this layer.

The moisture content of the samples tested ranged from 6% to 29%. The results of grain size analysis conducted on two samples of this material are summarized in Table 6-4 and are illustrated in Figure C3 in Appendix C.

Table 6-4: Gradation Results for the Silty Clayey Sand Fill

Soil Particle	Percentage (%)
Gravel	3 – 31
Sand	35 – 65
Silt	22 – 24
Clay	8 – 12

6.1.6 Rip-Rap

A 0.5 m-thick layer of rip-rap fill was encountered from surface in Borehole 20-01. The bottom elevation of this layer was encountered at elevation 103.3 m.

6.1.7 Topsoil

A 200 mm thick layer of topsoil was encountered from surface in Boreholes 20-02 and HF22-04.

6.1.8 Clayey Silt to Silty Clay (CL to CI)

A layer ranging from clayey silt with sand to silty clay was identified from surface in Borehole HF22-02, below the rip-rap in Borehole 20-01, below the topsoil in Boreholes 20-02 and HF22-04, and below the fill in Boreholes HF22-01, HF22-03, HF22-04, HF22-07 and HF22-08. Within the

clayey silt layer in Boreholes 20-01 and 20-02, a weathered crust with thickness ranging from 1.3 m to 2.4 m (bottom elevation 98.3 m to 100.9 m) was identified at the top of the layer. The thickness of the overall clayey silt to silty clay layer was found to range from 2.5 m to 9.8 m (underside elevation 93.4 m to 106.4 m).

The SPT 'N' values ranged from weight of hammer to 39 blows for 0.3 m of penetration; two refusal blow counts were obtained at the base of the deposit in Boreholes HF22-01 and HF22-08 which are attributed to the underlying glacial till layer and not the clayey silt to silty clay layer. The measured moisture content ranged from 10 to 35%. MTO 'N' vane testing indicated undrained shear strengths ranging from 41 to greater than 106 kPa with low to sensitive sensitivity. It is noted that the MTO 'N' vane was generally unable to penetrate the clayey silt to silty clay deposit within the upper portion of the deposit, the condition within this portion is estimated to be very stiff.

The results of grain size analysis conducted on nineteen samples of this material are summarized in Table 6-5 and are illustrated on Figures C4 to C7 in Appendix C.

Table 6-5: Gradation Results for Clayey Silt to Silty Clay

Soil Particle	Percentage (%)
Gravel	0 – 5
Sand	1 – 40
Silt	32 – 57
Clay	14 – 51

The results of Atterberg Limits testing on the fines fraction (minus the gravel and coarse sand fraction) of the samples are summarized in Table 6-6 and indicate the clayey silt to be of low to intermediate plasticity (CL to CI). Atterberg Limits analysis results are illustrated on Figure C11 to C13 in Appendix C.

Table 6-6: Atterberg Limit Results for Fines Portion of Clayey Silt to Silty Clay

Parameter	Moisture Content (%)
Liquid Limit	18 – 41
Plastic Limit	11 – 21
Plasticity Index	7 – 23

Consolidation testing was carried out on one sample of clayey silt retrieved in Borehole 19-01 during a previous investigation at the Choate Road overpass and three samples of clayey silt to silty clay retrieved in Boreholes 20-01, HF22-03, HF22-04 during the current investigation. The results are summarized below in Table 6-7 and presented in Appendix C.

Table 6-7: Consolidation Testing Results

Parameter	BH 19-01* ST1	BH 20-01 ST4	HF22-03 ST1	HF22-04 ST9
Elevation	96.3 m	100.4 m	99.4 m	97.8
w	24.6%	25.7%	26.9%	19.0%
e _o	0.661	0.680	0.779	0.620
p _o '	65 kPa	65 kPa	85 kPa	105 kPa
p _c '	180 kPa	175 kPa	242 kPa	194 kPa
C _c	0.243	0.167	0.214	0.162
C _r	0.039	0.03	0.044	0.014
c _v	0.105 mm ² /s	0.240 mm ² /s	0.200 mm ² /s	0.400 mm ² /s
c _{vr}	0.422 mm ² /s	0.273 mm ² /s	0.600 mm ² /s	0.400 mm ² /s

* - Retrieved during a previous drilling investigation

6.1.9 Sandy Silt

A thin layer of sandy silt, some gravel, was encountered in Boreholes 20-01 and 20-02 below the clayey silt layer. This layer had a thickness of 0.7 m and extended to depths ranging from 5.3 m to 7.6 m (elev. 96.2 and 94.5 m) below ground surface.

SPT 'N' values measured in the sandy silt ranged from 18 to 25 blows for 0.3 m of penetration, indicating a compact relative density. The moisture content of this layer ranged from 9% to 11%.

The results of a grain size analysis test conducted on a sample of this material found the composition to be 11% gravel, 36% sand, 39% silt and 14% clay. This gradation is illustrated on Figure C8 in Appendix C.

Atterberg Limits testing on the fines fraction (minus the gravel and coarse sand fraction) of the sandy silt resulted in a liquid limit of 16%, a plastic limit of 14% and a plasticity index of 2% indicating the sandy silt to be of low plasticity (ML). The results of this Atterberg Limits analysis are illustrated on Figure C14 in Appendix C.

6.1.10 Glacial Till

A glacial till deposit consisting of a heterogeneous mixture of clay, silt, sand, and gravel was encountered beneath the sandy silt in Boreholes 20-01 and 20-02 and beneath the clayey silt to silty clay in Boreholes HF22-01 through HF22-04, HF22-07 and HF22-08. The glacial till was inferred in Boreholes HF22-04 and HF22-08 as no samples were able to be obtained from the layer. The glacial till was noted to contain cobbles and boulders in several boreholes.

The top of the glacial till deposit ranges from Elevation 93.4 m and 106.4 m. The SPT 'N' values ranged from 10 blows for 0.3 m penetration to 100 blows for 50 mm penetration indicating a compact to very dense configuration. Where fully penetrated the thickness of the glacial till ranged from 0.9 m to 4.1 m (underside elevation 92.5 m to 101.0 m). Coring techniques were required to progress the boreholes through the glacial till in several boreholes.

The moisture content of the glacial till samples tested ranged from 2 to 13%. The results of grain size analysis conducted on selected samples of glacial till are summarized in Table 6-8 and are illustrated on Figures C9 in Appendix C.

Table 6-8: Gradation Results for Glacial Till

Soil Particle	Percentage (%)	
Gravel	4 – 58	
Sand	32 – 58	
Silt	10 – 32	23 – 35
Clay		10 – 17

The results of Atterberg Limits testing on the fines fraction (minus the gravel and coarse sand fraction) of one sample of the glacial till indicated a liquid limit of 13%, a plastic limit of 11% and a plasticity index of 2% indicating a silt of low plasticity (ML). Atterberg Limits analysis results are illustrated on Figure C15 in Appendix C.

6.2 Choate Road Overpass to the Ganaraska River

6.2.1 Overview / General

The Borehole Location and Soil Strata Drawing showing from the Choate Road Overpass to the Ganaraska River is shown in Drawing 2 provided in Appendix A. The stratigraphy encountered in the boreholes advanced at the toe of the Highway 401 embankment between the Choate Road



Overpass and the Ganaraska River Bridge is characterized by soft organic silt, overlying a deposit ranging from silty sand to sandy silt, overlying glacial till. Bedrock was found between elevations 91.1 m and 92.9 m within this section of the proposed widening.

More detailed descriptions of the individual strata are presented below.

6.2.2 Organic Silt (ML-OL to MI-OI)

Organic Silt (ML-OL to MI-OI) was encountered from ground surface in Boreholes 20-03, 20-04, and 20-05. The organic silt encountered within these boreholes was generally a mixture of silt and organics with varying amounts of sand. The thickness of this layer ranged from 1.5 to 3.0 m (bottom elevation 91.8 m to 94.7 m).

The SPT 'N' values ranged from weight of hammer to 15 blows for 0.3 m of penetration, indicating a very loose to compact relative density; but generally, very loose. Two shear vane tests conducted in Borehole 20-03 indicated an undrained shear strength of 69 kPa with the sensitivity ranging from 8.3 to 11. The measured moisture content of the organic silt ranged from 17 to 58%. An organic content test carried out on one sample of the organic silt indicated an organic content of 0.4%.

The results of grain size analyses conducted on selected samples of the organic silt layer are summarized in Table 6-9 and are illustrated on Figure C16 in Appendix C.

Table 6-9: Gradation Results for Organic Silt

Soil Particle	Percentage (%)
Gravel	0 – 4
Sand	7 – 44
Silt	35 – 71
Clay	15 – 22

The results of Atterberg Limits testing carried out on selected samples are summarized in Table 6-10 and indicate the organic silt to be of low to intermediate plasticity (ML-OL to MI-OI). Atterberg Limits analysis results are illustrated on Figure C19 in Appendix C.

Table 6-10: Atterberg Limit Results for Fines Portion of Organic Silt

Parameter	Moisture Content (%)
Liquid Limit	26 – 48
Plastic Limit	23 – 39
Plasticity Index	3 – 9

6.2.3 Silty Sand to Sandy Silt

A deposit ranging from silty sand to sandy silt was encountered below the organic silt in Boreholes 20-03 and 20-04. The thickness of this layer was found to be 1.5 m with the underside depth ranging from 3.0 m to 3.8 m (elevation 93.0 m to 93.2 m).

The SPT 'N' values ranged from 3 to 32 blows for 0.3 m of penetration indicating a very loose to dense condition; but typically, very loose to compact. The measured moisture content of the silty sand to sandy silt ranged from 17 to 27%.

The results of grain size analyses conducted on selected samples of this deposit are summarized in Table 6-11 and are illustrated on Figure C17 in Appendix C.

Table 6-11: Gradation Results for Silty Sand to Sandy Silt

Soil Particle	Percentage (%)
Gravel	0 – 13
Sand	44 – 53
Silt	29 – 48
Clay	8 – 12

6.2.4 Glacial Till

A layer of glacial till ranging in composition from silty sand with gravel to sand with silt and gravel was encountered below the silty sand to sandy silt in Boreholes 20-03 and 20-04, and below the organic silt in Borehole 20-05. This layer had a thickness ranging from 0.3 m to 0.7 m and extended to depths ranging from 3.6 to 4.1 m below ground surface (elev. 92.9 to 91.1 m).

SPT 'N' values measured in the glacial till ranged from 14 blows for 0.3 m of penetration to 100 blows for 150 mm of penetration indicating a compact to very dense condition. The moisture content of the samples tested ranged from 7% to 11%.



The results of grain size analyses conducted on two sample of the glacial till are summarized in Table 6-12 and are illustrated on Figure C18 in Appendix C.

Table 6-12: Gradation Results for Glacial Till

Soil Particle	Percentage (%)
Gravel	28 – 34
Sand	47 – 55
Silt & Clay	11 – 25

6.3 East of the Ganaraska River

6.3.1 Overview / General

The Borehole Location and Soil Strata Drawing showing East of the Ganaraska River is shown in Drawing 3 provided in Appendix A. The stratigraphy encountered in Boreholes 20-06, 20-07, HF22-05 and HF22-06, advanced north of the existing Highway 401 toe of slope east of the Ganaraska River, generally consists of organic silt, underlain by a layer of silty clay or silty sand, underlain by glacial till.

The stratigraphy encountered in Borehole HF22-09, advanced on the north shoulder of the existing Highway 401 embankment east of the Ganaraska River, consists of asphalt overlying granular embankment fill overlying cohesive embankment fill, underlain by a silty clay layer, underlain by glacial till.

More detailed descriptions of the individual strata are presented below.

6.3.2 Asphalt

A 100 mm thick layer of asphalt was encounter at ground surface in Borehole HF22-09.

6.3.3 Upper Embankment Fill

Silty sand with gravel fill was encountered directly below the asphalt surface in Borehole HF22-09. The thickness of the granular fill layer was 1.2 m (underside elevation 100.8 m). The SPT 'N' values ranged from 15 to 39 blows for 0.3 m of penetration, indicating a compact to dense condition.

The moisture content of the samples tested ranged from 3% to 10%. The results of a grain size analysis conducted on one sample of this material found the composition to be 31% gravel, 53% sand and 16% silt and clay; the gradation results are illustrated on Figure C20 in Appendix C.

6.3.4 Lower Embankment Fill

Fill ranging in composition from silty clay to clayey silt was encountered below the upper embankment fill in Borehole HF22-09. The thickness of the cohesive fill layer was 6.2 m (underside elevation 94.6 m). The SPT 'N' values ranged from 12 to 22 blows for 0.3 m of penetration. The silty clay to clayey silt fill material was not conducive to shear vane testing due to the high 'N' values but is estimated to have a very stiff consistency.

The moisture content of the samples tested ranged from 16% to 30%. The results of grain size analysis conducted on four samples of this material are summarized in Table 6-13 and are illustrated in Figure C21 in Appendix C.

Table 6-13: Gradation Results for the Cohesive Embankment Fill

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	9 – 16
Silt	44 – 48
Clay	36 – 45

Atterberg Limits testing was completed on four samples of the silty clay to clayey silt fill (minus the coarse sand fraction). The samples were found to range from low to intermediate plasticity (CL to CI), the results are summarized in Table 6-14 and are illustrated on Figure C28 in Appendix C.

Table 6-14: Atterberg Limit Results for the Cohesive Embankment Fill

Parameter	Moisture Content (%)
Liquid Limit	32 – 46
Plastic Limit	17 – 20
Plasticity Index	15 – 27



6.3.5 Topsoil

A 50 mm thick layer of topsoil was encountered at ground surface in both Boreholes 20-06 and 20-07.

6.3.6 Organic Silt (CI to MI-OI to MH-OH)

An organic silt (CI to MI-OI to MH-OH) deposit was encountered from ground surface in HF22-05 and HF22-06 and directly below the surficial topsoil layer in both Boreholes 20-06 and 20-07. The organic silt was generally a mixture of silt and organics with varying amounts of sand. The deposit ranged in thickness from 2.0 m to 3.8 m (underside elevation 91.2 m to 93.7 m).

The SPT 'N' values ranged from 1 to 25 blows for 0.3 m of penetration, indicating a very loose to compact relative density. Shear vane testing found the natural shear strength to range from 37 kPa to 73 kPa with the sensitivity ranging from 3.3 to 6. The measured moisture content of the organic silt ranged from 18 to 81%. Organic content testing conducted on two samples of the organic silt material indicated 1.88% and 2.48% losses on ignition at 550°C.

The results of a grain size analysis test conducted on five samples of this material are summarized in Table 6-15 and are illustrated on Figure C22 in Appendix C.

Table 6-15: Gradation Results for Organic Silt

Soil Particle	Percentage (%)
Gravel	0 – 4
Sand	8 – 36
Silt	41 – 69
Clay	14 – 24

The results of Atterberg Limits testing on selected samples of the organic silt (minus the coarse sand fraction) are summarized in Table 6-16 and indicate the organic silt to be of intermediate to high plasticity (CI to MI-OI to MH-OH). It is noted that Atterberg limits tests indicating intermediate plasticity silty clay (CI) have high sand contents which may have caused the test results to plot above the 'A' line. Atterberg Limits analysis results are illustrated on Figure C29 in Appendix C.

Table 6-16: Atterberg Limit Results for Organic Silt

Parameter	Moisture Content (%)
Liquid Limit	36 – 57
Plastic Limit	18 – 46
Plasticity Index	8 – 22

6.3.7 Clayey Silt to Silty Clay (CL to CI)

A layer of clayey silt to silty clay was encountered underlying the organic silt in Boreholes 20-06, below the silty sand in Borehole HF22-06 and below the cohesive embankment fill in Borehole HF22-09. This layer has a thickness ranging from 0.6 m to 4.7 m (underside elevation 89.9 m to 91.1 m).

SPT ‘N’ values in the clayey silt to silty clay layer ranged from 4 to 22 blows for 0.3 m of penetration. Shear vane testing conducted where possible found the natural shear strength to range from 44 kPa to 71 kPa with the sensitivity ranging from 3.2 to 4. The clayey silt to silty clay is estimated to generally be in a very stiff condition only reducing to a firm condition near the base of the deposit in Borehole HF22-09. The measured moisture content of the clayey silt to silty clay ranged from 14% to 48%.

The results of a grain size analysis test conducted on three samples of this material are summarized in Table 6-21 and are illustrated on Figure C24 in Appendix C.

Table 6-17: Gradation Results for Clayey Silt to Silty Clay

Soil Particle	Percentage (%)
Gravel	0
Sand	1 – 10
Silt	40 – 57
Clay	33 – 57

The results of Atterberg Limits testing on three samples of the clayey silt to silty clay (minus the coarse sand fraction) are summarized in Table 6-18 and indicate the clayey silt to silty clay to be of low to intermediate plasticity (CL to CI). Atterberg Limits analysis results are illustrated on Figure C30 in Appendix C.

Table 6-18: Atterberg Limit Results for Clayey Silt to Silty Clay

Parameter	Moisture Content (%)
Liquid Limit	31 – 45
Plastic Limit	17 – 25
Plasticity Index	14 – 20

6.3.8 Silty Sand

A thin layer of silty sand was encountered underlying the organic silt in Boreholes 20-07 and HF22-06. This layer has a thickness ranging from 0.3 m to 0.4 m (underside elevation 91.5 m to 93.4 m) below ground surface.

The SPT 'N' value measured in the silty sand was 20 blows for 0.3 m of penetration, indicating a compact relative density. The moisture content of the layer ranged from 10% to 18%.

A grain size analysis test conducted on a sample of the silty sand found the composition to be 6% gravel, 60% sand, 29% silt and 5% clay; the results of this test are illustrated on Figure C25 in Appendix C.

6.3.9 Glacial Till

A glacial till deposit consisting of a heterogeneous mixture of clay, silt, sand, and gravel was encountered beneath the organic silt in Borehole HF22-05, beneath the clayey silt to silty clay in Boreholes 20-06 and HF22-06, beneath the silty sand in Borehole 20-07 and beneath the cohesive embankment fill in Borehole HF22-09. The top of the glacial till deposit ranges from Elevation 89.9 to 91.5 m. All boreholes were terminated within this deposit at depths ranging from 6.7 to 15.4 m below ground surface (elevation 87.9 to 85.0 m).

The SPT 'N' values ranged from 10 blows for 0.3 m of penetration to 100 blows for 0 mm of penetration, indicating a compact to very dense relative density. Cobbles and boulders were identified within several boreholes. Although not identified in all boreholes, cobbles and boulders are inherently present within glacial till deposits. The moisture content of the samples tested ranged from 7 to 25%.

The results of grain size analysis conducted on selected samples of glacial till are summarized in Table 6-19 and are illustrated on Figures C26 and C27 in Appendix C.

Table 6-19: Gradation Results for Glacial Till

Soil Particle	Percentage (%)	
Gravel	2 – 55	
Sand	29 – 71	
Silt	10 – 16	16 – 46
Clay		2 – 12

6.4 Bedrock

The overburden materials were underlain by a grey limestone bedrock. The bedrock surface ranges from elevation 91.1 to 93.4 m in the boreholes where bedrock was cored. Photographs of the bedrock core are provided in Appendix C. Table 6-20 below summarizes the depths and elevations of the bedrock surface.

Table 6-20 Top of Bedrock Elevation

Section	Borehole	Ground Surface Elevation (m)	Depth Below Existing Grade (m)	Top of Bedrock Elevation (m)
West of Choate Rd Overpass	20-01	103.8	10.7	93.1
	20-02	99.8	6.6	93.2
	HF22-03	104.3	10.9	93.4
	HF22-04	105.0	12.3	92.7
	HF22-07	115.3	14.3	101.0*
	HF22-08	112.2	19.7	92.5*
Choate Rd Overpass to Ganaraska River	20-03	97.0	4.1	92.9
	20-04	96.0	3.6	92.4
	20-05	94.8	3.7	91.1
East of Ganaraska River	20-06	94.6	6.7	87.9*
	20-07	94.5	6.8	87.7*
	HF22-06	95.7	10.7	85.0*
	HF22-09	102.1	15.4	86.7*

* Inferred Bedrock by SPT and/or auger refusal.

Boreholes 20-01 through 20-05, HF22-03 and HF22-04 were advanced into the bedrock by coring with NQ-size coring equipment.

The bedrock encountered in these boreholes had a total core recovery ranging from 92% to 100%, the solid core recovery ranging from 0 to 98% (typically 82 to 98%) and the Rock Quality Designation (RQD) ranging from 0 to 82% (typically 47 to 87%). Based on the RQD value the bedrock is classified as very poor to good, but typically fair to good.

The unconfined compressive strength of the Limestone Bedrock was measured to range from 62.8 to 122.5 MPa from four core samples from Boreholes 20-02, 20-04 and HF22-03 indicating strong to very strong bedrock. The results are included in Appendix C.

6.5 Groundwater

Groundwater levels were measured in the standpipe piezometers installed in Boreholes 20-01, 20-05, 20-07, HF22-01, HF22-04 and HF22-06 as well as the piezometers installed in Boreholes 19-01 and 19-03 installed in a previous investigation at the Choate Road overpass. All piezometers other than the 2022 piezometers were decommissioned in accordance with Ontario MOE Regulation 903 following the final recorded reading. The 2022 piezometers were decommissioned in accordance with Ontario MOE Regulation 903 on June 22, 2023. The measurements are presented on the Record Borehole sheets in Appendix B and in Table 6-21 below:

Table 6-21: Groundwater Level Observations

Section	Borehole	Groundwater Level		Date of Measurement
		Depth (mbgs)	Elevation (m)	
West of Choate Rd Overpass	19-01*	5.2	97.5	July 7, 2020
		5.1	97.6	August 20, 2020
	20-01	3.5	100.3	July 8, 2020
		3.4	100.4	July 9, 2020
		3.7	100.1	July 15, 2020
	HF22-01	0.2	110.1	August 23, 2022
		0.2	110.1	August 24, 2022
		0.3	110.0	June 22, 2023
	HF22-04	4.7	100.3	August 23, 2022
		4.7	100.3	August 24, 2022
		3.9	101.1	June 22, 2023
Choate Rd Overpass to Ganaraska River	19-03*	1.2	96.7	July 7, 2020
		1.2	96.7	July 14, 2020

Section	Borehole	Groundwater Level		Date of Measurement
		Depth (mbgs)	Elevation (m)	
	20-05	0.8	94.0	July 8, 2020
		1.1	93.7	July 16, 2020
		0.8	94.0	August 20, 2020
East of Ganaraska River	20-07	0.3	94.2	July 14, 2020
		0.4	94.1	July 16, 2020
		0.3	94.2	August 20, 2020
	HF22-06	Flowing	>95.9	March 16, 2022
		Flowing	>95.9	March 22, 2022
		Flowing	>95.9	August 23, 2022
		Flowing	>95.9	August 24, 2022

* - Installed during a previous drilling investigation

It is noted that the elevation of artesian conditions encountered in Borehole HF22-06 is not known; water was observed flowing out of the top of the standpipe piezometer at an elevation of 95.9 m implying the artesian water head is above this elevation. The piezometer in HF22-06 was sealed temporarily with a locking J-plug between readings to prevent continuous flow. This artesian piezometer was sealed at the source in accordance with Ontario MOE Regulation 903 on June 22, 2023.

These observations are considered short term and it should be noted that fluctuations of the groundwater level are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant and/or prolonged precipitation.

6.6 Analytical Testing

Three samples of soil were submitted to SGS Canada Inc. in Lakefield, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are provided in Appendix C and are summarized in Table 6-22 below:

Table 6-22: Results of Chemical Analysis

Borehole	HF22-02	HF22-03	HF22-06
Sample	SS2B	SS4	SS4B
Depth (m)	0.6 – 1.0	2.3 – 2.9	2.6 – 2.7
Chloride (µg/g)	84	480	510
Sulphate (µg/g)	60	28	25
Sulphide (%)	< 0.04	< 0.04	< 0.04
pH (-)	8.1	8.6	8.5
Resistivity (Ohm-cm)	3,290	1,090	1,100
Conductivity (µS/cm)	304	919	905

7. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and Marathon Underground of Greely, Ontario supplied and operated the track mounted and portable drill rigs to carry out the drilling, sampling, in-situ testing, standpipe piezometer installation and decommissioning of the boreholes. Decommissioning of the piezometers was conducted by Thurber. Traffic control was performed in accordance with Ontario Book 7 for short duration closures; all signs, barrels, cones and traffic control personnel were provided by Thurber Engineering and Beacon Lite Ltd. of Kingston, Ontario. The field investigation was supervised on a full-time basis by Mr. Richard Howarth, C. Tech., Mr. Joe Lin and Mr. Scott Gittens. Overall supervision of the field investigation program was provided by Mr. Christopher Murray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratories in Ottawa and Pickering, Ontario. Analytical testing was completed by SGS Canada Inc. in Lakefield, Ontario. Unconfined compressive strength testing was carried out by Thurber's laboratory in Oakville, Ontario and Stantec's Laboratory in Ottawa, Ontario. Organic content testing was carried out by Stantec's Laboratory in Ottawa, Ontario and SGS Canada Inc. in Lakefield, Ontario. Consolidation testing was carried out by Thurber's Laboratory in Ottawa, Ontario. Interpretation of the factual data and preparation of this report was completed by Mr. Christopher Murray, P.Eng. The report was reviewed by Mr. Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.



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FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HWY 401 HIGH FILL EMBANKMENT WIDENING FROM 0.25 KM WEST OF CHOATE RD TO
0.15 KM EAST OF GANARASKA RIVER
NORTHUMBERLAND COUNTY – PORT HOPE, ONTARIO
ASSIGNMENT NO.: 4019-E-0021
GWP 4068-14-00

GEOCRES NO.: 30M16-079

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the design of the high fill widening to the north side of Highway 401 from approximately 0.25 km west of the Choate Road overpass to 0.15 km east of the Ganaraska River within the Municipality of Port Hope in Northumberland County. The discussion and recommendations presented in this report are based on the information provided by LEA Consulting (LEA), McIntosh Perry Consulting Engineers (MPCE) and the factual data obtained during the current field investigation. Thurber Engineering Limited (Thurber) carried out the assignment as a sub-consultant to the McIntosh Perry | LEA joint venture (MPLJV) under Agreement No. 4019-E-0021.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, LEA Consulting and McIntosh Perry Consulting Engineers and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

8.1 Existing Embankment

The existing Highway 401 embankment within the limits of the proposed widening contains both the Ganaraska River Bridge and the Choate Road Overpass structures, dividing it into three separate sections. The Highway 401 embankment west of the Choate Road overpass ranges



from approximately 8 m to 11 m in height, the embankment between the Choate Road overpass and the Ganaraska River Bridge is approximately 11 m in height and the embankment east of the Ganaraska River Bridge ranges from approximately 7 m to 9 m in height. The side slopes of all existing embankments extend down at approximately 2H:1V. The embankment slopes are vegetated with long grasses, shrubs, and occasional trees.

8.2 Proposed Widening

It is understood that the existing Highway 401 high fill embankment will be widened to the north by approximately 18 m at the crest to accommodate staged construction of the Choate Road Overpass and Ganaraska River Bridge and allow for future widening from 6 to 8 lanes. The existing grade of Highway 401 will be maintained and the widening will be restrained to within the existing MTO right of way with retaining walls as shown in the roadway alignment drawings dated September 2022 provided by MPLJV and included in Appendix A.

8.3 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations, existing ground surface conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC) version CSA S6-19.

It is assumed that any retaining wall structure has a consequence classification of *Typical Consequence*, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances for any structure. If the consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and revised.

As per Section 6.5.3 of the CHBDC, the degree of site prediction model understanding is considered to be *Typical* based on the current information.

The frost penetration depth and associated recommendations are provided in Section 12.5.

9. SEISMIC CONSIDERATIONS

9.1 Spectral and peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC)¹. The GSC seismic hazard calculation data sheet for

¹ <https://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/calc-en.php>



this site for the *reference* ground condition (Site Class C) is presented in Appendix G. The site coefficients used to determine the design spectral acceleration values are a function of the Site Class, PGA and $S_a(0.2)$. The PGA value at this site provided by GSC for a *reference* Site Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.112 g. This value is to be scaled by the $F(PGA)$ based on the *site-specific* Site Class, as discussed in Section 9.2.

9.2 CHBDC Seismic Site Classification and Performance Category

In accordance with Section 4.4.3.2 of the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy below the founding level. The Site Class was assessed based on the harmonic mean of the SPT ' N_{60} ' values within the upper 30 m measured during the drilling investigation. Based on the drilling investigation all sections of the proposed high fill widening can be classified as seismic Site Class D ($15 \leq N_{60} \leq 50$) in accordance with Section 4.4.3.2 of the CHBDC (S6-19) provided that the organic silt within the footprint of the proposed widening or retaining wall foundations is treated with ground improvement or sub-excavated. If the organic silt is left in place untreated, the widening section from the Choate Rd overpass to the Ganaraska River as well as the widening section east of the Ganaraska River should be classified as seismic Site Class E.

9.3 Liquefaction Potential

The soils beneath the anticipated high fill widenings and water table include very stiff to stiff clay, very loose organic silt, dense sandy silt, very loose silty sand and compact to very dense glacial till deposits. The potential for seismic liquefaction of the non-cohesive soils within the project limits were assessed using the Boulanger & Idriss (2014)² method for liquefaction assessment, a PGA value of 0.112g and a de-aggregated earthquake magnitude of 6.15. Based on this assessment, and due to the relatively low PGA value, the non-cohesive foundation soils (including organic silt) encountered at the borehole locations are considered to be not susceptible to liquefaction during a seismic event.

The clay deposits at this site are classified as not susceptible to cyclic mobility during a seismic event when assessed using the Boulanger & Idriss (2007)³ method.

² Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.

³ Boulanger, R. W., & Idriss, I. M. (2007). Evaluation of cyclic softening in silts and clays. Journal of geotechnical and geoenvironmental engineering, 133(6), 641-652.



10. GEOTECHNICAL ASSESSMENT / CONSIDERATIONS

The presence of Choate Road and the Ganaraska River naturally divide the high fill into three separate embankments:

- 1) West of the Choate Road Overpass;
- 2) Choate Road Overpass to Ganaraska River; and
- 3) East of the Ganaraska River.

Based on the results of the field and laboratory investigation and the information provided by the MPLJV with regards to the proposed project requirements, the geotechnical design considerations include:

- Property constraints (Choate Rd for the west embankment and the GRCA lands for the other two embankments) will limit the available footprint for proposed widening to the north. The retaining walls or reinforced earth slopes to support the proposed Highway 401 widening will be required.
- The surficial deposits east of Choate Road include weak compressible organic silt which will impact settlement and global stability of embankments and slopes and offer limited bearing resistance for wall foundations.
- The high groundwater table east of the Ganaraska River bridge.
- Embankment widening geometry including height, existing side slope inclination and the possible requirement for stabilizing berms.
- The stability and settlement of the existing Highway 401 WBL embankment due to the proposed widening.
- Construction and post-construction settlement of embankments and retaining walls.

11. EVALUATION OF DESIGN OPTIONS

Key elevations (approximate) based on the results of the field investigation and available background information are as follows:

- West of the Choate Road Overpass
 - Highway 401 surface 110 m East end, 113 m West end
 - Toe of Slope 99 m East end, 105 m West end
 - Embankment height 11 m East end, 8 m West end

- Choate Road Overpass to Ganaraska River
 - Highway 401 surface 106 m East end, 108 m West end
 - Toe of Slope 95 m East end, 97 m West end
 - Embankment height 11 m East end, 11 m West End
 - Bottom of Organic Silt 91.8 m East end, 94.5 m West end

- East of the Ganaraska River
 - Highway 401 surface 102 m East end, 103 m West end
 - Toe of Slope 95 m East end, 94 m West end
 - Embankment height 7 m East end, 9 m West end
 - Bottom of Organic Silt 91.9 m East end, 91.6 m West end

Given the height of the widened embankment and the space available within the MTO right of way to the north of the existing Highway 401 and the requirements of the proposed widening provided by the MPLJV, the following widening options were considered:

- Conventional Embankments
- RSS Walls
- RSS Slopes
- Concrete Retaining Walls

These foundation alternatives are discussed in the following paragraphs and evaluated from a geotechnical perspective in terms of their respective advantages, disadvantages, risks and consequences. The evaluation is summarized in the table provided in Appendix E. A preferred high fill widening alternative from a geotechnical engineering perspective is recommended.

- Conventional Embankments
Widening the existing high fill embankment with a conventional (non-reinforced) granular fill embankment is considered feasible from a geotechnical perspective. The existing organic silt encountered between Choate Road and Ganaraska River and east of Ganaraska river is recommended to be sub excavated with this option. Conventional embankments would need to be constructed with side slopes not steeper than 2H:1V; 2 m wide mid-height berms would be required anywhere the embankment exceeds 8 m above the widened toe of slope. Earth fill could also be considered for constructing conventional embankments but with side slopes not steeper than 3H:1V for such a high fill. It is understood that there is not sufficient property available to construct any section of the high fill widening with conventional embankments.



- RSS Walls

Vertical RSS walls are considered feasible from a geotechnical perspective for the widening of the high fill Highway 401 embankment. The existing organic silt encountered between Choate Road and Ganaraska River and east of Ganaraska river would need to be sub excavated below the RSS wall and replaced with a granular pad. The vertical RSS walls could be placed just inside the existing MTO right of way and a 2H:1V conventional embankment slope could be placed above the RSS wall to reduce the overall RSS wall height. The rigid concrete facing used for vertical RSS walls can accommodate more settlement than conventional retaining walls but less than vegetated RSS slopes.

- RSS Slopes

RSS slopes, similar to RSS walls, are proprietary systems formed with a block of reinforced soil with a vegetated face inclined at 70° to horizontal or less. These slopes can be designed to various angles and heights. Since there is no concrete facing, RSS slopes can accommodate more differential settlement than RSS walls. At this site it is considered feasible from a geotechnical perspective to construct the widening with an RSS slope. The existing organic silt encountered between Choate Road and the Ganaraska River and east of Ganaraska river would need to be sub excavated below the RSS slope and replaced with a granular pad. Consideration could be given to using a ground improvement technique such as stone columns or sub-excavating the organic silt and constructing the granular pad using rock fill in the wet under the RSS slope since more differential settlement can be accommodated than RSS walls. Using an RSS slope for this high fill widening would minimize the embankment fill required to construct the widening.

- Concrete Retaining Walls

Vertical concrete retaining walls are considered feasible from a geotechnical perspective for the widening of the high fill Highway 401 embankment. The existing organic silt encountered between Choate Road and Ganaraska River and east of Ganaraska river would need to be sub excavated below the RSS wall and replaced with a granular pad. The vertical concrete retaining walls could be placed just inside the existing MTO right of way and a 2H:1V conventional embankment slope could be placed above the concrete retaining wall to reduce the overall wall height. Concrete retaining walls cannot accommodate much differential settlement when compared to RSS walls and based on the required wall heights, substantial amounts of concrete and reinforcement would be required to construct concrete retaining walls.



The following treatment options for organic silt below the RSS slope east of the Ganarasaka River were considered:

- Sub Excavation Below the Water Table and Replacement with Rock Fill
- Ground Improvement with Stone Columns

These organic silt treatment alternatives east of the Ganaraska River are discussed in the following paragraphs and evaluated from a geotechnical perspective in terms of their respective advantages, disadvantages, risks and consequences. The evaluation is summarized in the table provided in Appendix E. A preferred organic silt treatment alternative from a geotechnical engineering perspective is recommended.

- Sub Excavation Below the Water Table and Replacement with Rock Fill

Given that approximately 3 m of organic silt will require sub excavation and the high ground water table east of the Ganaraska River, excavating and backfilling with rock fill below the water table and granular fill above the water table is expected to be the preferred approach to sub excavation. Sub excavation is a conventional method with readily available equipment but would be a slow operation completed in short sections and require much deeper temporary excavations in weak soils at the toe of the existing highway embankment than with ground improvement. Full sub excavation will also generate a large volume of organic silt requiring disposal as well as require a large volume of rock fill for backfill.

- Ground Improvement

Ground improvement such as construction of dense aggregate columns (stone columns) or controlled modulus columns (composite soil/concrete columns) to increase bearing capacity and reduce settlement of the foundation soils below the RSS slope footprint. The ground improvement system would need to be designed and constructed by a specialist contractor. This method would be relatively expedient in this application, reduce the requirement for a large sub excavation, could be installed through the existing embankment side slope and in front of the toe to reinforce the weak organic silt layer prior to completing temporary excavation for installation of the RSS slope.

12. FOUNDATION DESIGN RECOMMENDATIONS

Based on an evaluation of foundation design alternatives and the organic silt treatment options east of the Ganaraska River presented above, the geometry of the proposed Highway 401 high fill widening, the thickness of existing organic silt deposits, the existing groundwater table



elevations and the MTO right of way property available, the recommended embankment widening alternative is to construct the widening east of the Ganaraska river using an RSS slope and to construct the widenings between Choate Road and the Ganaraska River and west of Choate Road with RSS walls. Ground improvement is recommended below the RSS slope east of the Ganaraska River but sub excavation of the organic silt and construction of a granular pad below the RSS wall between Choate Road and the Ganaraska River must be completed in a fully dewatered excavation.

It is noted that based on floodplain mapping, portions of the RSS walls and slope will be located within a floodplain. RSS walls located within a floodplain must be designed by the RSS supplier for submerged conditions and the design must be accepted by the MTO RSS committee.

Foundation recommendations and considerations are presented in the following sections.

12.1 RSS Walls

RSS walls are recommended west of Choate Road and between Choate Road and the Ganaraska River. It is noted that both of these RSS walls extend into the foreslope below the Choate Road overpass; the recommendations presented herein are considered applicable to the design of the complete wall. For the purposes of analysis, the wall alignment shown in the drawings provided by MPLJV was used with a 2H:1V slope above RSS walls. For modeling purposes, the RSS reinforcement length has been assumed to be $0.8 \cdot H$ where H is the height of the RSS wall; where wall heights are reduced (such as within the foreslopes below Choate Road) the minimum RSS reinforcement length has been taken as 3.5 m. The actual length of reinforcement required for these RSS walls will be determined by the proprietary wall designer just prior to construction. The embankment widening material has been assumed to be OPSS.PROV 1010 Select Subgrade Material (SSM) above the RSS walls. The RSS walls should be designed, supplied and constructed in accordance with SP No. 599S22; it is understood that the Medium Site Performance RSS wall is required.

12.1.1 Bearing Resistance

Based on the proposed wall alignment provided by MPLJV and the assumptions outlined in Section 12.1, an analysis indicates the RSS walls may be founded on a minimum 1 m thick engineered granular fill pad constructed on the underlying undisturbed stiff/dense native soils and extending to undisturbed native clay or glacial till where organic silt is present. The engineered fill pads should consist of OPSS Granular A or Granular B Type II placed and compacted in accordance with OPSS.PROV 501 in a fully dewatered excavation. Engineered fill pads should be constructed with 1H:1V sides slopes with the crest of slope a minimum of 1 m beyond the edge

of footing and reinforced retained soil on all sides. It is anticipated that a temporary protection system will be required to support the existing embankment between Choate Road and the Ganaraska River due to the depth of excavation required for construction of the RSS wall.

RSS walls with a minimum embedment of 1.0 m and founded on an engineered fill pad as described above may be designed based on the preliminary factored geotechnical resistances in Table 12-1 below.

Table 12-1: RSS Wall Factored Geotechnical Resistances

Location	Founding Elevation (m)	Approximate Max Height (m)	ULS (kPa)	SLS (kPa) 50 mm Settlement
West of Choate Rd	98.0 East, 106.0 West	6.0	350	275
Choate Road to Ganaraska River	91.8 East, 94.0 West	6.5	450	325

The subgrade soils may become disturbed when saturated and should be protected with by prompt placement of the engineered fill pad placed immediately after excavation and inspection.

The factored geotechnical resistances at SLS corresponds to total settlement of 50 mm in accordance with the requirements of Medium Performance Category RSS Walls.

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
 - $\phi_{gu} = 0.5$ (static analysis; typical degree of understanding)
 - $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)

The geotechnical resistances are for vertical concentric loading and will need to be adjusted for the effects of inclined or eccentric loading, if applicable. The geotechnical resistance should be calculated as illustrated in the CHBDC Section 6.10. In addition, the geotechnical resistances assume that the footings are constructed on horizontal ground.

Resistance to lateral forces through sliding resistance between cast-in-place concrete and native till deposits or engineered fill pads should be evaluated using an unfactored coefficient of 0.50 for cast-in-place concrete.



12.1.2 Global Slope Stability

Stability analyses were carried out for the RSS wall within each section of the proposed widening using GeoStudio 2022 Slope/W software for limit equilibrium analysis under seismic, static drained and static undrained conditions. The following additional parameters and assumptions were used in the analysis:

- A seismic horizontal loading of 0.071g, equal to ½ of the site adjusted PGA value (0.142g) was used for seismic analysis.
- Existing embankment side slope geometry and slope above the RSS wall slope of 2H:1V
- Estimated soil stratigraphy based on the nearest boreholes

Table 12-2. Summary of RSS Wall Stability Analysis

Location	Approx. Max Fill Height(*) (m)	Sideslope Inclination above RSS Wall	Factor of Safety		
			Seismic Loading	Static Drained Conditions	Static Undrained Conditions
West of Choate Rd Station 22+600	7.6	2H:1V	1.7 (Figure F1)	1.5 (Figure F2)	1.9 (Figure F3)
West of Choate Rd Station 22+750	11.0	2H:1V	1.5 (Figure F4)	1.5 (Figure F5)	1.6 (Figure F6)
Choate Road to Ganaraska Choate Road East Foreslope	11.0	2H:1V	1.3 (Figure F7)	1.5 (Figure F8)	1.5 (Figure F9)
Choate Road to Ganaraska Station 22+850	10.7	2H:1V	1.4 (Figure F10)	1.5 (Figure F11)	1.6 (Figure F12)

Notes: (*) approximate difference between existing ground surface at toe and existing centerline

The calculated factors of safety meet the target values of 1.2 for seismic analysis, 1.5 for static drained analysis and 1.3 for temporary static undrained analysis.

12.2 RSS Slopes

An RSS slope is recommended east of the Ganaraska River to accommodate more differential settlement due to the high-water table and the requirement for ground improvement or sub excavation of organic silt and granular pad construction below the water table. For the purposes of analysis, the wall alignment shown in the drawings provided by MPLJV was used for the toe of a 70° to horizontal RSS slope with a 2H:1V slope above RSS slope. The embankment widening material has been assumed to be OPSS.PROV 1010 Select Subgrade Material (SSM) above the RSS slope. The RSS slope should be designed, supplied and constructed in accordance with SP No. 599S22; it is understood that the Medium Site Performance RSS slope is required.

12.2.1 Bearing Resistance

Based on the proposed wall alignment provided by MPLJV and the assumptions outlined in Section 12.2, analysis indicates the RSS slope may be founded on a minimum 1 m thick engineered fill pad constructed on the underlying undisturbed stiff/dense native soils and extending to undisturbed native clay or glacial till where organic silt is present. It is noted that east of the Ganaraska River it is expected that approximately 3 m of organic silt will require sub-excavation and there is not sufficient property to allow for a dewatered excavation with traditional side slopes and the dewatering effort within a temporary protection system would be substantial. Recommendations for constructing the engineered fill pad using select rockfill material below the water table are provided in Section 12.2.2. The engineered fill pad constructed above the water table should consist of OPSS.PROV 1010 Granular A or Granular B Type II material and be compacted in accordance with OPSS.PROV 501. Engineered fill pads should be constructed with a 1H:1V sides slopes with the crest of slope a minimum of 1 m from the face of the reinforced retained soil. Due to anticipated difficulty excavating below the existing embankment, the base of engineered fill pad at the back of the RSS slope must be a minimum of 1 m behind the back of the reinforced retained soil block, this is only applicable to the RSS slope option. The base of the RSS slope should be perched above the water table to allow for construction in the dry and may require the placement of a 1 m toe berm in from of the toe of the wall to provide sufficient embedment. It is noted that this method of construction will lead to additional total and differential settlement of the RSS slope due to settlement of the engineered fill pad placed below the water table and is the reason an RSS slope with vegetated face is recommended in this area since RSS slopes can accommodate more differential settlement than RSS walls.

RSS slopes with a minimum embedment of 1.0 m and founded on an engineered fill pad as described above may be designed based on the factored geotechnical resistances in Table 12-3 below.

Table 12-3: RSS Slope Factored Geotechnical Resistances

Location	Founding Elevation (m)	Approximate Max Height (m)	ULS (kPa)	SLS (kPa) 50 mm Settlement
East of Ganaraska River Station 22+950 to 23+035	91.0	5.5	500	350
East of Ganaraska River Station 23+035 to 23+075	92.0	3.0	350	240



The factored geotechnical resistances at SLS corresponds to total settlement of 50 mm in accordance with the requirements of Medium Performance Category RSS Walls.

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
 - $\phi_{gu} = 0.5$ (static analysis; typical degree of understanding)
 - $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)

The geotechnical resistances are for vertical concentric loading and will need to be adjusted for the effects of inclined or eccentric loading, if applicable. The geotechnical resistance should be calculated as illustrated in the CHBDC Section 6.10. In addition, the geotechnical resistances assume that the footings are constructed on horizontal ground.

12.2.2 Construction in Wet Conditions

Given that approximately 3 m of organic silt will require sub-excavation and the high ground water table east of the Ganaraska River, backfilling the sub excavation in the wet (below water level) is expected to be the preferred sub excavation approach. The limit of sub excavation in the wet remains the same as recommended for the RSS slope granular pad provided in Section 12.2.1. When backfilling is conducted in the wet, select rock fill should be used below the water table after removal of the organic silt. All rock fill source materials must be clean, hard, durable particles free of earth, humus, clay or other coatings, clay lumps, shale or shaley partings and other deleterious materials. The recommended gradation of the select rock fill is as follows:

Table 12-4: Select Rockfill Gradation

Sieve Size	Percent Passing (%)
150 mm	100
106 mm	50 – 100
75 mm	15 – 80
26.5 mm	0 – 15
0.075 mm	0 – 2

Care must be exercised not to destabilize the existing highway embankment while excavating the organic silt near the toe of the embankment. Sub excavation of organic silt below the water table



should follow OPSD 203.020 and be completed in short 5 m sections to maintain global stability of the existing embankment.

Rock fill used to backfill sub-excavated areas below the water table may be placed by end dumping. Granular fill must not be used to backfill excavations below the water table. The rock fill placement below the water level should follow OPSS.PROV 209.

Rock fill placed above the water level should be placed in a controlled manner (not end dumped) including blading, dozing and chinking of the rock to minimize voids and bridging. Rock fill above the water level must be compacted as per OPSS.PROV 206.

Once the select rock fill backfill is above the water level, granular fill consisting of OPSS.PROV 1010 Granular A or Granular B Type II should be placed in the dry up to the proposed base of RSS slope. Where granular fill is placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking shall be in accordance with OPSS.PROV 206. All granular fills must be compacted as per OPSS.PROV 501.

It is noted that when backfilling under water, if the organic silt is not completely removed, there is a risk of additional settlement.

12.2.3 Global Slope Stability

Stability analyses were carried out for the RSS slope at three locations using GeoStudio 2022 Slope/W software for limit equilibrium analysis under seismic, static drained and static undrained conditions. The following additional parameters and assumptions were used in the analysis:

- An RSS slope angle of 70° was assumed for stability modelling.
- A seismic horizontal loading of 0.071g, equal to ½ of the site adjusted PGA value (0.142g) was used for seismic analysis.
- Existing embankment side slope geometry and slope above the RSS wall slope of 2H:1V
- Estimated soil stratigraphy based on the nearest boreholes

Table 12-5. Summary of RSS Slope Stability Analysis

Location	Approx. Max Fill Height(*) (m)	Sideslope Inclination above RSS Slope	Factor of Safety		
			Seismic Loading	Static Drained Conditions	Static Undrained Conditions
East of Ganaraska River Station 22+970	8.6	2H:1V	1.4 (Figure F13)	1.6 (Figure F14)	1.6 (Figure F15)
East of Ganaraska River Station 23+050	7.0	2H:1V	1.4 (Figure F16)	1.5 (Figure F17)	1.6 (Figure F18)

Notes: () approximate difference between existing ground surface at toe and existing centerline*

The calculated factors of safety meet the target values of 1.2 for seismic analysis, 1.5 for static drained analysis and 1.3 for temporary static undrained analysis.

12.2.4 Ground Improvement

Ground Improvement such as stone columns or controlled modulus columns are considered potential options at this site below the RSS slope east of the Ganaraska River. If this option is selected, the Specialty Ground Improvement Contractor would be responsible for completing the design and construction of the ground improvement below the RSS slope. An overview of the design criteria for ground improvement are as follows:

- 1) The magnitude of the total maximum settlement within the footprint of the RSS slope must be limited to 50 mm of total settlement in accordance with Medium Site Performance RSS slope requirements and less than 25 mm post-construction settlement within 20 m of the east abutment of the Ganaraska River Bridge.
- 2) Differential settlement of the RSS slope constructed over the ground improvement area must meet the differential settlement limit of the Contractor's selected proprietary RSS slope.
- 3) The ground improvement and RSS slope are to be designed with a minimum factor of safety (FOS) of 1.5 for static stability and a minimum FOS of 1.2 for seismic stability.
- 4) A settlement limit of less than 25 mm should apply to the existing highway embankment, which is to remain in service during the construction period until the widened roadway is in service.

If ground improvement is the preferred treatment option for the organic silt below the RSS slope east of the Ganaraska River a Ground Improvement NSSP can be provided upon request.



12.3 Embankment Settlement

The settlement resulting from the maximum grade raise constructed with conventional granular fill within each section of the proposed embankment was assessed. Where applicable, it has been assumed that the organic silt material will be sub-excavated below the base of the RSS walls or slopes but not from beneath the existing embankment. Settlement calculations were performed using the multi-layer settlement analysis in Rocscience's Settle3 software. Subsurface stratigraphy was variable based on boreholes within each section of the embankment widening area. Loading was applied as multiple linear wedges of varying thicknesses based on the assumed widening geometry from the slope stability analysis models in Appendix F and using a unit weight for new embankment SSM fill of 20 kN/m^3 . The water table was defined based on piezometer readings within each sections of the widening. It is noted that engineering judgment and experience was used to select the material properties based on the stress range anticipated due to loading. Soil parameters used in the analysis for all three sections of the proposed embankment widening are presented in Table 12-6 below.

Table 12-6: Properties of Soil Used in Settlement Calculations

	Unit Weight [kN/m ³]	E [kPa]	e _o	P _c ' [kPa]	C _c	C _r	C _v [m ² /d]	C _{vr} [m ² /d]	C _a /C _c	B-bar
Existing Granular Fill	20	40,000	-	-	-	-	-	-	-	-
Existing Clay Fill	17	20,000	-	-	-	-	-	-	-	-
Clay (22+600)	17	-	0.779	190	0.214	0.044	0.017	0.052	0.03	0.9
Clay (22+750)	17	-	0.680	175	0.167	0.03	0.024	0.027	0.03	0.9
Clay (22+750)	17	-	0.680	175	0.167	0.03	0.024	0.027	0.03	0.9
Organic Silt	19	-	0.75	² (OCR)	0.5	0.1	0.00493	0.00493	0.0475	0.5
Glacial Till	21	100,000	-	-	-	-	-	-	-	-

Based on the above parameters and loading resulting from the assumed embankment widening geometry, the estimated embankment settlements are presented in Table 12-7 below:

Table 12-7. Summary of Estimated Embankment Widening Settlements

Location	Maximum Estimated Settlement (Cumulative)	Preload Required?
West of Choate Rd Station 22+600	1 Month: 40 mm 6 Months: 60 mm 20 Years: 65 mm	Yes
West of Choate Rd Station 22+750	1 Month: 50 mm 6 Months: 75 mm 20 Years: 80 mm	Yes
Choate Road to Ganaraska River Station 22+850	1 Month: 30 mm 6 Months: 50 mm 20 Years: 50 mm	No
East of Ganaraska River Station 22+970	1 Month: 30 mm 6 Months: 40 mm 20 Years: 50 mm	No
East of Ganaraska River Station 23+050	1 Month: 30 mm 6 Months: 35 mm 20 Years: 35 mm	No

The maximum settlement values, presented in Table 12-7 above, in all cases occur at the crest of the widened slope and decrease towards the existing crest of slope and the proposed RSS wall or slope. Based on the estimated maximum settlement values, a preload period at the full embankment height of 6 months is recommended for the section west of Choate Road prior to paving. The settlement between Choate Road and the Ganaraska River and east of the Ganaraska River is expected to be completed during construction provided the organic silt is sub excavated from below the footprint of the RSS wall or slope as discussed in Sections 12.1 and 12.2. Settlement within the preload area should be monitored with monitoring points to confirm when the preload period is complete.

The magnitude of the embankment self-compression constructed with granular materials is in the order of 0.5% of the newly reconstructed embankment height and is expected to occur during fill placement.



The MTO guidelines for settlement of approach embankments behind bridge abutments for post construction settlement over a period of 20 years after paving are outlined below:

- 25 mm within 20 m of the structure;
- 50 mm from 20 to 50 m from the structure;
- 75 mm from 50 to 75 m from the structure; and
- 100 mm greater than 75 m from the structure

Based on the estimated settlement of the embankment widenings and provided a 6 month preload period west of Choate Road prior to paving is carried out, settlement resulting from the embankment widening is expected to meet the above guidelines.

12.4 Backfill and Lateral Earth Pressure

12.4.1 Backfill

Backfill to the retaining walls consist of free-draining granular material conforming to Granular A or Granular B Type II meeting the OPSS.PROV 1010 specifications and SP110S06. Compaction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501.

12.4.2 Static Lateral Earth Pressure

Lateral earth pressure provided in the equations in the sections below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in the design.

Lateral earth pressures acting on vertical structures should be computed in accordance with the Section 6.12 of the CHBDC but under fully drained conditions, the lateral pressures are generally given by the following expression:

$$\sigma_h = K * (\gamma d + q)$$

where:

σ_h	=	static lateral earth pressure on the wall at depth d (kPa)
K	=	static earth pressure coefficient (see table below)
γ	=	unit weight of retained soil (see table below) adjusted below water level
d	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for use in design of vertical walls are shown in Table 12-8.

Table 12-8: Static Earth Pressure Coefficients

Material	Unit Weight (kN/m ³)	K _A (yielding wall)		K ₀ (non-yielding wall)	
		Backslope		Backslope	
		Horizontal	2H:1V	Horizontal	2H:1V
OPSS Granular A & B Type II	22.8	0.27	0.39	0.43	0.62
OPSS Granular B Type I	21.2	0.31	0.47	0.47	0.68
Undisturbed Native Glacial Till	21.0	0.27	0.39	0.43	0.62
OPSS SSM & Existing Embankment Fill	20.0	0.33	0.54	0.50	0.72

For rigid structures it is recommended that at-rest lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.27 of the Commentary to the CHBDC.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is generally preferred as it results in lower earth pressures acting on the wall.

The design of the retaining walls must incorporate measures such as weep holes and/or subdrains to permit drainage of the backfill and avoid the potential build-up of hydrostatic pressures behind the walls.

12.4.3 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14 of the CHBDC, structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using Mononobe Okabe Method with:

- $k_h = \frac{1}{2} * F(PGA) * PGA$, for structures that allow 25 to 50 mm of movement, and
- $k_h = F(PGA) * PGA$, for non-yielding walls

The coefficients of horizontal earth pressure for seismic loading presented in Table 12-9 may be used for vertical walls. The provided earth pressure coefficients are based on a 1 in 2475yr seismic event and a Seismic Site Class D.

Table 12-9: Combined Static and Seismic Earth Pressure Coefficients

Material	Unit Weight (kN/m ³)	K _{AE} (yielding wall)		K _{AE} (non-yielding wall)	
		Backslope		Backslope	
		Horizontal	2H:1V	Horizontal	2H:1V
OPSS Granular A & B Type II	22.8	0.31	0.50	0.35	0.72

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall/soil may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_{hAE} = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

- σ_{hAE} = combined static and seismic lateral earth pressure on wall at depth d (kPa)
- d = depth below the top of the wall where pressure is computed (m)
- K = static earth pressure coefficient
(K_A for yielding walls, K_o for non-yielding walls)
- γ = unit weight of retained soil (kN/m³), adjusted below water level
- K_{AE} = combined static and seismic earth pressure coefficient
- H = total height of the wall (m)

12.5 Sub Excavation of Organic Silt

Sub excavation of organic silt is required below the footprint of the RSS walls and is an option below the RSS slope as detailed in Sections 12.1 and 12.2. The sub excavation below the RSS slope may be carried out in the wet but the sub excavation below the RSS walls must be completed in a fully dewatered environment.

It is expected that the base of excavation will be variable and will extend to as deep as 3.0 m below the existing ground surface. It is expected that these temporary excavations east of the Ganraska River below the RSS slope will be done in the wet while the temporary excavations



between Choate and Ganaraska and west of Choate Road below the RSS walls will be done in the dry.

All excavations will need to be staged in 5 m lengths and backfilled immediately after to maintain the global stability of the existing Highway 401 embankment. Temporary protection systems will likely be required within the bridge foreslope areas due to the depth of the existing organic silt deposit and may be required to support the existing highway embankment between Choate Road and the Ganaraska River. Stability and/or support of temporary excavations would be the responsibility of the Contractor.

12.6 Frost Depth

The frost penetration depth at this site is 1.4 m as per OPSD 3090.101. Accordingly, a minimum of 1.4 m of earth cover, or equivalent insulation, must be provided above the base of the pile caps to serve as frost protection.

12.7 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in buried infrastructure. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The sulphate content in the soils is low ranging from 25 to 60 µg/g, see Section 6.6. The selection for class of concrete should include consideration of the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 6.6 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

13. CONSTRUCTION CONSIDERATIONS

13.1 Excavation

All excavation must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The fills at this site above the water level should be classified as Type 3 in accordance with OHSA and the glacial till should be



classified as Type 2 above the water level and Type 3 below the water level. The organic silt should be classified as Type 4 soil.

Excavation should occur in a dewatered environment (see Section 13.3) with the exception of the anticipated sub excavation of organic silt east of the Ganaraska river below the RSS slope footprint which should be carried out as described in Section 12.2.2. Subgrade preparation and placement of backfill below the RSS walls must be carried out in the dry. Excavations must be planned and carried out in a manner that does not impact on the stability of the existing highway embankments and bridges. The temporary cut slopes may have to be protected from precipitation and runoff to avoid surficial instabilities. The duration of temporary open excavations and cut slopes should be minimized to reduce the likelihood of causing instability concerns. Embankment and cut slope stability is the responsibility of the Contractor.

Material stockpiling is a temporary construction measure and the associated stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) and the construction of temporary construction access roads are also the Contractor's responsibility. Placement of the crane or temporary stockpiling must not destabilize the embankment or excavations.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 13.2.

13.2 Temporary Protection Systems

Temporary Protection Systems may be required during construction of the high fill widenings; temporary construction systems must be implemented in accordance with OPSS.PROV 539 as amended by SP105S09. Performance Level 2 (maximum 25 mm horizontal deflection) is considered appropriate where the protection supports the existing highway. More stringent performance levels may be required if the protection system is intended to support existing structures or utilities. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. It is noted that mass concrete, concrete and boulders were encountered in the west foreslope and may interfere with excavations and installation of temporary protection systems. The Contractor must be prepared to dislodge or penetrate such obstructions. An NSSP has been provided in Appendix H alerting the contractor of these obstructions.



Temporary protection systems will be supporting potentially deep excavations below high fill slopes and will require a robust system possibly with anchors. The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations. A suitable anchoring and/or bracing system may need to be incorporated into the temporary protection design to resist lateral earth pressure loadings. The Contractor should select the wall type and design taking into account the soil conditions encountered in the boreholes.

For free draining shoring systems, the short-term groundwater level should be assumed at the base of excavation both in front of and behind the wall.

The actual pressure distribution acting on the shoring system is a function of construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.

13.3 Subgrade Preparation

It is recommended that all topsoil and organic silt be sub-excavated from within the proposed footprint of all RSS walls and slopes and backfilled with granular fill. Excavations below RSS walls must be dewatered until fully backfilled with granular fill material. Excavation and backfill below the RSS slope east of the Ganaraska River should be in accordance with OPSD 203.020, OPSS.PROV 209 and Section 12.2.2 of this report. An NSSP on foundation excavation and construction in the wet has been provided in Appendix H.

The surface water depths and depths to groundwater at the time of construction will vary depending upon seasonal fluctuations, rainfall patterns and local conditions that may be impacted by the close proximity to a dam, for example.

13.4 Subgrade Sensitivity

It should be noted that where fine-grained soils are exposed following clearing, grubbing and stripping activities under the proposed embankment widening, these native soils are moisture sensitive and may become heavily disturbed when subjected to construction traffic. Site and subgrade drainage will be critical to maintain good trafficability of the subgrade for construction equipment. The Contractor must be aware of this issue so that they may adjust their operations to suit the subgrade conditions. An NSSP on protection of sensitive foundation soils has been provided in Appendix H.

13.5 Embankment Construction

Care must be taken during embankment construction to ensure that the existing Highway 401 embankment remains stable. Embankment construction and reinstatement after construction of the associated widening should be in accordance with OPSS.PROV 206 and OPSS.PROV 501.

The embankment widening material has been assumed to be OPSS.PROV 1010 Select SSM above the RSS walls and slope and can be placed at a slope of 2H:1V. If earth fill is to be substituted as embankment fill in place of OPSS.PROV 1010 SSM the embankment side slope would need to be reduced to 3H:1V. Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments with heights at or exceeding 8 m in granular or earth fill. Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, the existing earth or fill slope must be benched in accordance with OPSS 208.010. Fill should be placed started at the toe of the embankment and working upwards.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. Normal slope vegetation should be established as soon as possible after completion of the embankment fills to control surficial erosion in general accordance with OPSS.PROV 804.

13.6 Erosion Protection

The Contractor should provide silt fences and erosion control blankets as per OPSS.PROV 805 and OPSS 219.110 throughout the duration of construction to prevent transport of silt/sediment.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 803 OPSS.PROV 804. Slope vegetation should be established as soon as possible after completion of construction in order to limit surficial erosion and water should be prevented from running down an unprotected slope.

13.7 Dewatering

Subgrade preparation and construction of RSS wall foundations must be carried out in the dry. All excavations for foundation construction must be dewatered prior to the placement of granular fill, as per OPSS.PROV 902 and NSSP FOUN0003.



The Contractor must be prepared to control the groundwater and surface water flow at the site to permit construction in a dry and stable excavation. Water from either surface flow and/or groundwater must be diverted away from the excavation at all times. Groundwater perched within the embankment fill and surface runoff will tend to seep into and accumulate in open excavations.

Dewatering design and decisions regarding dewatering, must be carried out by the Contractor.

14. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Obstructions (ie: boulders, buried debris)

Buried obstructions may be encountered during construction and interfere with excavations and temporary protection/dewatering systems. The Contractor must be prepared to dislodge or penetrate such obstructions. Where obstructions are encountered near the surface, the Contractor may choose to remove such obstructions, provided it does not destabilize the existing embankment or foundation elements. A NSSP alerting bidders to the potential of encountering obstructions has been provided in Appendix H.

- Slope Stability

Care must be taken during construction to ensure the stability of the existing high fill slopes during construction of the widening.

- Protection Systems

Temporary protection systems are anticipated to be required between Choate Road and the Ganaraska River for the sub excavation of organic silt material as well as near the existing bridge fore slopes. Given that the existing Highway 401 embankment is to remain in service during construction and temporary protection systems will be supporting potentially deep excavations below high fill slopes and will require a robust system; possibly rock socketed soldier pile and lagging with tie back anchors.

- Equipment Selection

The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies.



- Dewatering

Dewatering for granular pad construction is required below RSS walls. Near the Ganaraska River the sub-excavation of organic silt will extend well below the river level and may require significant dewatering effort.

The successful performance of the project will depend largely upon good workmanship and quality control during construction. Observation of the excavation, foundation construction and backfilling operations by qualified geotechnical personnel will be required during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.

15. CLOSURE

Engineering analysis and preparation of this report were carried out by Mr. Christopher Murray, P.Eng. The report was reviewed Mr. Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:



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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

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5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

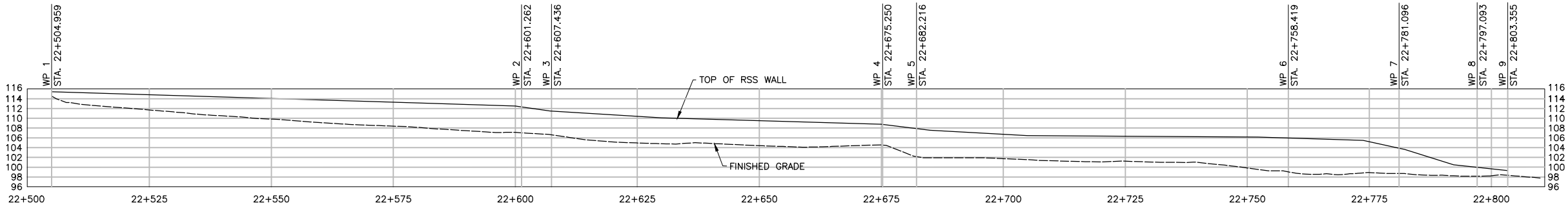
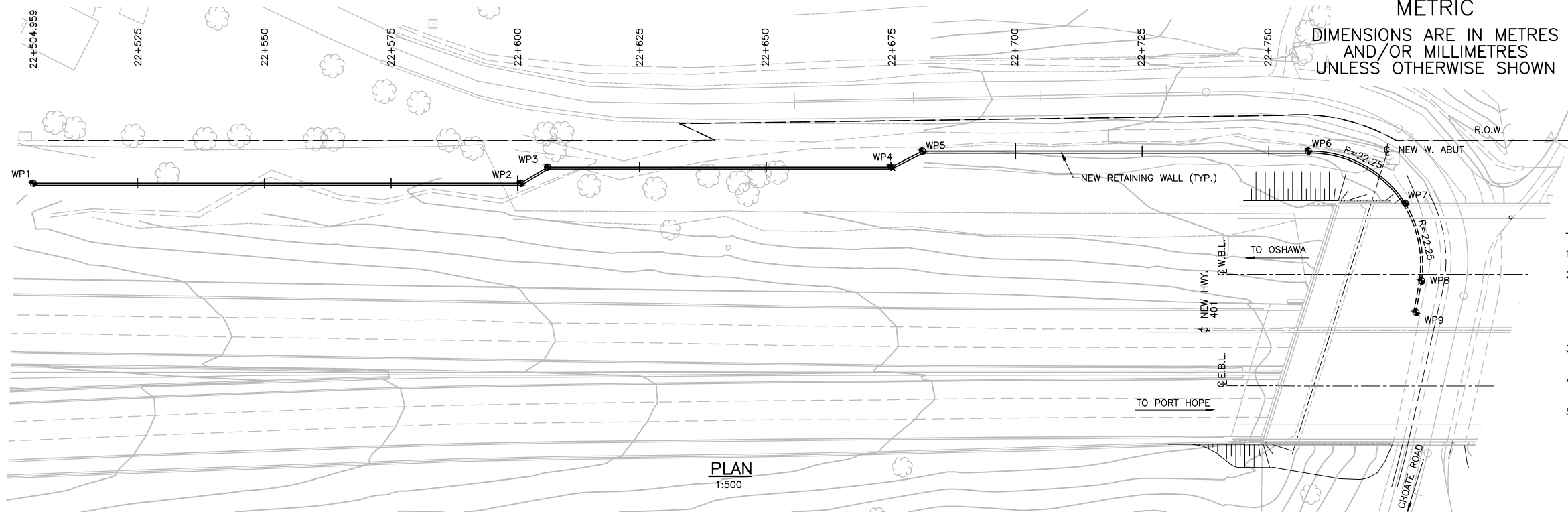
7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



Appendix A Drawings

General Arrangement Drawings
Borehole Locations and Stratra Drawings



STATION	22+504.959	22+525.000	22+550.000	22+575.000	22+600.000	22+625.000	22+650.000	22+675.000	22+700.000	22+725.000	22+750.000	22+775.000	22+800.000
RETAINING WALL TOP ELEVATION	115.418	114.818	114.062	113.292	112.521	111.455	109.373	108.757	106.706	106.316	105.966	105.215	99.970
FINISHED GRADE ELEVATION	114.528	111.701	109.933	108.397	107.037	106.623	104.949	104.514	101.752	101.217	99.834	98.916	98.160

ELEVATION
1:500

LIST OF DRAWINGS

- RETAINING WALL CHOATE ROAD OVERPASS
- RETAINING WALL BETWEEN CHOATE ROAD AND GANARASKA RIVER
- RETAINING WALL GANARASKA RIVER BRIDGE
- BOREHOLE LOCATIONS AND SOIL STRATA - I
- BOREHOLE LOCATIONS AND SOIL STRATA - II
- BOREHOLE LOCATIONS AND SOIL STRATA - III
- BOREHOLE LOCATIONS AND SOIL STRATA - IV
- BOREHOLE LOCATIONS AND SOIL STRATA - V
- INSPECTOR GUARD DETAILS

COORDINATES OF WORK POINTS			
WP No.	STATION	NORTHING	EASTING
WP1	22+504.959	4870626.017	401144.474
WP2	22+601.262	4870639.954	401239.761
WP3	22+607.436	4870643.885	401244.522
WP4	22+675.250	4870653.700	401311.622
WP5	22+682.216	4870657.684	401317.335
WP6	22+758.419	4870668.713	401392.735
WP7	22+780.796	4870661.308	401413.141
WP8	22+796.793	4870646.623	401418.563
WP9	22+803.055	4870640.364	401418.372

DRAFT

REVISIONS									
DATE	BY	DESCRIPTION							
DESIGN	ST	CHK	NB	CODE	CHBDC	S6-19	LOAD	DATE	JANUARY 2023
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								DWG	1

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100 mm ON ORIGINAL DRAWING

HWY. 401
CONT No
WP No

RETAINING WALL
CHOATE ROAD OVERPASS

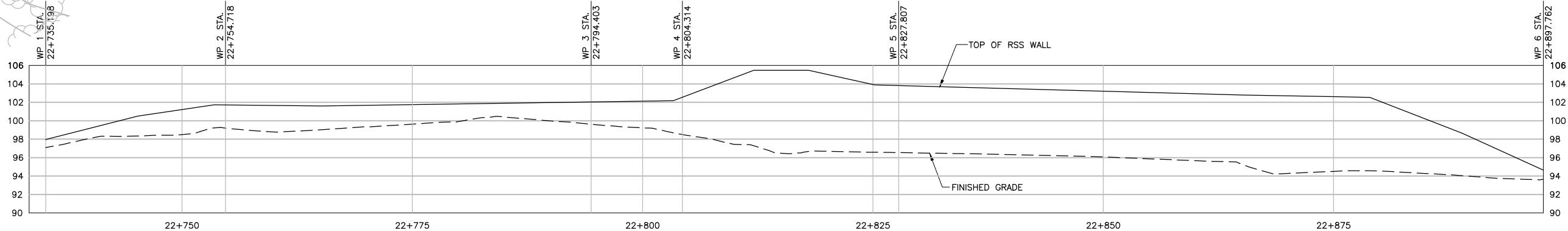
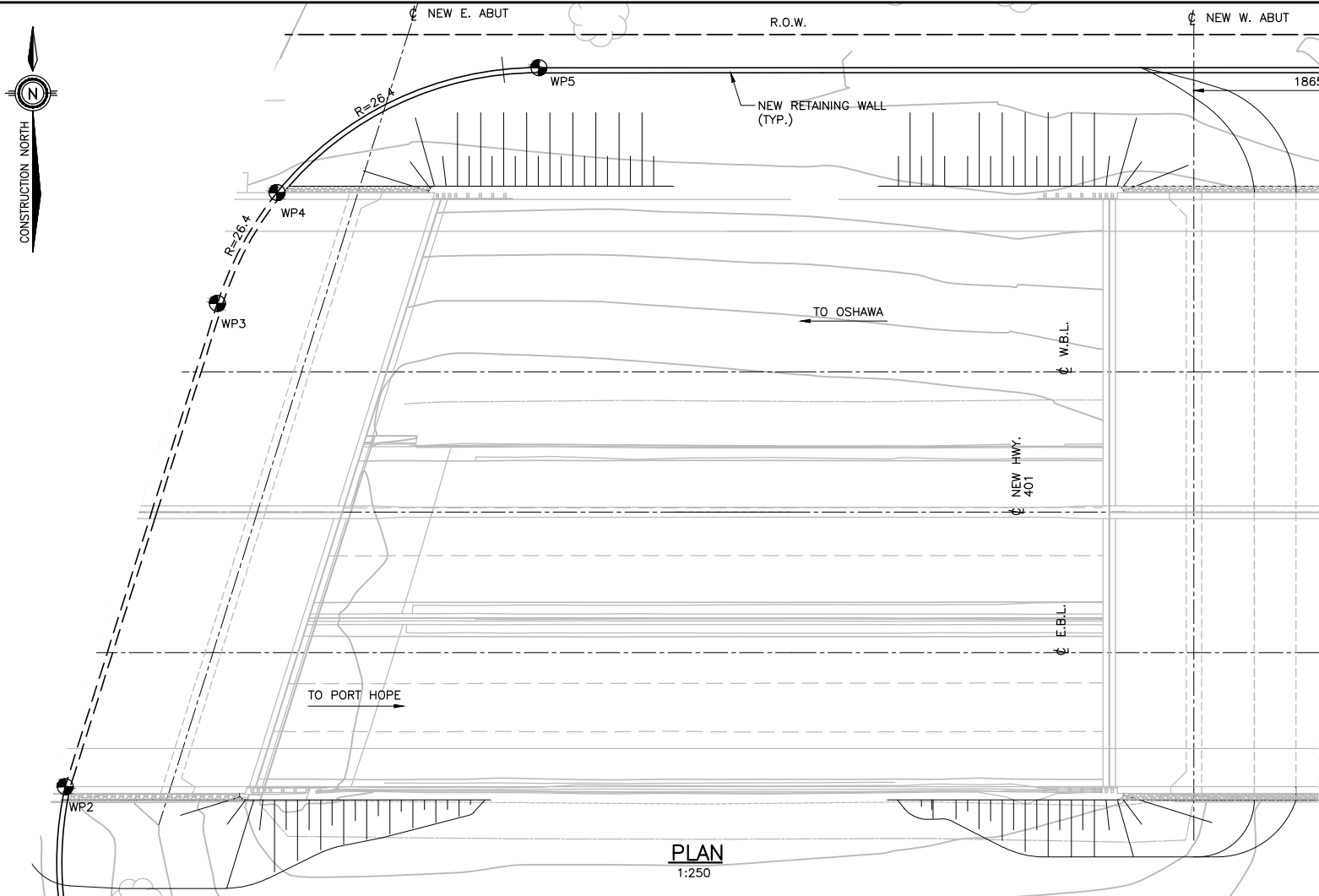
SHEET
171



GENERAL NOTES:

- RSS WALL SHALL BE ACCORDING TO DSM #9.70.56.
- RSS WALL SHALL HAVE THE FOLLOWING ATTRIBUTES:

APPLICATION :	WALL
PERFORMANCE :	MEDIUM
GEOMETRY :	VERTICAL
APPEARANCE :	MEDIUM
- MAXIMUM BEARING CAPACITY IS 275 kPa AT SLS AND 300 kPa AT ULS.
- THE MINIMUM SOIL COVER TO THE TOP OF ENGINEERED FILL PAD SHALL BE AT LEAST 1000mm.
- THE ENGINEERED FILL PAD MUST BE PLACED AND COMPACTED IN A FULLY DE-WATERED EXCAVATION.



STATION	22+735.198	22+750.000	22+754.718	22+775.000	22+794.403	22+800.000	22+804.314	22+825.000	22+827.807	22+850.000	22+875.000	22+897.762
RETAINING WALL TOP ELEVATION	97.970	101.207	101.705	101.744	102.038	102.123	102.549	103.927	103.813	103.204	102.606	94.628
FINISHED GRADE ELEVATION	97.101	98.292	99.207	99.637	99.623	99.227	98.498	96.584	96.541	96.066	94.503	93.665

ELEVATION
1:250

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

WORKPOINT COORDINATES

COORDINATES OF WORK POINTS			
WP No.	STATION	NORTHING	EASTING
WP1	22+747.914	4870599.134	401440.380
WP2	22+754.234	4870617.496	401435.075
WP3	22+793.919	4870656.672	401441.406
WP4	22+803.830	4870665.934	401444.765
WP5	22+827.323	4870678.583	401463.645
WP6	22+897.278	4870688.711	401532.863

HWY. 401
CONT No
WP No

RETAINING WALL BETWEEN
CHOATE ROAD AND
GANARASKA RIVER



SHEET
172



GENERAL NOTES:

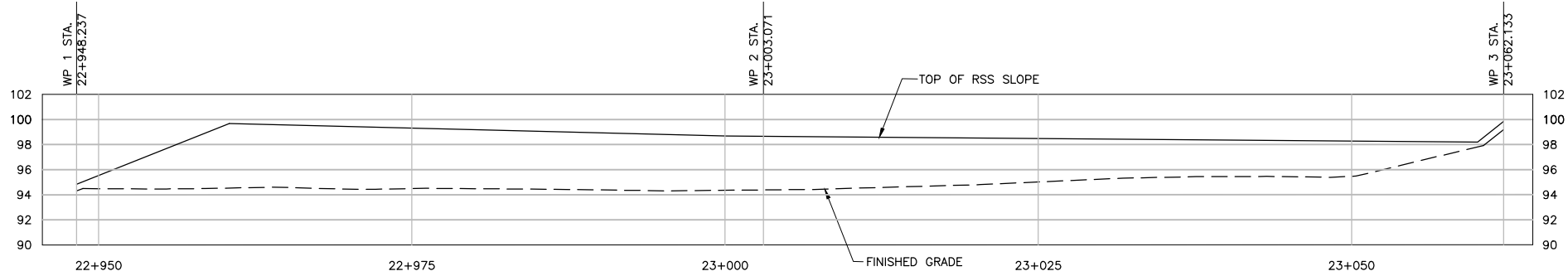
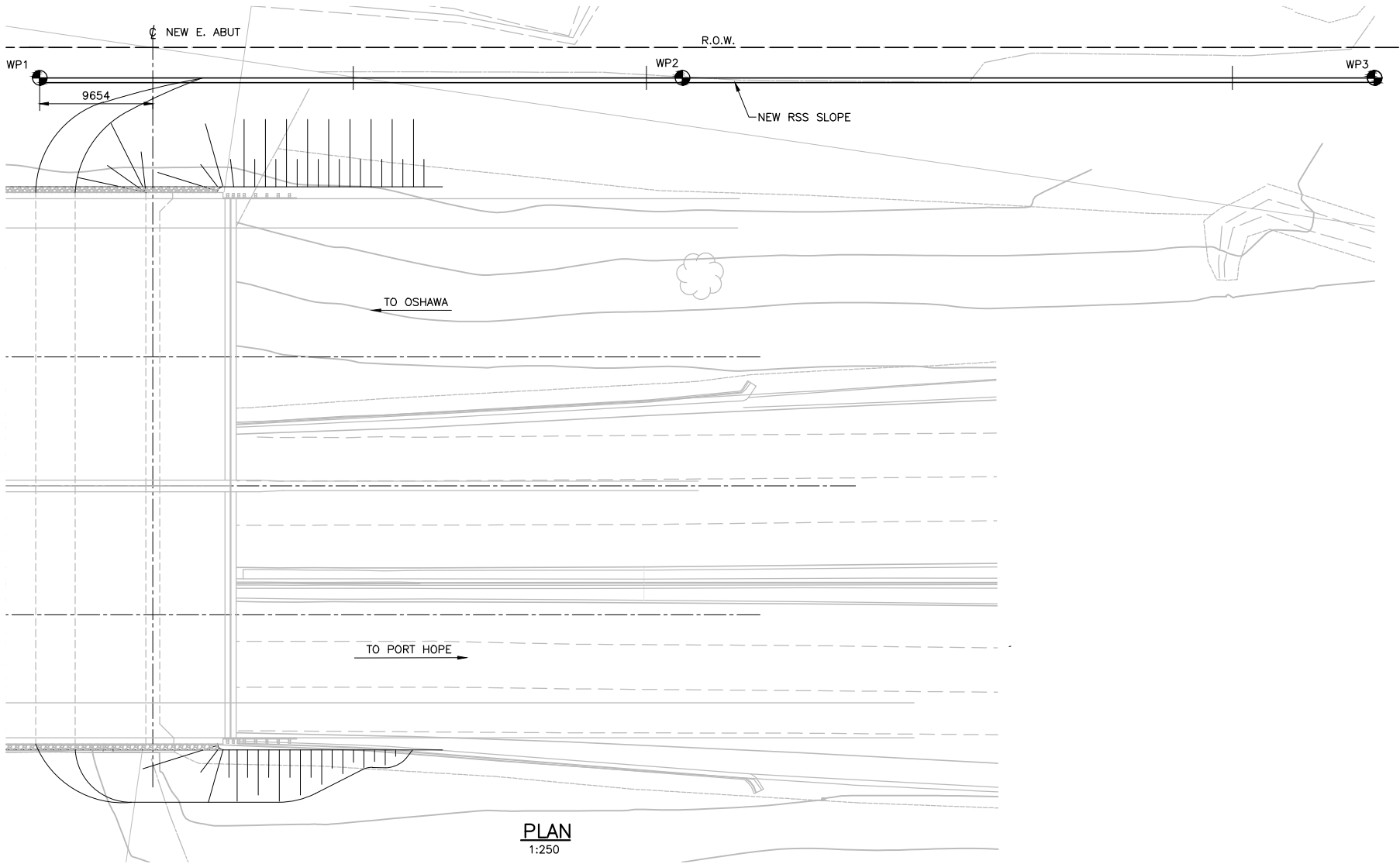
- RSS WALL SHALL BE ACCORDING TO DSM #9.70.56.
- RSS WALL SHALL HAVE THE FOLLOWING ATTRIBUTES:

APPLICATION :	WALL
PERFORMANCE :	MEDIUM
GEOMETRY :	VERTICAL
APPEARANCE :	MEDIUM
- MAXIMUM BEARING CAPACITY IS 325 kPa AT SLS AND 350 kPa AT ULS.
- THE MINIMUM SOIL COVER TO THE TOP OF ENGINEERED FILL PAD SHALL BE AT LEAST 1000mm.
- THE ENGINEERED FILL PAD MUST BE PLACED AND COMPACTED IN A FULLY DE-WATERED EXCAVATION.
- SUB-EXCAVATION OF ORGANIC SILT IS REQUIRED.
- ALL EXCAVATIONS NEED TO BE STAGED IN 5.0 m LENGTHS AND BACKFILLED IMMEDIATELY.

DRAFT

REVISIONS		DATE		BY		DESCRIPTION	
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						SCHEME -	
						DWG 2	

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STATION	22+948.237	22+950.000	22+975.000	23+000.000	23+003.071	23+025.000	23+050.000	23+062.133
RETAINING WALL TOP ELEVATION	94.535 95.537		99.308	98.683 98.658		98.481	98.28	99.84
FINISHED GRADE ELEVATION	94.299 94.485		94.490	94.356 94.385		95.013	95.467	99.202

ELEVATION
1:250

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

COORDINATES OF WORK POINTS			
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WP1	22+948.237	4870696.047	401583.026
WP2	23+003.071	4870703.990	401637.282
WP3	23+062.133	4870712.542	401695.722

HWY. 401
CONT No
WP No

RETAINING WALL
GANARASKA RIVER BRIDGE

SHEET
173

Joint Venture

- GENERAL NOTES:
- RSS SLOPE SHALL BE ACCORDING TO DSM#9.70.56.
 - RSS SLOPE SHALL HAVE THE FOLLOWING ATTRIBUTES:

APPLICATION :
PERFORMANCE :
GEOMETRY :
APPEARANCE :

SLOPE
MEDIUM
SLOPE
MEDIUM WITH VEGETATED FACE
 - MAXIMUM BEARING CAPACITY:

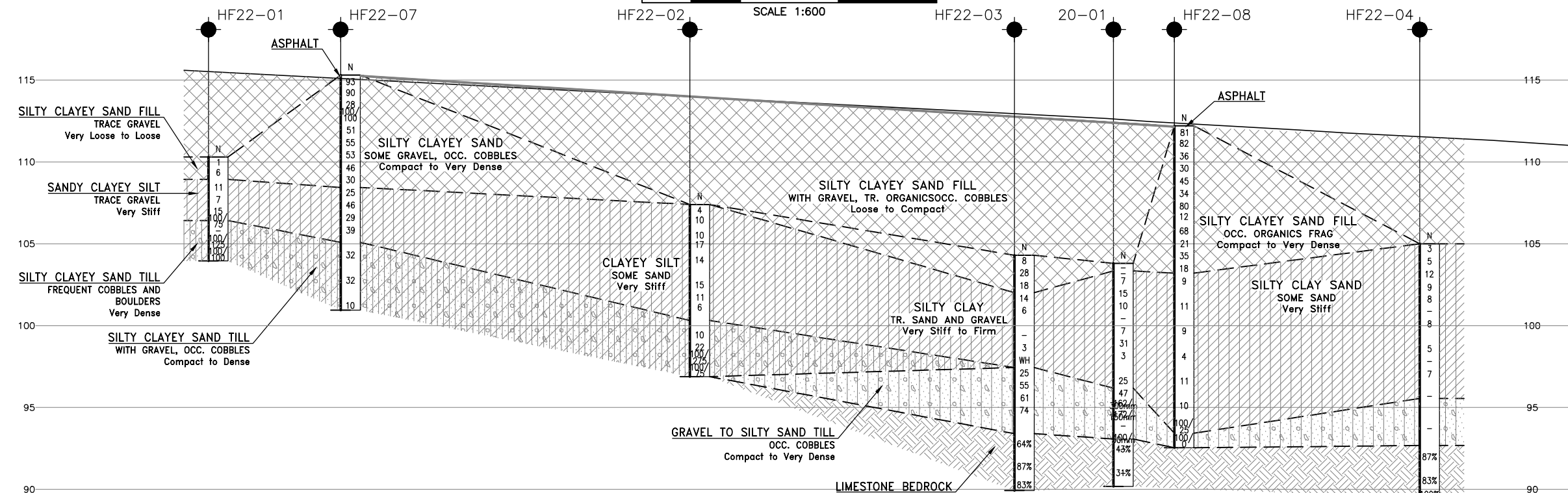
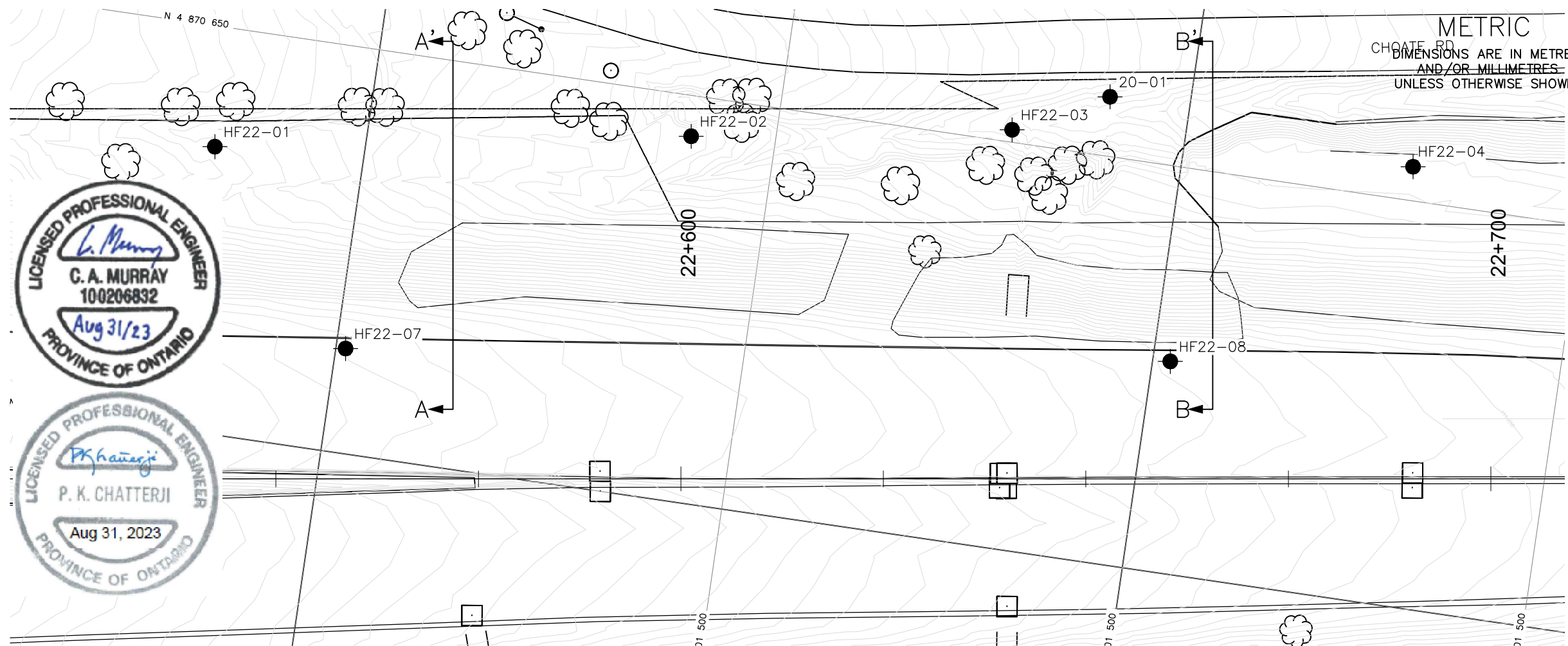
STATION 22+950 TO 23+035
STATION 23+035 TO 23+075

350 kPa AT SLS AND 400 kPa AT ULS
240 kPa AT SLS AND 300kPa AT ULS
 - THE MINIMUM SOIL COVER TO THE TOP OF ENGINEERED FILL PAD SHALL BE AT LEAST 1000mm.
 - SUB-EXCAVATION OF ORGANIC SILT OR GROUND IMPROVEMENT IS REQUIRED.
 - ALL EXCAVATIONS NEED TO BE STAGED IN 5.0 m LENGTHS AND BACKFILLED IMMEDIATELY.
 - THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING THE SUBGRADE BY IMPLEMENTING ADEQUATE GROUNDWATER CONTROL MEASURES AND MINIMIZING CONSTRUCTION AND PERSONNEL TRAFFIC ON THE FOUNDING SUBGRADE.
 - ALL ROCKFILL MATERIALS SHALL BE CLEAN, HARD, DURABLE PARTICLES FREE OF EARTH, HUMUS, CLAY OR OTHER COATINGS, CLAY LUMPS, SHALE OR SHALEY PARTINGS AND OTHER MATERIALS.

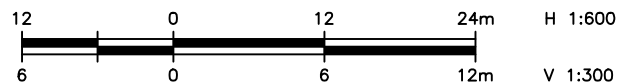
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REVISIONS		DATE	BY	DESCRIPTION
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PROFILE ALONG HWY 401

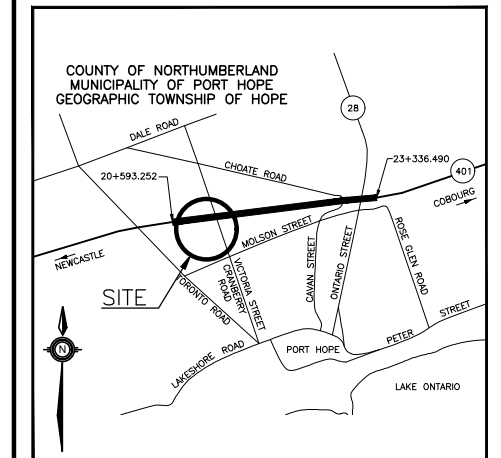


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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No

HIGHWAY 401 HIGH FILL WIDENING
WEST OF CHOATE RD

BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN
LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
20-01	103.8	4 870 657.3	401 290.1
HF22-01	110.3	4 870 635.2	401 181.6
HF22-02	107.4	4 870 645.0	401 239.6
HF22-03	104.3	4 870 651.5	401 278.7
HF22-04	105.0	4 870 654.2	401 328.4
HF22-07	115.3	4 870 612.9	401 201.2
HF22-08	112.2	4 870 626.0	401 302.2
20-02	99.8	4 870 669.4	401 361.5
301	110.2	4 870 634.9	401 378.1
19-01	102.7	4 870 653.6	401 402.3

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M16-079

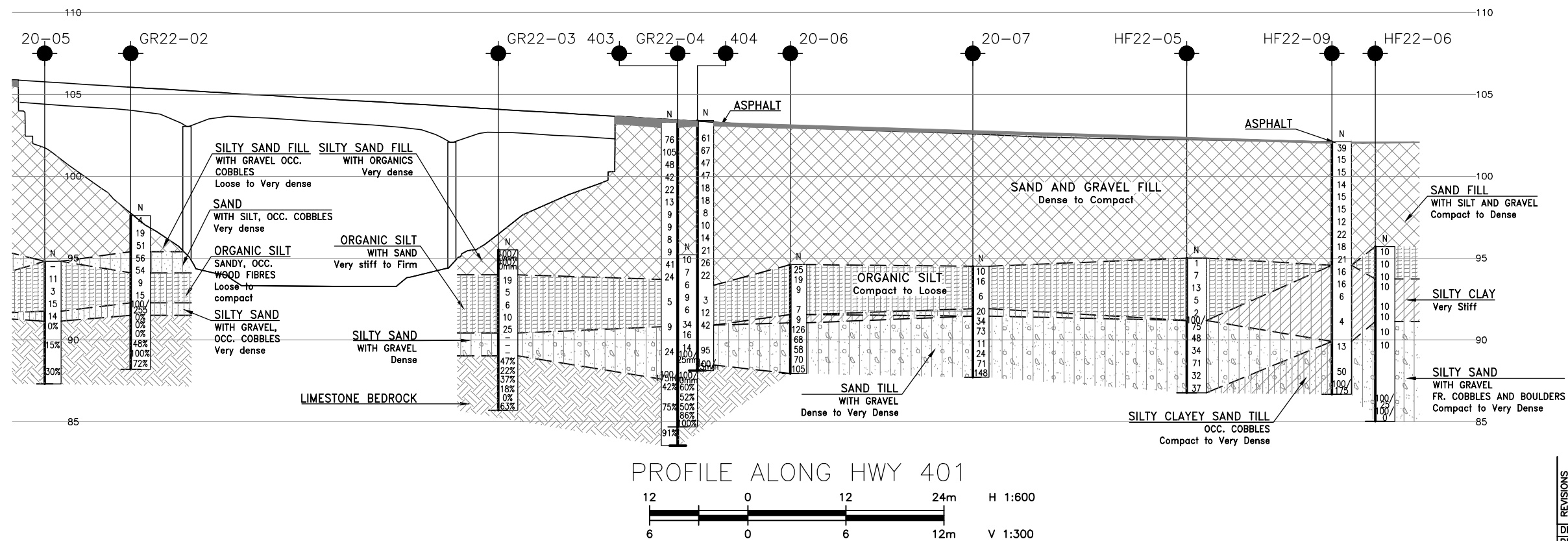
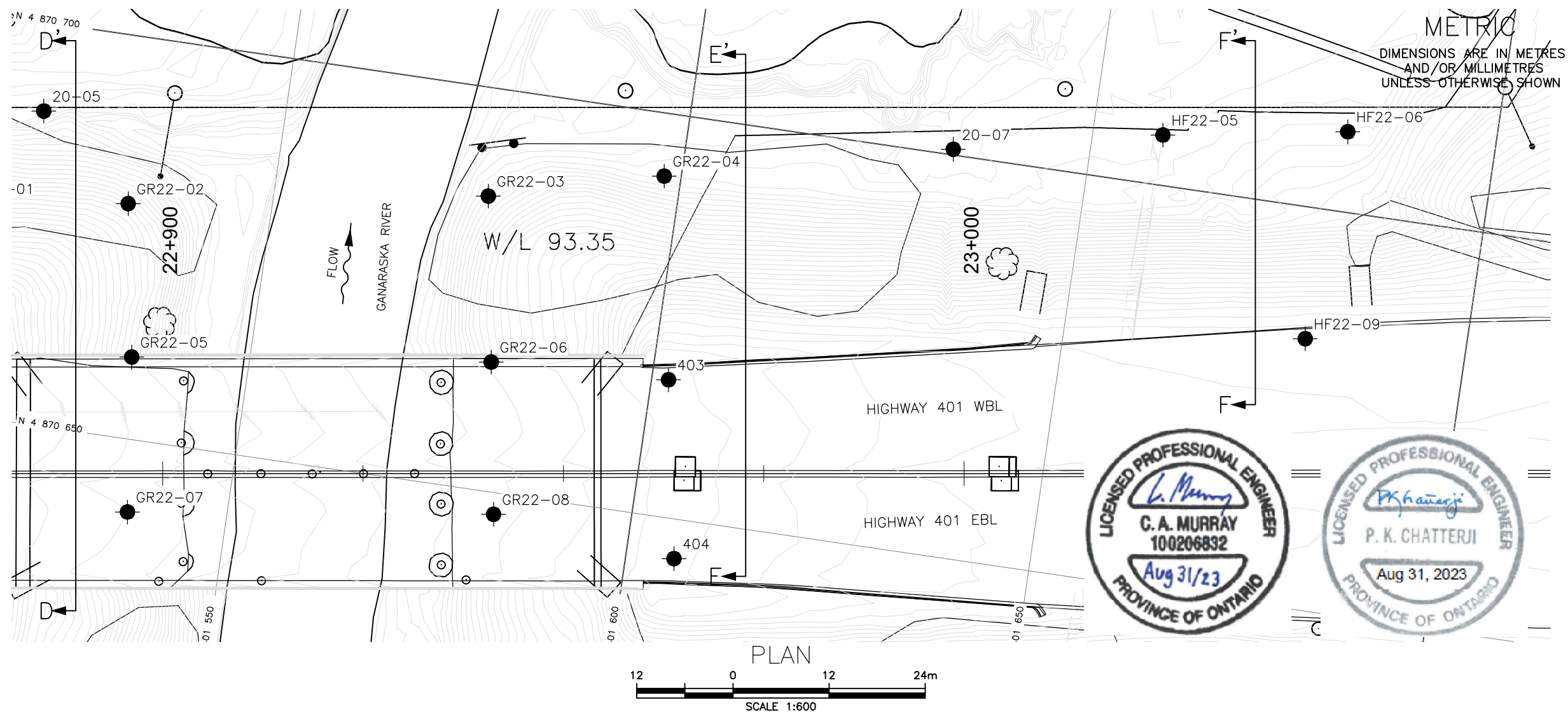
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LEGEND

- | NO | ELEVATION | NORTHING | EASTING |
|---------|-----------|-------------|-----------|
| CR22-01 | 99.3 | 4 870 664.4 | 401 407.4 |
| 19-02 | 97.5 | 4 870 646.0 | 401 423.2 |
| 19-03 | 97.9 | 4 870 650.0 | 401 430.9 |
| 19-04 | 101.6 | 4 870 653.2 | 401 446.2 |
| CR22-02 | 99.9 | 4 870 666.4 | 401 450.9 |
| 20-03 | 97.0 | 4 870 678.4 | 401 453.0 |
| 303 | 107.7 | 4 870 647.2 | 401 463.0 |
| 19-05 | 100.0 | 4 870 668.9 | 401 469.0 |
| 20-04 | 96.0 | 4 870 681.6 | 401 482.9 |
| 401 | 106.0 | 4 870 654.5 | 401 513.7 |
| GR22-01 | 98.7 | 4 870 676.0 | 401 511.2 |
| 20-05 | 94.8 | 4 870 689.0 | 401 520.1 |

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 10.

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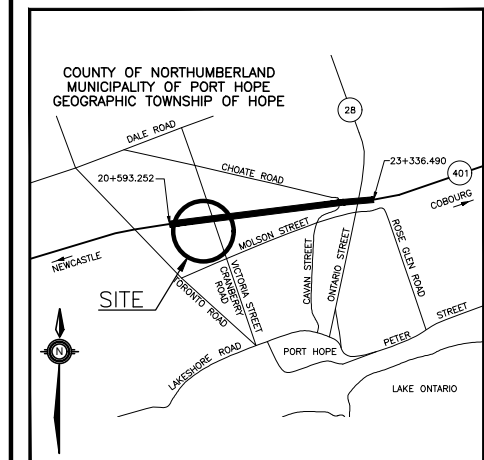
CONT No	
WP No	
HIGHWAY 401 HIGH FILL WIDENING EAST OF GANARASKA RIVER	

BOREHOLE LOCATIONS AND SOIL STRATA

LEA  **McINTOSH PERRY** 
Joint Venture








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- | | |
|---|---------------------------------------|
|  | Borehole |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

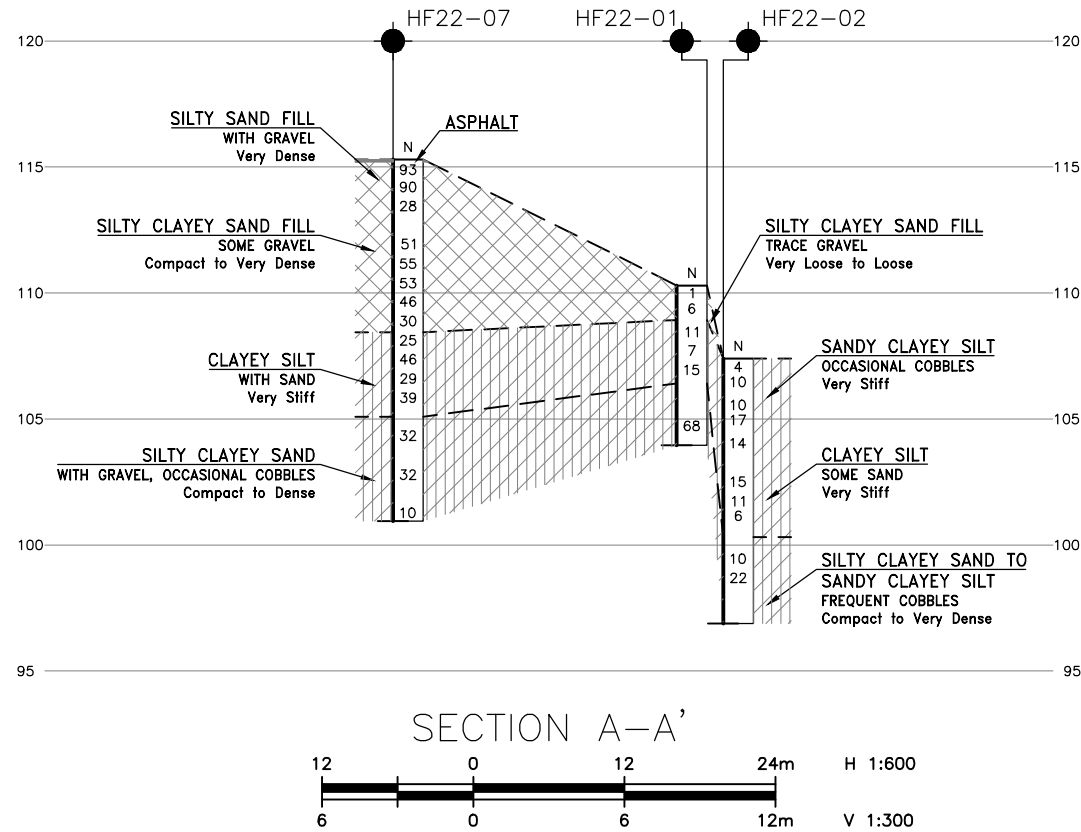
NO	ELEVATION	NORTHING	EASTING
20-05	94.8	4 870 689.0	401 520.0
GR22-02	97.6	4 870 679.1	401 532.2
GR22-03	95.5	4 870 686.5	401 576.5
403	103.3	4 870 667.1	401 602.1
GR22-04	95.2	4 870 692.2	401 597.9
404	103.4	4 870 645.1	401 606.0
20-06	94.6	4 870 699.7	401 610.7
20-07	94.5	4 870 667.1	401 602.1
HF22-05	95.0	4 870 706.3	401 658.7
HF22-09	102.1	4 870 683.7	401 680.0
HF22-06	95.7	4 870 710.0	401 681.5

-NOTES-

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- 3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M16-079

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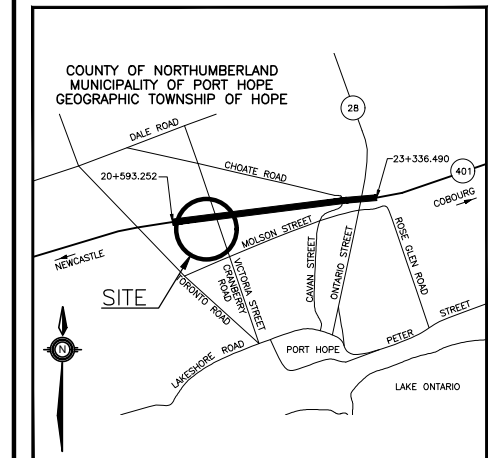


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No

HIGHWAY 401 HIGH FILL WIDENING
CHOATE RD TO
GANARASKA RIVER
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
4



KEYPLAN

LEGEND

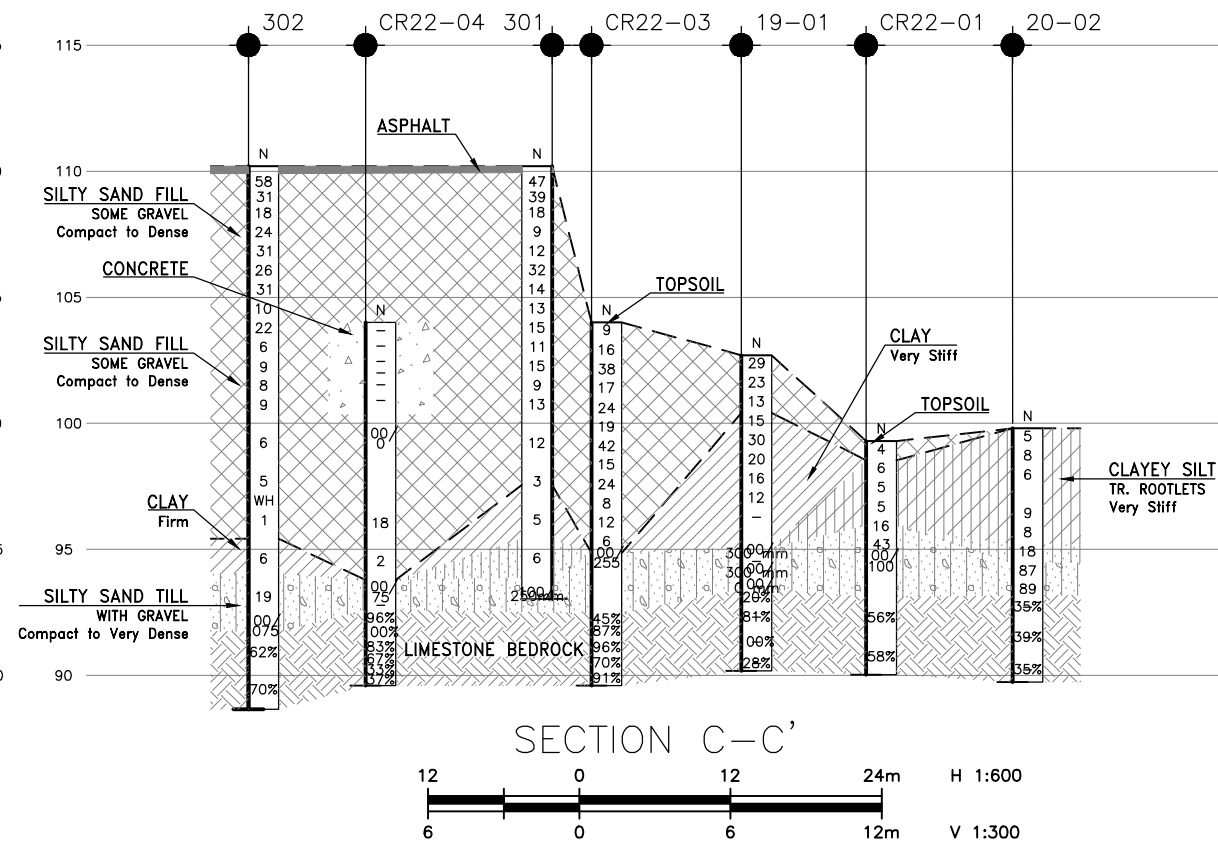
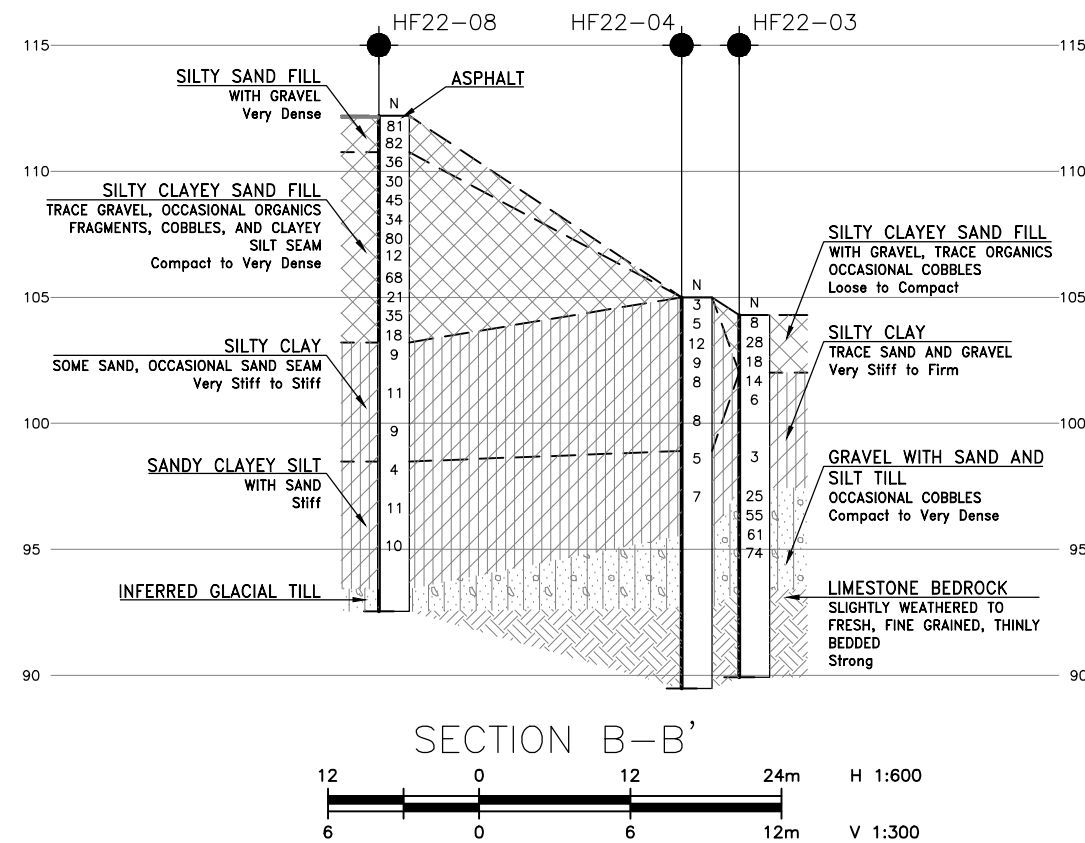
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
HF22-01	110.3	4 870 635.2	401 181.6
HF22-02	107.4	4 870 645.0	401 239.6
HF22-07	115.3	4 870 612.9	401 201.2
HF22-03	104.3	4 870 651.5	401 278.7
HF22-04	105.0	4 870 654.2	401 328.4
HF22-08	112.2	4 870 626.0	401 302.2
301	110.2	4 870 634.9	401 378.1
302	110.2	4 870 611.1	401 381.9
19-01	102.7	4 870 653.6	401 402.3
CR22-01	99.3	4 870 664.4	401 407.4
CR22-03	104.0	4 870 641.9	401 404.3
CR22-04	104.0	4 870 623.4	401 401.9

-NOTES-

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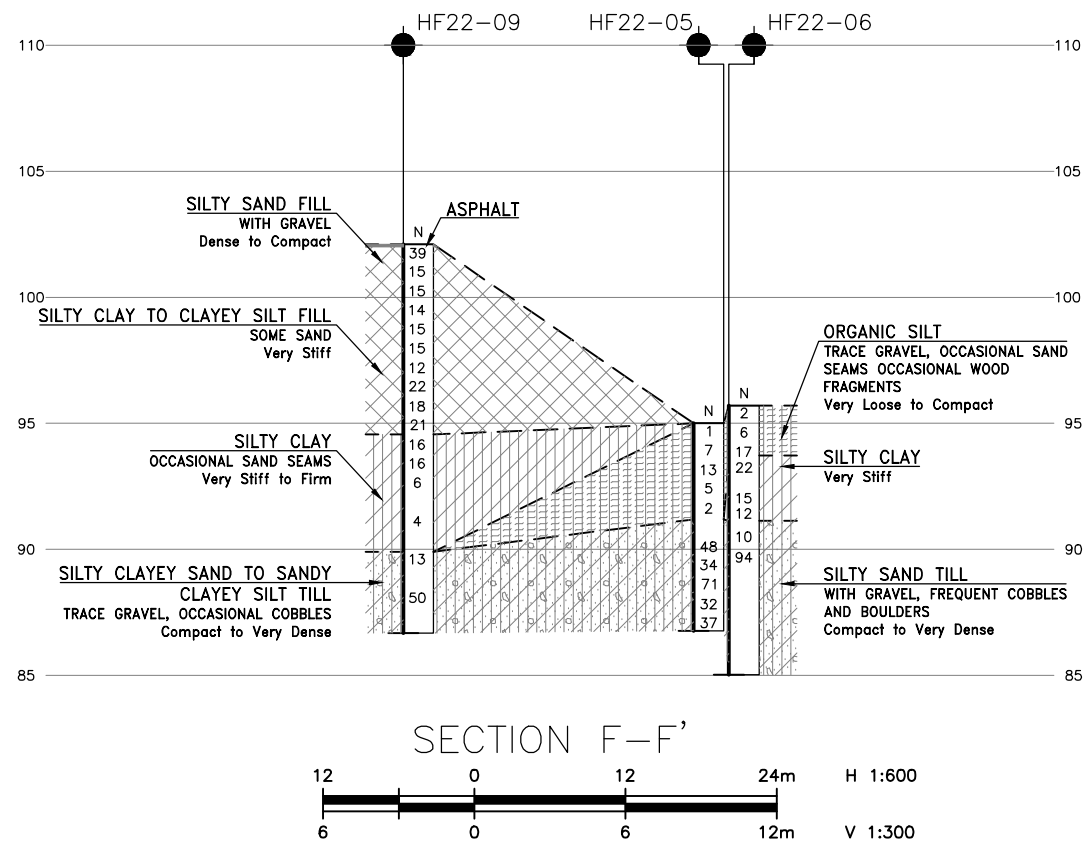
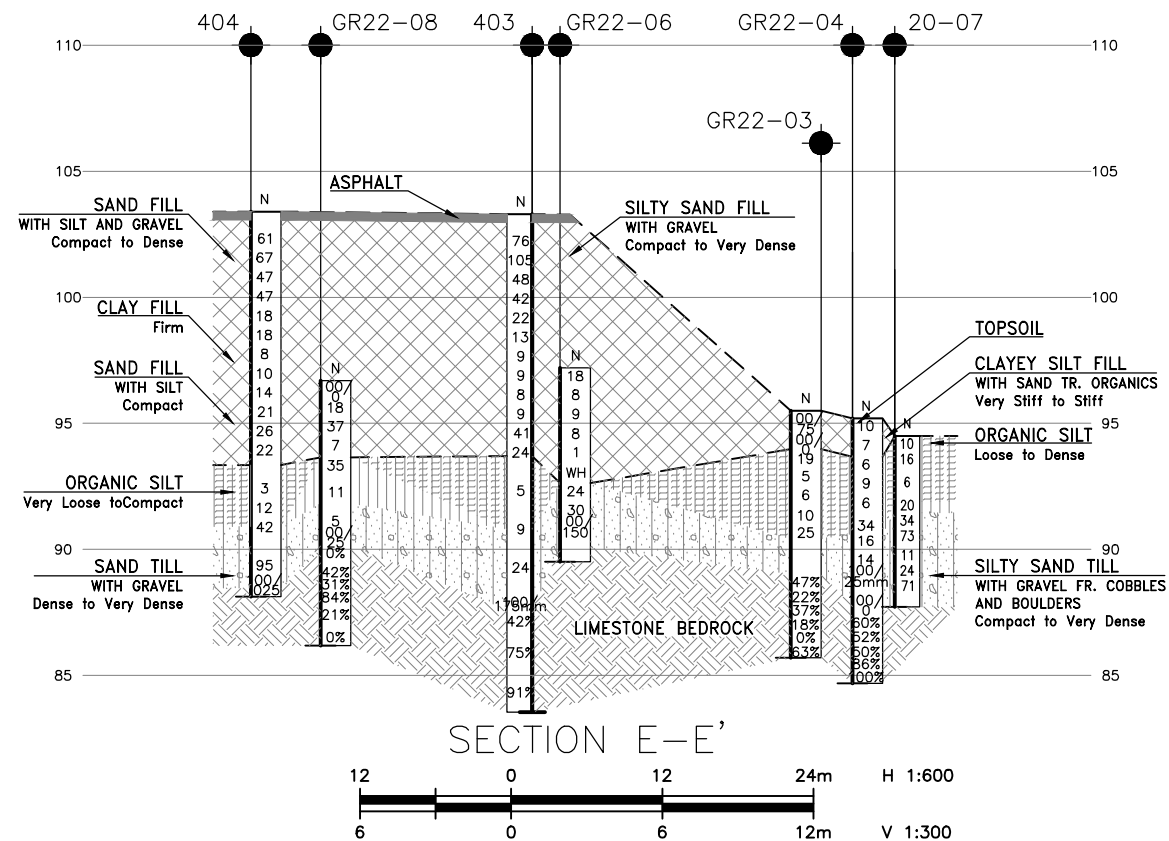
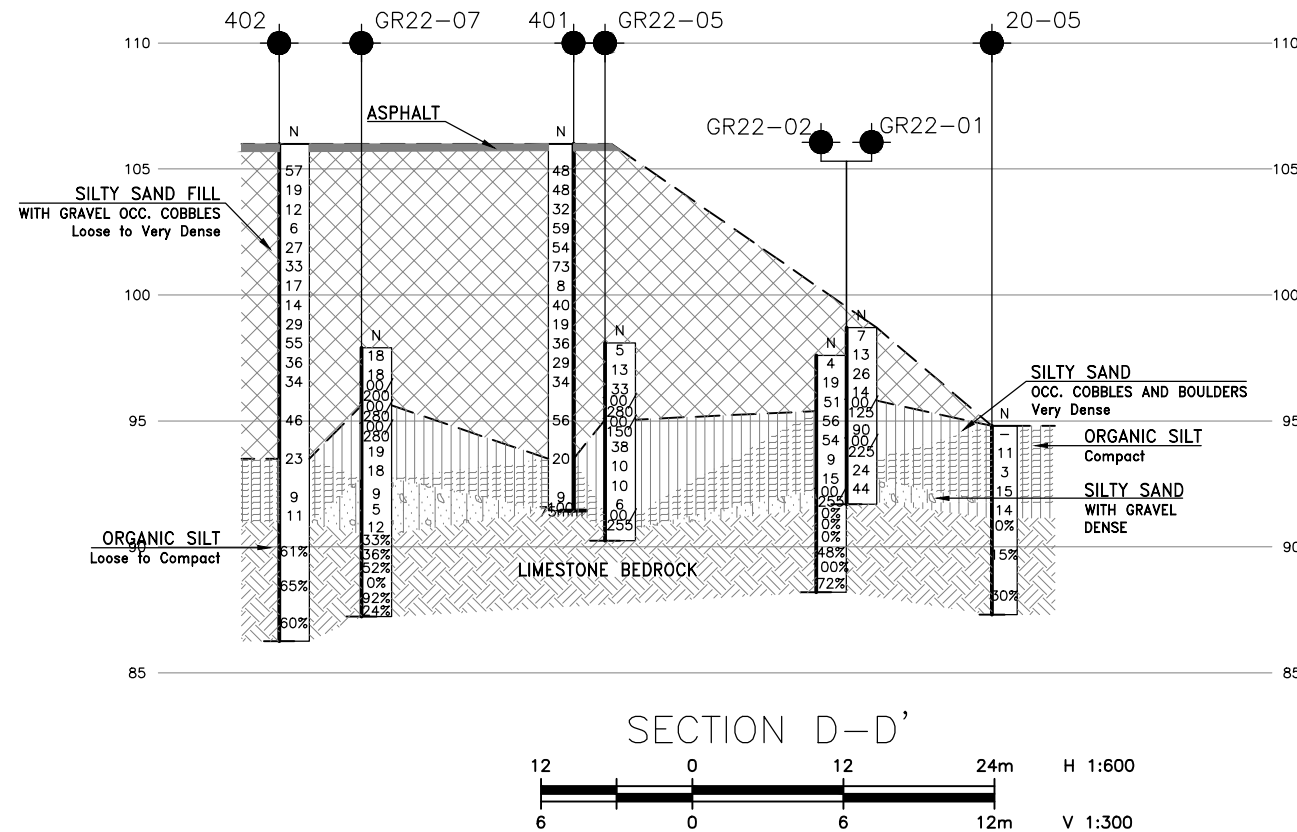
GEOCRES No. 30M16-079



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CM	CHK PKC	CODE
DRAWN	MC	CHK CM	SITE
LOAD	DATE	JAN 2023	
STRUCT	DWG	4	



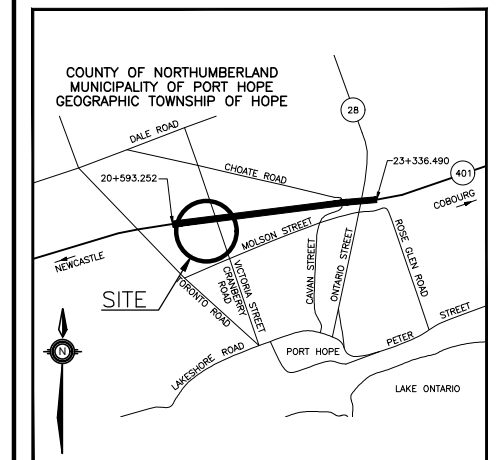
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

HIGHWAY 401 HIGH FILL WIDENING
CHOATE RD TO
GANARASKA RIVER
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
5



KEYPLAN

LEGEND

●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
GR22-01	98.7	4 870 676.0	401 511.2
GR22-02	97.6	4 870 679.1	401 532.2
GR22-05	98.1	4 870 660.2	401 535.4
GR22-07	97.9	4 870 641.0	401 537.7
GR22-03	95.5	4 870 686.5	401 576.5
GR22-04	95.2	4 870 692.2	401 597.9
GR22-06	97.2	4 870 666.1	401 579.9
GR22-08	96.7	4 870 647.3	401 582.9
HF22-05	95.0	4 870 706.3	401 658.7
HF22-06	95.7	4 870 710.0	401 681.5
HF22-09	102.1	4 870 683.7	401 680.0

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCREs No. 30M16-079

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CM	CHK PKC	CODE
DRAWN	MC	CHK CM	SITE
			LOAD
			STRUCT
			DWG 5
			DATE JAN 2023



Appendix B Field Investigation and Testing

Symbols and Terms
Current Record of Boreholes Sheets
Historical Record of Boreholes Sheets



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No 20-01

1 OF 2

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.96957°, Long: -78.297472°
MTM z10: N 4 870 657.3 E 401 290.1 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE CME 45 Trackmount HSA / NW Casing / NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2020.07.06 - 2020.07.06 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
103.8	Ground Surface							20 40 60 80 100						
0.0	RIP-RAP		1A	GS	-			○ UNCONFINED + FIELD VANE						
103.3								● QUICK TRIAXIAL × LAB VANE						
0.5	Clayey SILT (CL) with sand (Crust) Very Stiff to Stiff Grey to Grey-Brown		1B	GS	-									
			1	SS	7									
			2	SS	15									
			3	SS	10									
100.9														
2.9	Clayey SILT (CL) Stiff to Firm Grey		4	ST	-									
			5	SS	7									
			6	SS	31									
			7	SS	3									
96.9														
6.9	Sandy SILT (ML), some gravel Compact Grey		8	SS	25									
96.2														
7.6	Silty SAND with gravel Freq. Cobb/Blds Dense to Very Dense Grey GLACIAL TILL		9	SS	47									
			10	SS	162/ 300mm									
	- 100 mm cobble @ 9 m		1	NQ	-									
			11	SS	172/ 150mm									
	- 200 mm boulder @ 9.9 m		2	NQ	-									

Continued Next Page

+ 3, × 3: Numbers refer to
Sensitivity 20
15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-01

2 OF 2

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.96957°, Long: -78.297472°
MTM z10: N 4 870 657.3 E 401 290.1 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE CME 45 Trackmount HSA / NW Casing / NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2020.07.06 - 2020.07.06 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa															
								20	40	60	80	100											
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										WATER CONTENT (%)					
	Continued From Previous Page						20	40	60	80	100	20	40	60									
93.1	Silty SAND with gravel Freq. Cobb/Blds Dense to Very Dense Grey GLACIAL TILL		12	SS	100/ 50mm											FI	RUN #1 TCR=100% SCR=94% RQD=78%						
10.7	LIMESTONE BEDROCK Very Strong Grey Slightly Weathered Thinly Bedded Fine Grained		1	RUN	-											4							
																2							
																1							
																2							
																4	RUN #2 TCR=98% SCR=92% RQD=82%						
																2							
																3							
																3							
																4							
90.2			2	RUN	-											2							
13.6	End of Borehole																						
	19 mm PVC standpipe piezometer installed on completion WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.07.08 3.5 100.3 2020.07.09 3.4 100.4 2020.07.15 3.7 100.1																						

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-02

1 OF 2

METRIC





GWP# 4005-17-00 LOCATION Lat: 43.96967°, Long: -78.29658° MTM z10: N 4 870 669.4 E 401 361.5 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE CME 45 Trackmount HSA / NW Casing / NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2020.07.07 - 2020.07.07 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20	40	60	80						100	
99.8	Ground Surface																	
0.0	TOPSOIL (200 mm)																	
0.2	Clayey SILT (CL), some sand (Crust) Very Stiff Brown		1	SS	5													
			2	SS	8													
98.3																		
1.5	Clayey SILT (CL) Very Stiff Grey - N-vane maxed out at 106 kPa - unable to push shear vane - unable to push shear vane		3	SS	6													
					4	SS	9											
			5	SS	8													
95.2																		
4.6	Sandy SILT, some gravel Compact Grey		6	SS	18													
94.5																		
5.3	Silty SAND with gravel Very Dense Grey GLACIAL TILL		7	SS	87													
			8	SS	89													
93.2																		
6.6	LIMESTONE BEDROCK Very Strong Grey Slightly Weathered Thinly Bedded Fine Grained		1	RUN	-													
					2	RUN	-											
			3	RUN	-													
										</								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 10 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT 	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
80.7	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 	WATER CONTENT (%) 		

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-03

1 OF 1

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.969739°, Long: -78.295439°
MTM z10: N 4 870 678.4 E 401 453.0 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE CME 45 Trackmount HSA / NW Casing / NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2020.07.07 - 2020.07.07 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100		20 40 60		20 40 60				
97.0	Ground Surface															
0.0	ORANIC SILT (ML-OL), with sand Very Loose Brown		1	SS	WH	96									4 44 35 17	
			2	SS	WH											
			</													

DOUBLE LINE 28171 PORT HOPE - WIDENING.GPJ 2012TEMPLATE(MTO).GDT 27/11/20



+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-04

1 OF 1

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.969764°, Long: -78.295065°
MTM z10: N 4 870 681.6 E 401 482.9 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE CME 45 Trackmount HSA / NW Casing / NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2020.07.08 - 2020.07.08 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W P W W L				GR	SA	SI	CL		
								20 40 60 80 100				WATER CONTENT (%)										
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																
96.0	Ground Surface																					
0.0	ORGANIC SILT (ML-OL), with sand Very Loose Brown		1	SS	WH												0	38	47	15		
			2	ST	-																Organic Content = 0.4%	
94.5																						
1.5	Silty SAND, some gravel Compact Grey-Brown		3	SS	13													13	46	29	12	
93.7																						
2.3	Sandy SILT Dense Grey-Brown		4	SS	32													0	44	48	8	
93.0																						
3.0	Silty SAND with gravel Compact to Dense Grey-Brown		5	SS	20																	
92.4	GLACIAL TILL																					
3.6	LIMESTONE BEDROCK Very Strong Grey Slightly Weathered Thinly Bedded Fine Grained		1	RUN	-																RUN #1 TCR=92% SCR=82% RQD=51%	
			2	RUN	-																	RUN #2 TCR=100% SCR=93% RQD=62% UCS=102MPa
			3	RUN	-																	RUN #3 TCR=100% SCR=93% RQD=70%
88.3	End of Borehole																					
7.7																						

DOUBLE LINE 28171 PORT HOPE - WIDENING.GPJ 2012TEMPLATE(MTO).GDT 27/11/20

RECORD OF BOREHOLE No 20-05

1 OF 1

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.969825°, Long: -78.2946°
MTM z10: N 4 870 689.0 E 401 520.1 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE CME 45 Trackmount HSA / NW Casing / NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2020.07.08 - 2020.07.08 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
94.8	Ground Surface							20	40	60	80	100							
0.0	ORGANIC SILT (MI-OI) Very Loose to Compact Brown to Brown-Grey		1	GS	-														
	- silt seams		2	SS	11														
			3	SS	3														
	- silt seams		4	SS	15														
91.8																			
3.0	Silty SAND , with gravel Compact Grey		5	SS	14														
91.1	GLACIAL TILL																		
3.7	LIMESTONE BEDROCK Very Strong Slightly Weathered Thinly Bedded Grey Fine Grained		1	RUN															
			2	RUN															
87.3																			
7.5	End of Borehole																		
	19 mm PVC standpipe piezometer installed WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.07.10 0.8 94.0 2020.07.15 1.1 93.7 2020.07.16 1.1 93.7 2020.08.20 0.8 94.0																		

DOUBLE LINE 28171 PORT HOPE - WIDENING GPJ 2012TEMPLATE(MTO).GDT 27/11/20

RECORD OF BOREHOLE No 20-06

1 OF 1

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.96991°, Long: -78.293469° MTM z10: N 4 870 699.7 E 401 610.7 ORIGINATED BY RH
 HWY 401 BOREHOLE TYPE Portable COMPILED BY SH
 DATUM Geodetic DATE 2020.07.14 - 2020.07.14 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L								
94.6	Ground Surface							20	40	60	80	100						GR	SA	SI	CL
0.0	TOPSOIL (50 mm)																				
	ORGANIC SILT (MI-OI) Compact to Loose Brown		1	SS	25		94														
			2	SS	19																
			3	SS	9		93														
			4	SS	7		92														
91.6																					
3.0	CLAY (Cl), some sand Stiff Grey		5	SS	9		91														
91.0																					
3.6	Silty SAND with gravel Very Dense Grey-Brown GLACIAL TILL		6	SS	126		90														
			7	SS	68																
			8	SS	58																
			9	SS	70		89														
			10	SS	105																
87.9							88														
6.7	End of Borehole on Split Spoon Refusal																				

DOUBLE LINE 28171 PORT HOPE - WIDENING.GPJ 2012TEMPLATE(MTO).GDT 27/11/20

RECORD OF BOREHOLE No 20-07

1 OF 1

METRIC

GWP# 4005-17-00 LOCATION Lat: 43.969916°, Long: -78.29319°
MTM z10: N 4 870 700.7 E 401 633.1 ORIGINATED BY RH
HWY 401 BOREHOLE TYPE Portable COMPILED BY SH
DATUM Geodetic DATE 2020.07.13 - 2020.07.13 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
94.5	Ground Surface							20	40	60	80	100							
0.0	TOPSOIL (50 mm)							20	40	60	80	100							
91.9	ORGANIC SILT (MH-OH) Compact to Loose Grey		1	SS	10		94												
			2	SS	16														
			3	SS	6														
91.5	Silty SAND Compact Grey		4	SS	20		92												
87.7	Silty SAND, with to some gravel Compact to Very Dense Grey-Brown GLACIAL TILL		5	SS	34		91												
			6	SS	73														
			7	SS	11														
			8	SS	24														
			9	SS	71														
			10	SS	148														
6.8	End of Borehole on Split Spoon Refusal Stickup 19 mm PVC standpipe piezometer installed. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.07.14 0.3 94.2 2020.07.15 0.4 94.1 2020.07.16 0.4 94.1 2020.08.20 0.3 94.2																		

+ 3, x 3: Numbers refer to
Sensitivity 20
15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HF22-01

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969386°, Long: -78.298828° Highway 401/ High Fill Widening, MTM z10: N 4 870 635.2 E 401 181.6 ORIGINATED BY SG
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.06.20 - 2022.06.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
110.3	Ground Surface							20	40	60	80	100					GR SA SI CL
0.0	SILTY CLAYEY SAND trace Gravel Very Loose to Loose Brown FILL		1	SS	1		110										3 65 24 8
			2	SS	6									o			
108.9							109										
1.4	SANDY CLAYEY SILT (CL) trace Gravel Very Stiff Brown		3	SS	11									o			3 33 50 14
														o			
			4	SS	7		108							o			3 33 50 14
			5	SS	15		107							o			2 28 41 29
106.4			6	SS	100/												
3.9	SILTY CLAYEY SAND trace Gravel Frequent Cobbles and Boulders Very Dense Grey GLACIAL TILL - 200 mm boulder at 4.5 m				75mm		106										
			1	NQ	-												
			2	NQ	-												
			7	SS	100/		105							o			4 57 29 10
			8	SS	125mm 68									o			
104.0			9	SS	100/		104							o			
6.3	End of Borehole				100mm												
	Piezometer installed consists of 19-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen																
	Water level readings:																
	DATE DEPTH (m) ELEV. (m)																
	2022.08.23 0.2 110.1																
	2022.08.24 0.2 110.1																
	2023.06.22 0.3 110.0																
	Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 8-30-23

RECORD OF BOREHOLE No HF22-02

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969466°, Long: -78.298103° Highway 401/ High Fill Widening, MTM z10: N 4 870 645.0 E 401 239.6 ORIGINATED BY SG
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.06.13 - 2022.06.16 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
107.4	Ground Surface							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							
0.0	SANDY CLAYEY SILT (CL) Occasional Cobbles Very Stiff Brown to Grey		1	SS	4		107								
			2	SS	10										0 20 48 32
			3	SS	10		106								
			4	SS	17		105								4 30 42 24
104.5															
2.9	CLAYEY SILT (CL) some Sand Very Stiff Grey		5	SS	14		104								
			6	SS	15		103								
			7	SS	11		102								
			8	SS	6		101								0 7 51 42
100.3															
7.1	SILTY CLAYEY SAND to SANDY CLAYEY SILT Frequent Cobbles Compact to Very Dense Grey GLACIAL TILL		9	SS	10		100								
			10	SS	22		99								4 44 35 17
			11	SS	100/ 275mm		98								

Continued Next Page


+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HF22-02

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969466°, Long: -78.298103°
Highway 401/ High Fill Widening, MTM z10: N 4 870 645.0 E 401 239.6 ORIGINATED BY SG
HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.06.13 - 2022.06.16 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
							20	40	60	80	100						
	Continued From Previous Page																
96.9	SILTY CLAYEY SAND to SANDY CLAYEY SILT Frequent Cobbles Very Dense Grey GLACIAL TILL		1	NQ	-												
10.5	End of Borehole		12	SS	100/75mm												
	Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																

RECORD OF BOREHOLE No HF22-03

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.9695201°, Long: -78.297615° Highway 401/ High Fill Widening, MTM z10: N 4 870 651.5 E 401 278.7 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE D50 Turbo Track Mount/ NW /NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.05.18 - 2022.05.18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
104.3	Ground Surface							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>204060</div>					
0.0	SILTY CLAYEY SAND with Gravel Trace organics Occasional cobbles Loose to Compact Brown to Grey FILL		1	SS	8		104						31 35 22 12
			2	SS	28		103						
			3	SS	18								
102.0							102						
2.3	SILTY CLAY (CI) Trace Sand and Gravel Very Stiff to Firm Light Brown to Grey		4	SS	14		101						
			5	SS	6								
	-S _u > 106 kPa						100						
	-S _u > 106 kPa		1	ST	-		99						0 6 47 47 OED: e _o = 0.779 C _c = 0.214 C _r = 0.044
			6	SS	3		98						
			7	SS	WH								
97.4													
6.9	GRAVEL with Sand and Silt to SILTY SAND with Gravel Occasional cobbles Compact to Very Dense Grey GLACIAL TILL		8	SS	25		97						
			9	SS	55		96						58 32 10 (SI+CL)
			10	SS	61								
			11	SS	74		95						

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HF22-03

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.9695201°, Long: -78.297615° Highway 401/ High Fill Widening, MTM z10: N 4 870 651.5 E 401 278.7 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE D50 Turbo Track Mount/ NW /NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.05.18 - 2022.05.18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
	Continued From Previous Page							20 40 60 80 100							
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
93.4	GRAVEL with Sand and Silt to SILTY SAND with Gravel Occasional cobbles Compact to Very Dense Grey GLACIAL TILL						94								
10.9	LIMESTONE BEDROCK Slightly weathered to Fresh Grey Fine grained Thinly to medium bedded Strong		1	RUN	-		93							FI >10	
														1	
														1	
														2	
							92							1	
			2	RUN	-									3	
														2	
														1	
							91							3	
														1	
			3	RUN	-									4	
89.9															
14.4	End of Borehole						90							4	

DOUBLE LINE 33089 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 8-30-23

RECORD OF BOREHOLE No HF22-04

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969537°, Long: -78.296996° Highway 401/ High Fill Widening, MTM z10: N 4 870 654.2 E 401 328.4 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE D50 Turbo Track Mount/ NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.05.18 - 2022.05.19 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
105.0	Ground Surface															
0.0	TOPSOIL (200 mm)															
0.2	SILTY CLAY (CI) some Sand Very Stiff Grey		1	SS	3											
			2	SS	5		104								0 10 43 47	
			3	SS	12		103									
			4	SS	9		102									
			5	SS	8											
			6	SS	-		101									
			7	SS	8		100								0 10 39 51	
	-s _u > 106 kPa															
	-s _u > 106 kPa															
98.9							99									
6.1	CLAYEY SILT (CL) with Sand, trace Gravel Very Stiff Grey		8	SS	5										2 13 42 43	
			9	ST	-		98								4 19 40 37 OED: e _o = 0.620 C _c = 0.162 C _r = 0.014	
			10	SS	7		97									
	-s _u > 106 kPa															
	-s _u > 106 kPa						96									
95.6	- Shelby Tube Refusal at 9.6 m		11	ST	-											
9.4	INFERRED GLACIAL TILL															

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
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 (%) STRAIN AT FAILURE


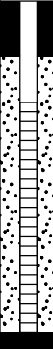

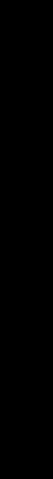
DOUBLE LINE 330599 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 8-30-23

RECORD OF BOREHOLE No HF22-04

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969537°, Long: -78.296996° Highway 401/ High Fill Widening, MTM z10: N 4 870 654.2 E 401 328.4 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE D50 Turbo Track Mount/ NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.05.18 - 2022.05.19 CHECKED BY CM



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)										
	Continued From Previous Page							20 40 60 80 100											
92.7 12.3	INFERRED GLACIAL TILL Frequent Cobbles and Boulders Very Dense - Borehole advanced with NQ coring below 10.2 m due to being interpreted as Bedrock						94									FI 1 2 2 3 0 1 4 2 1 1 0	RUN #1 TCR=100% SCR=100% RQD=87% RUN #2 TCR=96% SCR=96% RQD=83% RUN #3 TCR=100% SCR=100% RQD=100%		
			1	NQ	-	93													
89.5 15.5	LIMESTONE BEDROCK Slightly weathered to Fresh Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-		92												
						91													
			2	RUN	-	90													
			3	RUN	-														
	End of Borehole																		
	Piezometer installed consists of 19-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen Water level readings: DATE DEPTH (m) ELEV. (m) 2022.08.23 4.7 100.3 2022.08.24 4.7 100.3 2023.06.22 3.9 101.1																		

RECORD OF BOREHOLE No HF22-05

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969963°, Long: -78.2928701° Highway 401/ High Fill Widening, MTM z10: N 4 870 706.3 E 401 658.7 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.03.16 - 2022.03.17 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS ▽*	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
95.0	Ground Surface														
0.0	ORGANIC SILT (Cl to MH-OH) trace Gravel Trace Rootlets Occasional Sand Seams Very Loose to Compact Dark Grey		1	SS	1										
			2	SS	7										
			3	SS	13										
			4	SS	5										
			5	SS	2										
91.2															
3.8	GRAVEL with Sand and Silt to SILTY SAND with Gravel Dense to Very Dense Brownish Grey GLACIAL TILL		6	SS	100/ 75mm										
			7	SS	48										
			8	SS	34										
			9	SS	71										
			10	SS	32										
			11	SS	37										
86.8															
8.2	End of Borehole Water level at ground surface on completion of drilling. Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.														

DOUBLE LINE 33099 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 8-30-23

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

METRIC

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+³, ×³: Numbers refer to Sensitivity

METRIC

Lat: 43.969993°, Long: -78.292586°
Highway 401/ High Fill Widening, MTM z10: N 4 870 710.0 E 401 681.5

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No HF22-07

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969182°, Long: -78.298588° Highway 401/ High Fill Widening, MTM z10: N 4 870 612.9 E 401 201.2 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA COMPILED BY AO
 DATUM Geodetic DATE 2022.07.27 - 2022.07.27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
115.3	Ground Surface													
0.0	ASPHALT (100 mm)													
0.1	SILTY SAND with Gravel Very Dense Brown FILL		1	SS	93		115							
			2	SS	90		114							26 51 23 (SI+CL)
113.9	SILTY CLAYEY SAND to SANDY CLAYEY SILT some Gravel Occasional Cobbles Compact to Very Dense Brown FILL		3	SS	28		113							
1.4			4	SS	100/ 100mm		112							12 62 15 11
			5	SS	51		111							
			6	SS	55		110							
			7	SS	53		109							7 49 28 16
			8	SS	46		108							
			9	SS	30		107							6 44 31 19
108.4	CLAYEY SILT (CL) with Sand Very Stiff Brown		10	SS	25		106							
6.9			11	SS	46									
			12	SS	29									1 30 37 32
			13	SS	39									

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+³, ×³: Numbers refer to Sensitivity
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 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HF22-07

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969182°, Long: -78.298588° Highway 401/ High Fill Widening, MTM z10: N 4 870 612.9 E 401 201.2 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA COMPILED BY AO
 DATUM Geodetic DATE 2022.07.27 - 2022.07.27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page						20	40	60	80	100						
105.1	CLAYEY SILT (CL) with Sand																
10.2	SILTY SAND with Gravel Occasional Cobbles Compact to Dense Grey GLACIAL TILL						105										
		14	SS	32													
		15	SS	32													
							103										
							102										
101.0			16	SS	10												
14.3	End of Borehole - Auger Refusal						101										

DOUBLE LINE 330099 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 8-30-23

RECORD OF BOREHOLE No HF22-08

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969288°, Long: -78.297327° Highway 401/ High Fill Widening, MTM z10: N 4 870 626.0 E 401 302.2 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA COMPILED BY AO
 DATUM Geodetic DATE 2022.07.26 - 2022.07.26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT w _P NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L WATER CONTENT (%)				
112.2	Ground Surface							20	40	60	80	100						
0.0	ASPHAL (100 mm)							20	40	60	80	100						
0.1	SILTY SAND with Gravel Brown Very dense Brown FILL		1	SS	81		112							○				32 54 14 (SI+CL)
			2	SS	82		111							○				
110.8																		
1.4	SILTY CLAYEY SAND to SANDY CLAYEY SILT trace Gravel Occasioanal organics fragments, cobbles, and clayey silt seams Compact to very dense Brown FILL		3	SS	36		110							○				
			4	SS	30		109							○				1 46 32 21
			5	SS	45									○				
			6	SS	34		108							○				
			7	SS	80		107							○				
			8	SS	12		106							○				
			9	SS	68		105							○				
			10	SS	21									○				
			11	SS	35		104							He				3 39 33 25
			12	SS	18									○				
103.2							103							○				
9.0	SILTY CLAY (CI) some Sand Occasional Sand seams Very Stiff to Stiff Brown		13	SS	9									○				

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No HF22-09

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969756°, Long: -78.292609° Highway 401/ High Fill Widening, MTM z10: N 4 870 683.7 E 401 680.0 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA COMPILED BY AO
 DATUM Geodetic DATE 2022.07.25 - 2022.07.25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			
102.1	Ground Surface							<div><div></div><div>20406080100</div></div>			
0.0	ASPHALT (100 mm)							<div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>			
0.1	SILTY SAND with Gravel Dense to compact Brown FILL		1	SS	39			<div><div>W P</div><div>W</div><div>W L</div></div>			31 53 16 (SI+CL)
100.8			2	SS	15			<div>WATER CONTENT (%)</div>			
1.3	SILTY CLAY to CLAYEY SILT some Sand Very Stiff Brown FILL		3	SS	15						0 9 46 45
			4	SS	14						
	- Occasional organic inclusions from a depth of 2.7 to 7.5 m		5	SS	15						1 11 44 44
			6	SS	15						
			7	SS	12						
			8	SS	22						0 16 48 36
			9	SS	18						0 15 46 39
			10	SS	21						
94.6	CLAYEY SILT (CL) to SILTY CLAY (CI) Occasional Sand seams Very Stiff to Firm Grey		11	SS	16						0 7 40 53
7.5			12	SS	16						
			13	SS	6						0 1 42 57

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HF22-09

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969756°, Long: -78.292609° Highway 401/ High Fill Widening, MTM z10: N 4 870 683.7 E 401 680.0 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA COMPILED BY AO
 DATUM Geodetic DATE 2022.07.25 - 2022.07.25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
						20	40	60	80	100	20	40	60				
	Continued From Previous Page																
	SILTY CLAY (CI) Occasional Sand seams Very Stiff to Firm Grey		14	SS	4												
89.9																	
12.2	SILTY CLAYEY SAND to SANDY CLAYEY SILT trace Gravel Occasional Cobbles Compact to Very Dense Grey GLACIAL TILL		15	SS	13												

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 8-30-23

RECORD OF BOREHOLE No 401

1 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 654.5 E 401 513.7 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG
 DATUM Geodetic DATE 2016.05.31 - 2016.05.31 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L				GR	SA	SI	CL	
												20 40 60 80 100								
106.0																				
0.0																				
105.7	280 mm ASPHALT																			
0.3	Silty sand with gravel Dense to very dense Brown FILL		1	GS																
			2	SS	48		105													
			3	SS	48		104													
			4	SS	32															
	-gravel and cobbles		5	SS	59		103													
			6	SS	54		102													
			7	SS	73		101													
101.1	-gravel and cobbles		8	SS	8		100													
4.9	Sandy silt to sandy clay Loose to dense Brown FILL		9	SS	40															
			10	SS	19		99													
			11	SS	36		98													
	-clayey		12	SS	29		97													
			13	SS	34															

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
+³, ×³: Numbers refer to Sensitivity
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 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 401

2 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 654.5 E 401 513.7 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG
 DATUM Geodetic DATE 2016.05.31 - 2016.05.31 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								UNCONFINED + FIELD VANE													
								QUICK TRIAXIAL x LAB VANE													
Continued From Previous Page							20 40 60 80 100				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L										
95.6	Sand with silt Very dense Brown FILL		14	SS	56		95														
10.4																					
93.5																					
12.5	Sandy Organic SILT (ML-OL) Compact to loose Dark brown - some wood fragments		15	SS	20		94														
91.5			16	SS	9		93														
91.4	Weathered Limestone Bedrock		17	SS	100		92														
14.6																					
	End of Borehole on Inferred Bedrock					75mm															

ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

RECORD OF BOREHOLE No 402

1 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 631.4 E 401 517.2 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)									
106.0								20	40	60	80	100									
0.0	300 mm ASPHALT																				
105.7																					
0.3	Silty sand with gravel, occasional cobbles Loose to very dense Brown FILL		1	GS																	
			2	SS	57		105														
			3	SS	19		104														
	- cobbles		4	SS	12																
			5	SS	6		103														
			6	SS	27		102														
			7	SS	33		101														
100.5																					
5.5	Silty sand with gravel, occasional cobbles Compact to very dense Brown to greyish-brown FILL		8	SS	17		100														
			9	SS	14																
			10	SS	29		99														
			11	SS	55		98														
			12	SS	36																
			13	SS	34		97														

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 402

2 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 631.4 E 401 517.2 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								UNCONFINED + FIELD VANE									
								QUICK TRIAXIAL x LAB VANE									
Continued From Previous Page							20 40 60 80 100										
95.5	Silty sand Dense Brown to greyish-brown FILL		14	SS	46		95										
93.5	Organic SILT (MH-OH) Loose to compact Greyish-brown to dark brown		15	SS	23		94										
12.5							93										
							92										
91.5	CLAY (CL) , some organics Firm Dark brown		17	SS	11		91										
14.5																	
91.2																	
14.8	Silty, Clayey SAND (SC-SM) with gravel TILL Compact Grey						90										
91.0																	
15.0																	
90.5	Moderately weathered BEDROCK - augered to 15.5 m BEDROCK Limestone Slightly weathered Thinly to moderately bedded Fair Quality Grey		1	HQ			89										
15.5																	
							88										
							87										
86.3	End of Borehole																
19.7																	

ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

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+³, ×³: Numbers refer to Sensitivity
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 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 402

3 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 631.4 E 401 517.2 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
	Groundwater level was measured in open borehole at 14.0m BGS (elev. 92.0 m) on 2016/06/01																

ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

RECORD OF BOREHOLE No 403

1 OF 3

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 667.1 E 401 602.1 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY JAG
 DATUM Geodetic DATE 2016.05.30 - 2016.05.30 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
								20 40 60 80 100					
103.3													
0.0	350 mm ASPHALT												
103.0													
0.3	Silty sand with gravel Compact to very dense Brown FILL		1	GS									
			2	SS	76								
			3	SS	105								
			4	SS	48								
			5	SS	42								
	-gravel and cobbles		6	SS	22								
			7	SS	13								
97.8													
5.5	Clay, trace sand Firm Brown to greyish-brown FILL		8	SS	9								
			9	SS	9								
			10	SS	8								
95.4			11	SS	9								
7.9	Silty sand some gravel Compact to dense Brown to greyish-brown FILL		12	SS	41								
			13	SS	24								
93.7													
9.6	Organic SILT (MH-OH) occasional wood pieces												

ONTMT4S GANARASKA RIVER BRIDGE.GPJ 2012TEMPLATE(MTO).GDT 24/4/18

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC





[illegible]

RECORD OF BOREHOLE No 404

1 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 645.1 E 401 606.0 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								WATER CONTENT (%)						
103.4														
0.0	240 mm ASPHALT													
103.0														
0.3	Sand with silt and gravel Compact to dense Brown FILL		1	GS										
			2	SS	61									
			3	SS	67									
			4	SS	47									
			5	SS	47									
			6	SS	18									
98.2	Clay Firm Brown FILL													
			7	SS	18									
5.2														
95.4	Sand with silt Compact Greyish-brown FILL													
			8	SS	8									
			9	SS	10									
			10	SS	14									
7.9														
														
			11	SS	21									
			12	SS	26									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 404

2 OF 2

METRIC

GWP# 4078-14-00 LOCATION Site 21-231, MTM Zone 10: N 4 870 645.1 E 401 606.0 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JAG
 DATUM Geodetic DATE 2016.01.06 - 2016.01.06 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
Continued From Previous Page							WATER CONTENT (%)						
							20 40 60						
93.3	Organic SILT (MH-OH) Very loose to compact Dark brown						93						0 3 74 23
10.1			14	SS	3								
			15	SS	12								
			16	SS	42								
90.9	SAND (SP) with gravel TILL Dense to very dense Brown to grey						91						16 81 3 (SI+CL)
12.5													
			17	SS	95								
88.4	Weathered Limestone BEDROCK - augered to 15.3 m						89						
14.9			18	SS	100/25mm								
88.1													
15.3	End of Borehole on inferred bedrock Groundwater level was measured in open borehole at 9.1 m BGS (elev. 94.3 m) on 2016/06/01												

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GR22-01

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.9697101°, Long: -78.294713° Highway 401/ Ganaraska River, MTM z10: N 4 870 676.0 E 401 511.2 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing COMPILED BY AO
 DATUM Geodetic DATE 2022.04.13 - 2022.04.14 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
98.7	Ground Surface							20	40	60	80	100					
0.0 98.4	TOPSOIL (255 mm)																
0.3	SILTY SAND some gravel Occasional Cobbles and Boulders Loose to compact Brown FILL		1	SS	7		98										
			2	SS	13												
			3	SS	26		97										12 43 24 21
			4	SS	14		96										
95.8																	
2.9	SILTY SAND (SM) Occasional Cobbles and Boulders Very dense Brown		5	SS	100/ 125mm		95										
			6	SS	90												2 70 28 (SI+CL)
			7	SS	100/ 225mm		94										
93.6																	
5.1	ORGANIC SILT Compact Dark grey		8	SS	24		93										
92.7																	
6.0	SILTY SAND with Gravel Dense Brown GLACIAL TILL		9	SS	44		92										
91.8																	
90.9	PROBABLE LIMESTONE BEDROCK		1	NO	-												
7.0	End of Borehole Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																

DOUBLE LINE 33089 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

+³, ×³: Numbers refer to Sensitivity 20
15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GR22-02

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969735°, Long: -78.294451° Highway 401/ Ganaraska River, MTM z10: N 4 870 679.1 E 401 532.2 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.12 - 2022.04.12 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
97.6	Ground Surface																GR SA SI CL
0.0 97.3	TOPSOIL (255 mm)																
0.3	SILTY SAND with gravel Occasional Cobbles Loose to very dense Brown FILL		1	SS	4												19 44 37 (SI+CL)
			2	SS	19												
			3	SS	51												
95.4																	
2.2	SAND (SP-SM) with silt Occasional Cobbles Very dense Brown-grey		4	SS	56												1 90 9 (SI+CL)
			5	SS	54												
94.1																	
3.5	ORGANIC SILT, Sandy Occasional wood fibres Loose to compact Dark grey		6	SS	9												0 35 45 20
			7	SS	15												
92.3																	
5.3	SILTY SAND with Gravel Occasional Cobbles Very dense Grey		8	SS	100/ 255mm												FI
91.5	GLACIAL TILL																
6.1	LIMESTONE BEDROCK Slightly weathered to fresh Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-												RUN #1 TCR=66% SCR=33% RQD=0%
			2	RUN	-												RUN #2 TCR=100% SCR=78% RQD=0%
			3	RUN	-												RUN #3 TCR=97% SCR=75% RQD=0%
			4	RUN	-												RUN #4 TCR=84% SCR=76% RQD=48%
			5	RUN	-												RUN #5 TCR=100% SCR=100% RQD=100%
			6	RUN	-												RUN #6 TCR=82% SCR=82% RQD=72%
88.2																	
9.4	End of Borehole																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No GR22-03

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969796°, Long: -78.293898° Highway 401/ Ganaraska River, MTM z10: N 4 870 686.5 E 401 576.5 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.03.28 - 2022.03.28 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
95.5	Ground Surface		1	SS	100/75mm							
0.0 0.1	TOPSOIL (75mm) (frozen)		2	SS	100/0mm							
	SILTY SAND with organics frequent cobbles and boulders very dense FILL											
94.0												
1.5	ORGANIC SILT with sand Frequent Cobbles and Boulders to 2.1m Very stiff to firm Dark grey		3	SS	19							
			4	SS	5							0 16 62 22
			5	SS	6							Organic Content = 1.0%
			6	SS	10							
			7	SS	25							
90.4												
5.1	SILTY SAND (SM) with gravel Frequent Cobbles and Boulders Dense Grey GLACIAL TILL		1	NQ	-							15 40 33 12
			2	NQ	-							
			3	NQ	-							
89.0												
6.5	LIMESTONE BEDROCK Moderately to slightly weathered Grey Fine grained Thinly to medium bedded Strong to very strong		4	RUN	-							RUN #4 TCR=95% SCR=62% RQD=47%
			5	RUN	-							RUN #5 TCR=59% SCR=35% RQD=22%
			6	RUN	-							RUN #6 TCR=100% SCR=85% RQD=37%
			7	RUN	-							RUN #7 TCR=97% SCR=90% RQD=18%
			8	RUN	-							RUN #8 TCR=87% SCR=75% RQD=0%
			9	RUN	-							RUN #9 TCR=100% SCR=100% RQD=63%
85.7												
9.8	End of Borehole											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity
20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GR22-03

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969796°, Long: -78.293898° Highway 401/ Ganaraska River, MTM z10: N 4 870 686.5 E 401 576.5 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.03.28 - 2022.03.28 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					
	Monitoring well installed consists of 38-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen.																
	Water level readings:																
	DATE DEPTH (m) ELEV. (m)																
	2022.03.30 2.0 93.5																
	2022.03.31 1.9 93.6																
	2022.08.23 1.8 93.7																
	2022.08.24 1.9 93.7																
	Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																

RECORD OF BOREHOLE No GR22-04

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969844°, Long: -78.293631° Highway 401/ Ganaraska River, MTM z10: N 4 870 692.2 E 401 597.9 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.03.17 - 2022.03.18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100				
								20 40 60 80 100				
95.2	Ground Surface											
0.0	TOPSOIL (150 mm)											
0.2	CLAYEY SILT with sand Trace Organics Very stiff to stiff Dark brown-grey FILL		1	SS	10		95					
			2	SS	7		94					
93.7												
1.5	ORGANIC SILT Loose to dense Dark brown		3	SS	6		93					
			4	SS	9		92					
			5	SS	6		91					
90.6			6	SS	34		90					
4.6	SILTY SAND with Gravel Frequent Cobbles and Boulders Compact to very dense GLACIAL TILL		7	SS	16		89					
			8	SS	14		88					
			9	SS	100/ 25mm		87					
87.8			10	SS	100/ 0mm		86					
7.4	LIMESTONE BEDROCK Moderately weathered to fresh Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-							
			2	RUN	-							
			3	RUN	-							
			4	RUN	-							
			5	RUN	-							

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RUN #1
TCR=75%
SCR=58%
RQD=0%
RUN #2
TCR=92%
SCR=92%
RQD=60%
RUN #3
TCR=86%
SCR=73%
RQD=52%
RUN #4
TCR=100%
SCR=100%
RQD=50%
RUN #5
TCR=100%
SCR=92%

RECORD OF BOREHOLE No GR22-04

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969844°, Long: -78.293631°
Highway 401/ Ganaraska River, MTM z10: N 4 870 692.2 E 401 597.9 ORIGINATED BY JZL
HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.03.17 - 2022.03.18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
Continued From Previous Page																				
	LIMESTONE BEDROCK		6	RUN	-		85									1	RQD=86% RUN #6 TCR=100% SCR=100%			
84.7																				
10.5	End of Borehole															0	RQD=100%			
<p>Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.</p>																				

RECORD OF BOREHOLE No GR22-05

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969564°, Long: -78.294415° Highway 401/ Ganaraska River, MTM z10: N 4 870 660.2 E 401 535.4 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing COMPILED BY AO
 DATUM Geodetic DATE 2022.04.11 - 2022.04.11 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
98.1	Ground Surface													
0.0	SILTY SAND with Gravel Occasional Cobbles Loose to compact Brown FILL		1	SS	5		98							
			2	SS	13		97							
			3	SS	33		96							
			4	SS	100/ 280mm									
95.1														
3.0	SAND (SW-SM) with silt, some Gravel Dense to loose Grey		5	SS	100/ 150mm		95							
			6	SS	38		94							14 74 12 (SI+CL)
			7	SS	10		93							
			8	SS	10		92							
			9	SS	6									
91.3														
6.8	ORGANIC SILT, frequent Cobbles Very dense Dark grey		10	SS	100/ 255mm		91							3 46 35 16
90.8														
7.3	PROBABLE LIMESTONE BEDROCK		1	NQ	-									
90.3														
7.8	End of Borehole Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.													

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GR22-06

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969611°, Long: -78.29386°
Highway 401/ Ganaraska River, MTM z10: N 4 870 666.1 E 401 579.9 ORIGINATED BY JZL
HWY 401 BOREHOLE TYPE Portable / NW Casing COMPILED BY AO
DATUM Geodetic DATE 2022.03.31 - 2022.03.31 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
97.2	Ground Surface							20 40 60 80 100						
0.0	SANDY CLAYEY SILT Occasional rock fragments Compact to loose Brown FILL		1	SS	18		97							2 35 63 (SI+CL)
			2	SS	8		96							
95.7														
1.5	SAND with silt Loose Brown FILL		3	SS	9		95							0 93 7 (SI+CL)
			4	SS	8									
94.2														
3.0	SAND with gravel, probable voids Occasional wood pieces Very loose Grey FILL		5	SS	1		94							
			6	SS	WH		93							
92.6														
4.6	SILTY SAND (SM) trace gravel Compact to very dense Brown to grey GLACIAL TILL		7	SS	24		92							
			8	SS	30									9 67 24 (SI+CL)
			9	SS	100/		91							
	-Frequent Cobbles and Boulders below 6.2m				150mm									
90.1														
7.1	PROBABLE LIMESTONE BEDROCK		1	NQ	-		90							
89.5														
7.7	End of Borehole													
	Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.													

DOUBLE LINE 33089 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-2

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GR22-07

1 OF 2

METRIC


GWP# 4068-14-00 LOCATION Lat: 43.969391°, Long: -78.2943901°
Highway 401/ Ganaraska River, MTM z10: N 4 870 641.0 E 401 537.7 ORIGINATED BY JZL
HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
DATUM Geodetic DATE 2022.04.06 - 2022.04.06 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
97.9	Ground Surface							20	40	60	80	100						
0.0	CLAYEY SILT, sandy Occasional Rock fragments Compact to dense Brown FILL		1	SS	18		97											3 45 27 25
			2	SS	18		96											
			3	SS	100/ 200mm													
95.6																		
2.3	SAND (SW-SM) with silt, some gravel Very dense to compact Grey-brown		4	SS	100/ 280mm		95											
			5	SS	100/ 280mm		94											
			6	SS	19		93											11 80 9 (SI+CL)
			7	SS	18		92											
92.7							91											
5.2	SILTY SAND (SM) some gravel Loose to compact Grey GLACIAL TILL		8	SS	9		90											
			9	SS	5		89											13 56 31 (SI+CL)
			10	SS	12													
90.5																		
7.4	LIMESTONE BEDROCK Slightly weathered to fresh Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-		90											RUN #1 TCR=94% SCR=94% RQD=33% RUN #2 TCR=96% SCR=96% RQD=36%
			2	RUN	-		89											RUN #3 TCR=100% SCR=95% RQD=52%
			3	RUN	-													RUN #4 TCR=100% SCR=91% RQD=0%
			4	RUN	-													RUN #5 TCR=100% SCR=100%
			5	RUN	-		88											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					W _P	W	W _L				
								SHEAR STRENGTH kPa					WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE											
								● QUICK TRIAXIAL × LAB VANE											
								20 40 60 80 100					20 40 60						
Continued From Previous Page																			
	LIMESTONE BEDROCK																0	GR SA SI CL	
87.2			6	RUN	-												>10	RUN #6 TCR=82% SCR=55% RQD=24%	
10.7	End of Borehole																0		
Monitoring well installed consists of 38-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen.																			
Water level readings:																			
DATE DEPTH (m) ELEV. (m)																			
2022.04.11 4.1 93.3																			
Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																			

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No GR22-08

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969442°, Long: -78.293825° Highway 401/ Ganaraska River, MTM z10: N 4 870 647.3 E 401 582.9 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.01 - 2022.04.01 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
96.7	Ground Surface							20	40	60	80	100							
0.0	SILTY SAND with Gravel Occasional Rock fragments Loose to dense Brown FILL		1	SS	100/ 0mm		96												
			2	SS	18														
			3	SS	37		95												
			4	SS	7		94												
93.7																			
3.0	SILTY SAND (SM) Dense to compact Brown-grey		5	SS	35		93												
			6	SS	11		92												
91.8																			
4.9	GRAVEL with Sand trace Silt Loose to very dense Grey GLACIAL TILL		7	SS	5		91												
			8	SS	100/ 25mm														
90.1																			
6.6	LIMESTONE BEDROCK Moderately weathered Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-		90												
			2	RUN	-														
			3	RUN	-														
			4	RUN	-		89												
			5	RUN	-														
			6	RUN	-		88												
			7	RUN	-														
							87												

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GR22-08

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969442°, Long: -78.293825° Highway 401/ Ganaraska River, MTM z10: N 4 870 647.3 E 401 582.9 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.01 - 2022.04.01 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
	Continued From Previous Page																
	LIMESTONE BEDROCK		8	RUN	-											GR SA SI CL	
86.2																RQD=21% RUN #8 TCR=89% SCR=52%	
10.5	End of Borehole															RQD=0%	
	Unstabilized water level at 1.9 m depth upon completion of drilling.																
	Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 301

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969357°, Long: -78.29638°
Site 21-230, MTM Zone 10: N 4 870 634.9 E 401 378.1 ORIGINATED BY CM
HWY 401 BOREHOLE TYPE HSA COMPILED BY CM
DATUM Geodetic DATE 2016.05.31 - 2016.05.31 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W P W W L								
								○ UNCONFINED + FIELD VANE													
								● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)								
							20	40	60	80	100		20	40	60						
110.2																					
0.0																					
110.0		260 mm ASPHALT																			
0.3		SILTY SAND with gravel dense brown FILL																			
			1	SS	47																
			2	SS	39																
108.7																					
1.5		SILTY SAND, some gravel compact brown FILL																			
			3	SS	18																
108.0																					
2.3		SILTY SAND, clayey, trace gravel loose to dense brown FILL																			
			4	SS	9																
			5	SS	12																
			6	SS	32																
			7	SS	14																
104.9																					
5.3		SILTY SAND loose to compact brown FILL																			
			8	SS	13																
			9	SS	15																
			10	SS	11																
			11	SS	15																
			12	SS	9																
			13	SS	13																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 301

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969357°, Long: -78.29638° Site 21-230, MTM Zone 10: N 4 870 634.9 E 401 378.1 ORIGINATED BY CM
 HWY 401 BOREHOLE TYPE HSA COMPILED BY CM
 DATUM Geodetic DATE 2016.05.31 - 2016.05.31 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	Continued From Previous Page							20 40 60 80 100					W _p W W _L				
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
								20 40 60 80 100					20 40 60				
99.1	SILTY SAND loose to compact brown FILL		14	SS	12		100										
11.1	sandy SILT to SILTY SAND very loose to loose brown FILL						99										
97.6			15	SS	3		98										
12.6	CLAY (CL) firm grey						97										
			16	SS	5		96								0 1 50 49		
95.5																	
14.8	Sandy SILT (ML) loose grey		17	SS	6		95								6 27 52 15		
93.9							94										
16.3	SILTY SAND (SM) with gravel TILL very dense grey																
93.1	- slight hydrocarbon odour		18	SS	100/ 250mm												
17.2	End of Borehole on probable bedrock Groundwater level was measured in the open borehole at 14.2 m BGS (elev. 96.0 m) on 2016/05/31																

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

RECORD OF BOREHOLE No 302

1 OF 3

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969143°, Long: -78.296337° Site 21-230, MTM Zone 10: N 4 870 611.1 E 401 381.9 ORIGINATED BY CM
 HWY 401 BOREHOLE TYPE HSA / HQ Coring COMPILED BY CM
 DATUM Geodetic DATE 2016.06.01 - 2016.06.01 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
								20 40 60 80 100				w _P w w _L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
110.2																			
0.0																			
109.9							110												
0.3																			
	SILTY SAND with gravel dense brown FILL		1	SS	58													33 53 14 (SI+CL)	
109.3																			
0.9																			
	SILTY SAND, some gravel compact to dense brown FILL		2	SS	31		109												
			3	SS	18														
			4	SS	24		108												
			5	SS	31		107												
			6	SS	26		106												
			7	SS	31		105												
			8	SS	10		104												
			9	SS	22														
103.4																			
6.9																			
	SILTY SAND loose brown FILL		10	SS	6		103											2 72 26 (SI+CL)	
			11	SS	9		102												
			12	SS	8														
			13	SS	9		101											1 84 15 (SI+CL)	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



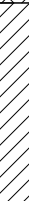
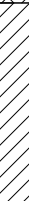
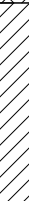



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 302

2 OF 3

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969143°, Long: -78.296337° Site 21-230, MTM Zone 10: N 4 870 611.1 E 401 381.9 ORIGINATED BY CM
 HWY 401 BOREHOLE TYPE HSA / HQ Coring COMPILED BY CM
 DATUM Geodetic DATE 2016.06.01 - 2016.06.01 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								20 40 60 80 100			W P W W L					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
Continued From Previous Page							100									
97.3	SILTY SAND loose brown FILL		14	SS	6											
13.0	SILTY SAND to sandy SILT very loose brown FILL		15	SS	5											
95.4	CLAY (CL) firm grey		16	SS	WH		97									
14.8	CLAY (CL) firm grey		17	SS	1		96									
94.1	CLAY (CL) firm grey		18	SS	6		95									
16.2	SILTY SAND (SM) with gravel TILL compact to very dense grey slight hydrocarbon odour		19	SS	19		94									
91.8	BEDROCK limestone faintly weathered to fresh fair quality moderately bedded grey		20	SS	100/		93									
18.5	BEDROCK limestone faintly weathered to fresh fair quality moderately bedded grey				75mm		92									
			1	RUN			91									
					</											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

RECORD OF BOREHOLE No 302

3 OF 3

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969143°, Long: -78.296337°
Site 21-230, MTM Zone 10: N 4 870 611.1 E 401 381.9 ORIGINATED BY CM
HWY 401 BOREHOLE TYPE HSA / HQ Coring COMPILED BY CM
DATUM Geodetic DATE 2016.06.01 - 2016.06.01 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20 40 60 80 100										
Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						

METRIC

Lat: 43.969457°, Long: -78.295319°
Site 21-230, MTM Zone 10: N 4 870 647.2 E 401 463.0

DOUBLE LINE 22645 CHOATERD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

+³, ×³: Numbers refer to Sensitivity

METRIC

SOIL PROFILE			SAMPLES			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>UNIT WEIGHT</div> <div>REMARKS & GRAIN SIZE DISTRIBUTION (%)</div>						
97.5	CLAY with sand stiff to very stiff brown FILL					
10.2	SILTY SAND with gravel compact to dense grey FILL		14	SS	11	
95.2						
12.5	Sandy SILT (ML), some gravel, trace organics loose to compact brown - strong hydrocarbon odour		15	SS	45	
92.9						
14.8	SILTY SAND (SM) with gravel TILL very dense grey					
92.4	BEDROCK limestone moderately weathered poor quality - advanced into bedrock by augering from 15.3 m to 16.1 m grey		17	SS	100/25mm	
15.3						
90.8			1	RUN		
16.9	BEDROCK limestone fresh fair to good quality moderately bedded grey		2	RUN		
			3	RUN		
87.7						

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 303

3 OF 3

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969457°, Long: -78.295319°
 Site 21-230, MTM Zone 10: N 4 870 647.2 E 401 463.0 ORIGINATED BY CM
 HWY 401 BOREHOLE TYPE HSA / HQ Coring COMPILED BY CM
 DATUM Geodetic DATE 2016.05.30 - 2016.05.30 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
20.0	End of Borehole Standpipe Readings: Date Depth (m) Elev. (m) 05/31/2016 10.9 96.8													

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

RECORD OF BOREHOLE No 304

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969254°, Long: -78.295205° Site 21-230, MTM Zone 10: N 4 870 624.8 E 401 472.5 ORIGINATED BY CM
 HWY 401 BOREHOLE TYPE HSA COMPILED BY CM
 DATUM Geodetic DATE 2016.06.01 - 2016.06.01 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
107.6								20	40	60	80	100								
0.0	180 mm ASPHALT																			
0.2	SILTY SAND with gravel very dense brown FILL		1	SS	52		107												27 59 14 (SI+CL)	
106.7																				
0.9	SILTY SAND compact brown FILL		2	SS	28		106													
			3	SS	16															
			4	SS	24		105													
	- with gravel																			
104.6																				
3.0	Sandy SILT loose to compact brown FILL		5	SS	7		104												9 39 38 14	
			6	SS	11															
			7	SS	7		103													
102.3																				
5.3	Silty CLAY with gravel firm brown FILL		8	SS	2		102													
101.7																				
5.9	Sandy SILT loose brown FILL		9	SS	5		101													
100.8																				
6.9	CLAY some sand stiff brown FILL		10	SS	9		100												0 10 50 40	
			11	SS	14															
			12	SS	10		99													
			13	SS	15		98													
98.0																				
9.6	SILTY SAND compact																			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

RECORD OF BOREHOLE No 304

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969254°, Long: -78.295205° Site 21-230, MTM Zone 10: N 4 870 624.8 E 401 472.5 ORIGINATED BY CM
 HWY 401 BOREHOLE TYPE HSA COMPILED BY CM
 DATUM Geodetic DATE 2016.06.01 - 2016.06.01 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							w _p w w _L		
	Continued From Previous Page							20	40	60	80	100		20	40	60	
	SILTY SAND compact brown FILL						97										
			14	SS	18									○			
95.9							96										
11.7	SAND some gravel very dense grey													○			
			15	SS	63		95										
94.4							94							○			
13.3	Sandy SILT (ML) some gravel, trace organics loose brown																
			16	SS	9		93										
92.8																	
14.8	GRAVEL (GM), Silty with Sand TILL very dense brown													○			
92.2			17	SS	100/												49 34 17 (SI+CL)
15.4	End of Borehole Groundwater level was measured in the open borehole at 14.1 m BGS (elev. 93.5 m) on 2016/06/01				200mm												

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-01

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969523°, Long: -78.296074° Site 21-230, MTM Zone 10: N 4 870 653.6 E 401 402.3 ORIGINATED BY NW
 HWY 401 BOREHOLE TYPE Portable / NW casing / NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2019.02.23 - 2019.02.24 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P			NATURAL MOISTURE CONTENT W			LIQUID LIMIT W _L			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	SHEAR STRENGTH kPa					WATER CONTENT (%)					GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

METRIC

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

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 19-02

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969451°, Long: -78.295816° Site 21-230, MTM Zone 10: N 4 870 646.0 E 401 423.2 ORIGINATED BY AC
 HWY 401 BOREHOLE TYPE HSA / NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2019.02.21 - 2019.02.21 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)						
								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					<div><div>W P W W L</div><div>204060</div></div>						
97.5																GR	SA	SI	CL
0.0																			
0.1	ASPHALT (75 mm)		1	GS	-		97							○					
	SAND with silt and gravel compact dark brown to brown FILL		2	SS	27									○					31 59 10 (SI+CL)
96.0							96							○					
1.5	SILTY CLAY (CL-ML) with sand very stiff grey-brown		3	SS	7									○					1 15 62 22
94.9			4	SS	27		95							○					
2.6	SILTY SAND (SM) with gravel, occasional cobbles TILL very dense grey-brown to grey		5	SS	70									○					30 43 21 6 non-plastic
			6	SS	123		94							○					
														○					
92.8			7	SS	100/		93							○					
4.7	BEDROCK limestone with silt seams slightly weathered fine grained thinly bedded grey		1	RUN	-	125 mm													RUN #1 TCR=97% SCR=69% RQD=46%
							92												
			2	RUN	-														RUN #2 TCR=100% SCR=88% RQD=88%
							91												
							90												RUN #3 TCR=100% SCR=94% RQD=94%
			3	RUN	-														
89.0							89												
8.5	End of Borehole																		

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-03

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969487°, Long: -78.295719° Site 21-230, MTM Zone 10: N 4 870 650.0 E 401 430.9 ORIGINATED BY SOB
HWY 401 BOREHOLE TYPE HSA / NQ coring COMPILED BY AC
DATUM Geodetic DATE 2019.02.19 - 2019.02.19 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
97.9								20	40	60	80	100						
0.0																		
0.1	ASPHALT (75 mm)																	
	SILTY SAND with gravel very dense brown FILL		1	GS	-													25 60 15 (SI+CL)
			2	SS	100/ 75 mm													
96.4																		
1.5	SILTY SAND with gravel compact brown FILL		3	SS	15													27 43 30 (SI+CL)
95.6																		
2.3	SILTY SAND very loose grey FILL		4	SS	3													1 59 32 8 non-plastic
94.9																		
3.0	SILTY SAND (SM) with gravel TILL compact to very dense brown		5	SS	27													
			6	SS	62													20 55 25 (SI+CL)
93.2			7	SS	100/ 150 mm													
4.7	BEDROCK limestone fresh fine grained thinly bedded grey		1	RUN	-													RUN #1 TCR=100% SCR=100% RQD=92% UCS=106.4MPa
			2	RUN	-													RUN #2 TCR=100% SCR=93% RQD=85%
			3	RUN	-													RUN #3 TCR=100% SCR=92% RQD=79%
89.8																		
8.1	End of Borehole																	
Standpipe Readings:																		
Date Depth (m) Elev. (m)																		
02/21/2019 1.5 96.4																		
02/23/2019 1.6 96.3																		
02/24/2019 1.5 96.4																		
02/25/2019 1.5 96.4																		

DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

+³, ×³: Numbers refer to Sensitivity 20
15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-04

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969513°, Long: -78.295527° Site 21-230, MTM Zone 10: N 4 870 653.2 E 401 446.2 ORIGINATED BY NW
 HWY 401 BOREHOLE TYPE Portable / NW casing / NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2019.02.25 - 2019.02.26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								20 40 60 80 100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	W _P	W			W _L
101.6	0.0	SILT with sand some organics frozen brown FILL	1	SS	58												
101.0	0.6	SILTY CLAYEY SAND, trace gravel compact brown FILL	2	SS	18												8 43 33 16
100.1																	
	1.5	CLAY with sand very stiff brown FILL	3	SS	4												
			4	SS	11												
			5	SS	7												1 14 47 38
	97.8																
	3.8	SILTY SAND with gravel compact to dense grey FILL	6	SS	12												
			7	SS	32												
			8	SS	11												17 48 28 7 non-plastic
	95.5																
	6.1	SAND (SP-SM) with silt some gravel TILL compact to very dense grey	9	SS	100/ 275 mm												10 79 11 (SI+CL)
			10	SS	22												
			11	SS	62												
			12	SS	100/ 275 mm												
	92.9																
	8.7	BEDROCK limestone fresh fine grained thinly bedded grey	1	RUN	-												RUN #1 TCR=97% SCR=97% RQD=42%

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE


DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

RECORD OF BOREHOLE No 19-04

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969513°, Long: -78.295527° Site 21-230, MTM Zone 10: N 4 870 653.2 E 401 446.2 ORIGINATED BY NW
 HWY 401 BOREHOLE TYPE Portable / NW casing / NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2019.02.25 - 2019.02.26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
								20 40 60 80 100	W P W W L									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page							20	40	60	80	100	20	40	60			
89.6	BEDROCK limestone fresh fine grained thinly bedded grey						91										RUN #2 TCR=100% SCR=95% RQD=47%	
																3		
			2	RUN	-													2
																		3
			3	RUN	-		90										9	
12.0	End of Borehole																2	
	A half-weight (32 kg) drop hammer was used to advance the split-spoon sampler. The "N" values above have been corrected to estimate the "N" value that would have been obtained with a standard 64 kg hammer.																	

RECORD OF BOREHOLE No 19-05

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969651°, Long: -78.295241°
Site 21-230, MTM Zone 10: N 4 870 668.9 E 401 469.0 ORIGINATED BY NW
HWY 401 BOREHOLE TYPE Portable / NW casing / NQ coring COMPILED BY AC
DATUM Geodetic DATE 2019.02.21 - 2019.02.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20 40 60 80 100					W _P W W _L								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
100.0							20	40	60	80	100										
0.0		SILT with sand, some organics and root material loose brown FILL		1	SS	6												3 21 57 19 non-plastic			
99.2																					
0.8		CLAY with sand very stiff brown FILL		2	SS	11															
				3	SS	20												2 19 45 34			
97.7																					
2.3		SILTY SAND to Sandy SILT some gravel compact to loose brown FILL		4	SS	12															
				5	SS	6															
				6	SS	6												8 42 38 12			
95.4																					
4.6		SILTY SAND with gravel very dense grey FILL		7	SS	105															
94.8																					
5.2		SANDY CLAY (CL) some organics very stiff to stiff brown		8	SS	12												0 30 49 21			
93.3																					
6.7		GRAVEL with silt and sand, occasional cobbles TILL		9	SS	100/ 0 mm															
92.8		very dense grey																			
7.2		BEDROCK limestone slightly weathered to fresh fine grained thinly bedded grey		1	RUN	-												RUN #1 TCR=100% SCR=100% RQD=19%			
				2	RUN	-												RUN #2 TCR=100% SCR=100% RQD=72%			
				3	RUN	-												RUN #3 TCR=100% SCR=100% RQD=13%			
				4	RUN	-												RUN #4 TCR=100% SCR=100% RQD=11%			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 0
(%) STRAIN AT FAILURE


DOUBLE LINE 22645 CHOATE RD.GPJ 2012TEMPLATE(MTO).GDT 10/2/20

RECORD OF BOREHOLE No 19-05

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969651°, Long: -78.295241°
Site 21-230, MTM Zone 10: N 4 870 668.9 E 401 469.0 ORIGINATED BY NW
HWY 401 BOREHOLE TYPE Portable / NW casing / NQ coring COMPILED BY AC
DATUM Geodetic DATE 2019.02.21 - 2019.02.22 CHECKED BY CM






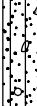


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
							20	40	60	80	100	W _p	W	W _L				
89.6	BEDROCK limestone															3		
10.4	slightly weathered to fresh fine grained thinly bedded grey End of Borehole A half-weight (32 kg) drop hammer was used to advance the split-spoon sampler. The "N" values above have been corrected to estimate the "N" value that would have been obtained with a standard 64 kg hammer.																	

RECORD OF BOREHOLE No CR22-01

1 OF 1

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969619°, Long: -78.296009° Highway 401/ Choate Road, MTM z10: N 4 870 664.4 E 401 407.4 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE D50 Track Mount/ NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.05.07 - 2022.05.07 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>			<div><div>204060</div><div>○</div></div>			kN/m ³	GR SA SI CL	
99.3	Ground Surface														
0.0	TOPSOIL (150 mm)														
0.2	SANDY SILT some Gravel Trace Clay and Organics Loose		1	SS	4		99								10 28 48 14
98.5	Dark brown														
0.8	FILL														
	CLAYEY SILT (CL) trace rootlets Very stiff Brown to light brown		2	SS	6		98								
			3	SS	5										
			4	SS	5		97								
95.9	-S _u > 106 kPa		5	SS	16		96								0 1 50 49
3.4	SILTY SAND with Gravel Occasional cobbles Dense to very dense Light brown														
	GLACIAL TILL		6	SS	43		95								17 52 25 6
	-Frequent Cobbles and Boulders below 4.7 m		7	SS	100/100mm										
			1	NQ	-		94								
93.1															
6.2	LIMESTONE BEDROCK Slightly weathered to Fresh Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-		93								
			2	RUN	-		92								
															
90.0															
9.3	End of Borehole														

DOUBLE LINE 33089 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-29

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CR22-02

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969631°, Long: -78.295467° Highway 401/ Choate Road, MTM z10: N 4 870 666.4 E 401 450.9 ORIGINATED BY JZL
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.18 - 2022.04.19 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT			NATURAL MOISTURE CONTENT			LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _P	W	W _L	WATER CONTENT (%)	GR	SA	SI	CL						
99.9	Ground Surface																									
0.0	TOPSOIL (150 mm)																									
0.2	SANDY CLAYEY SILT trace Gravel and Organics Occasional cobbles Loose to Very Dense Brownish grey FILL		1	SS	6																			3 41 34 22		
			2	SS	9																					
			3	SS	100/ 125mm																					
97.6																										
2.3	SILTY CLAYEY SAND with Gravel Compact to Dense Dark grey FILL		4	SS	28																			20 39 26 15		
			5	SS	37																					
			6	SS	45																					
			7	SS	23																					
94.7																										
5.2	SANDY SILT with Gravel Occasional Cobbles and Boulders Compact to Very Dense Grey GLACIAL TILL		8	SS	22																					
			9	SS	100/ 200mm																					
93.4																										
6.5	LIMESTONE BEDROCK Slightly weathered to Fresh Grey Fine grained Thinly to medium bedded Strong to very strong		1	RUN	-																			RUN #1 TCR=100% SCR=76% RQD=40%		
			2	RUN	-																			RUN #2 TCR=100% SCR=97% RQD=68%		
			3	RUN	-																			RUN #3 TCR=100% SCR=100% RQD=100%		
			4	RUN	-																			RUN #4 TCR=100% SCR=90% RQD=60%		
			5	RUN	-																			RUN #5 TCR=100% SCR=100% RQD=100%		
			6	RUN	-																			RUN #6 TCR=100% SCR=100% RQD=100%		
90.2																										
9.7	End of Borehole																									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-29

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CR22-03

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969417°, Long: -78.296052° Highway 401/ Choate Road, MTM z10: N 4 870 641.9 E 401 404.3 ORIGINATED BY JZL/AO
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.20 - 2022.04.26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W _p	W	W _L
104.0	Ground Surface																
0.0	TOPSOIL (150 mm)																
0.2	SILTY SAND trace Gravel, trace Clay Occasional Cobbles and Boulders Loose to dense Brown FILL		1	SS	9										0 70 30 (SI+CL)		
			2	SS	16												
			3	SS	38												
			4	SS	17										0 70 24 6		
			5	SS	24												
			6	SS	19												
			7	SS	42												
			8	SS	15										15 74 11 (SI+CL)		
			9	SS	24												
			10	SS	8												
			11	SS	12										1 77 9 13		
			12	SS	6												
94.9																	
9.1	SILTY SAND with Gravel Frequent Cobbles and Boulders Very Dense Grey GLACIAL TILL		13	SS	100/ 255mm												

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-29

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CR22-04

1 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969251°, Long: -78.296086° Highway 401/ Choate Road, MTM z10: N 4 870 623.4 E 401 401.9 ORIGINATED BY JZL/AO
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.28 - 2022.05.05 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL
104.0	Ground Surface																		
0.0	CONCRETE and BOULDERS FILL		1	NQ	-														
			2	NQ	-														
			3	NQ	-														
			4	NQ	-														
			5	NQ	-														
			6	NQ	-														
100.3	INFERRED COBBLES with Sand Infill FILL																		
3.7	Note: Portable NW Casing became blocked within Cobbles at 4.6 m. Unable to clear blockage to conduct splitspoon samples until 7.6 m		1	SS	100/0mm														
96.4																			
7.6	SAND (SP) some to trace Silt Compact to Very Loose Brown FILL		2	SS	18								○				1 92 7 (SI+CL)		
			3	SS	2								○				3 96 1 (SI+CL)		

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CR22-04

2 OF 2

METRIC

GWP# 4068-14-00 LOCATION Lat: 43.969251°, Long: -78.296086° Highway 401/ Choate Road, MTM z10: N 4 870 623.4 E 401 401.9 ORIGINATED BY JZL/AO
 HWY 401 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.04.28 - 2022.05.05 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					
93.8																	
10.2	SILTY SAND with Gravel Frequent Cobbles and Boulders Very Dense Grey GLACIAL TILL		4	SS	100/ 75mm		93									FI	
92.6			1	NQ	-											2	
11.4	LIMESTONE BEDROCK Fresh Grey Fine grained Thinly to medium bedded Strong to very strong		2	RUN	-		92									0	RUN #2 TCR=100% SCR=96% RQD=96%
			3	RUN	-											2	RUN #3 TCR=100% SCR=100% RQD=100%
			4	RUN	-		91									3	RUN #4 TCR=93% SCR=93% RQD=83%
			5	RUN	-											1	RUN #5 TCR=97% SCR=94% RQD=67%
			6	RUN	-											3	RUN #6 TCR=95% SCR=83% RQD=33%
			7	RUN	-		90									2	RUN #7 TCR=95% SCR=65% RQD=37%
89.6																6	
14.4	End of Borehole Monitoring well installed consists of 38-mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen. Water level readings: DATE DEPTH (m) ELEV. (m) 2022.05.09 6.3 97.7 2022.09.26 7.3 96.7 2022.09.30 7.3 96.7 Note: A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.																

DOUBLE LINE 33059 - HWY 401 CHOATE AND GANARASKA DD.GPJ 2012TEMPLATE(MTO).GDT 22-9-29

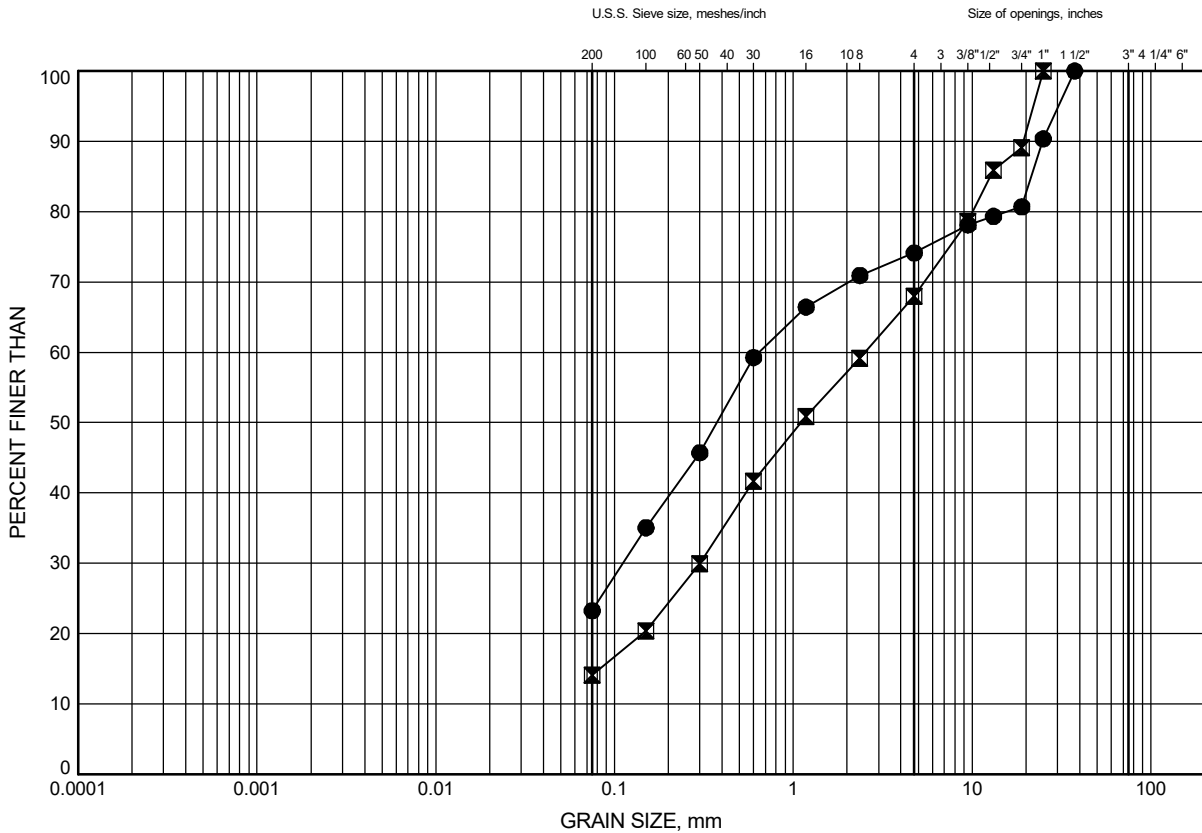


Appendix C Laboratory Testing

Particle Size Analysis Figures
Atterberg Limits Figures Unconfined
Consolidation Testing Results
Unconfined Compressive Strength Testing Results
Analytical Testing Results
Bedrock Core Photographs

GRAIN SIZE DISTRIBUTION

West of Choate - FILL: Upper Embankment



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-07	1.1	114.2
⊠	HF22-08	0.4	111.8

Date November 2022

GWP# 4068-14-00

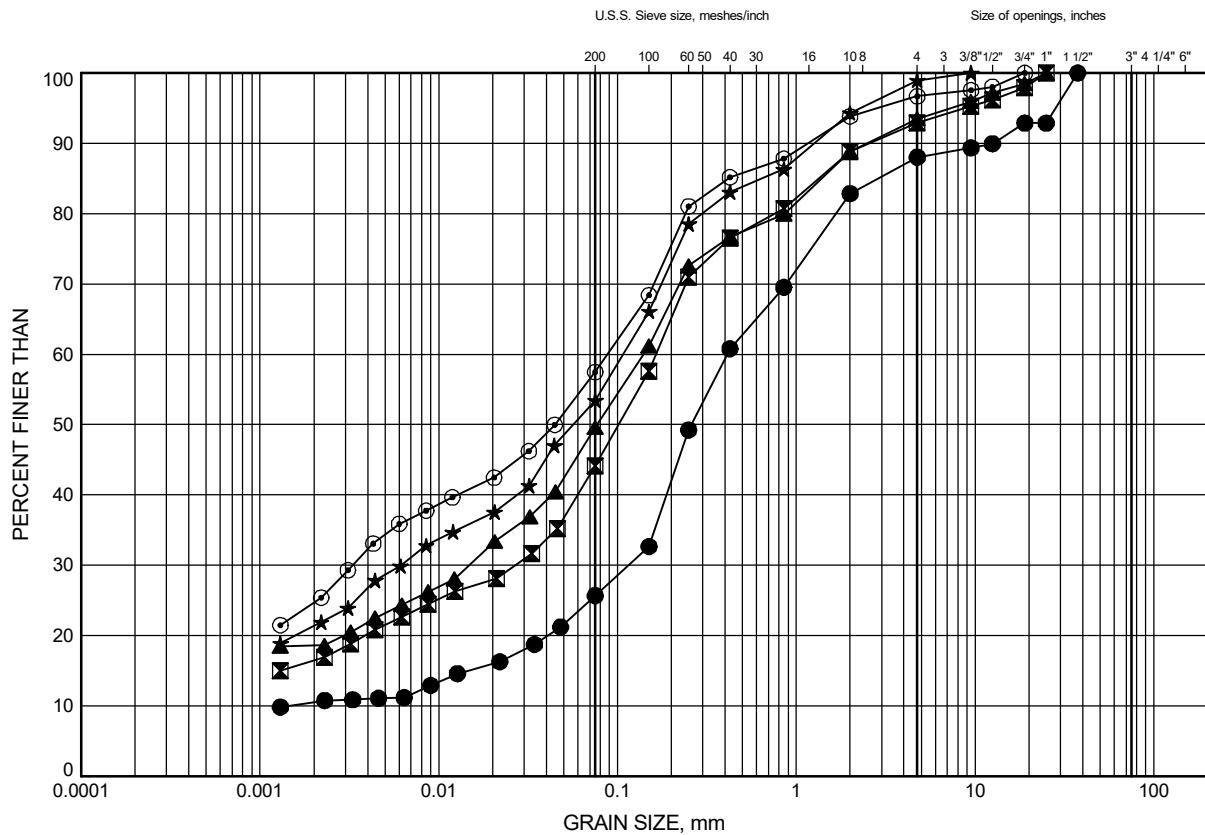


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - FILL: Lower Embankment



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-07	3.4	111.9
⊠	HF22-07	4.9	110.4
▲	HF22-07	6.4	108.9
★	HF22-08	3.4	108.8
⊙	HF22-08	7.9	104.3

Date November 2022

GWP# 4068-14-00

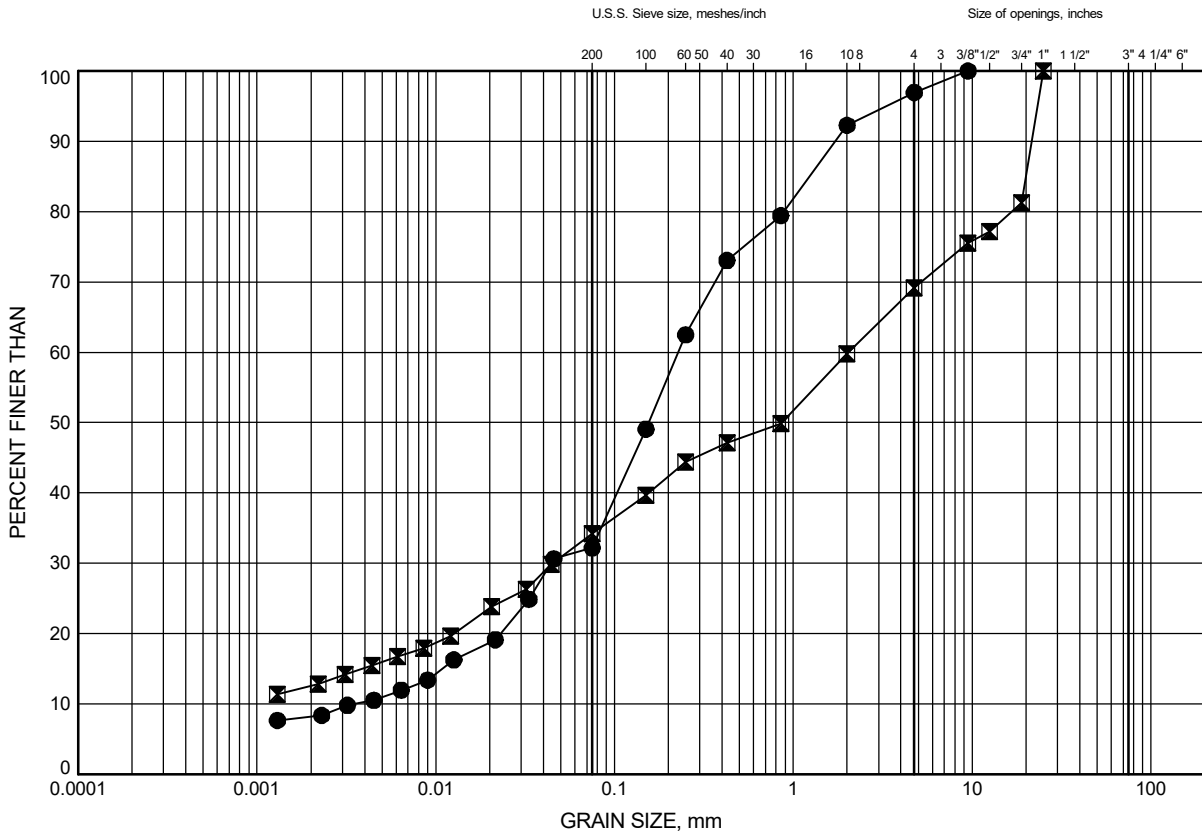


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - FILL: Silty Clayey Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-01	0.9	109.4
⊠	HF22-03	0.3	104.0

Date November 2022

GWP# 4068-14-00

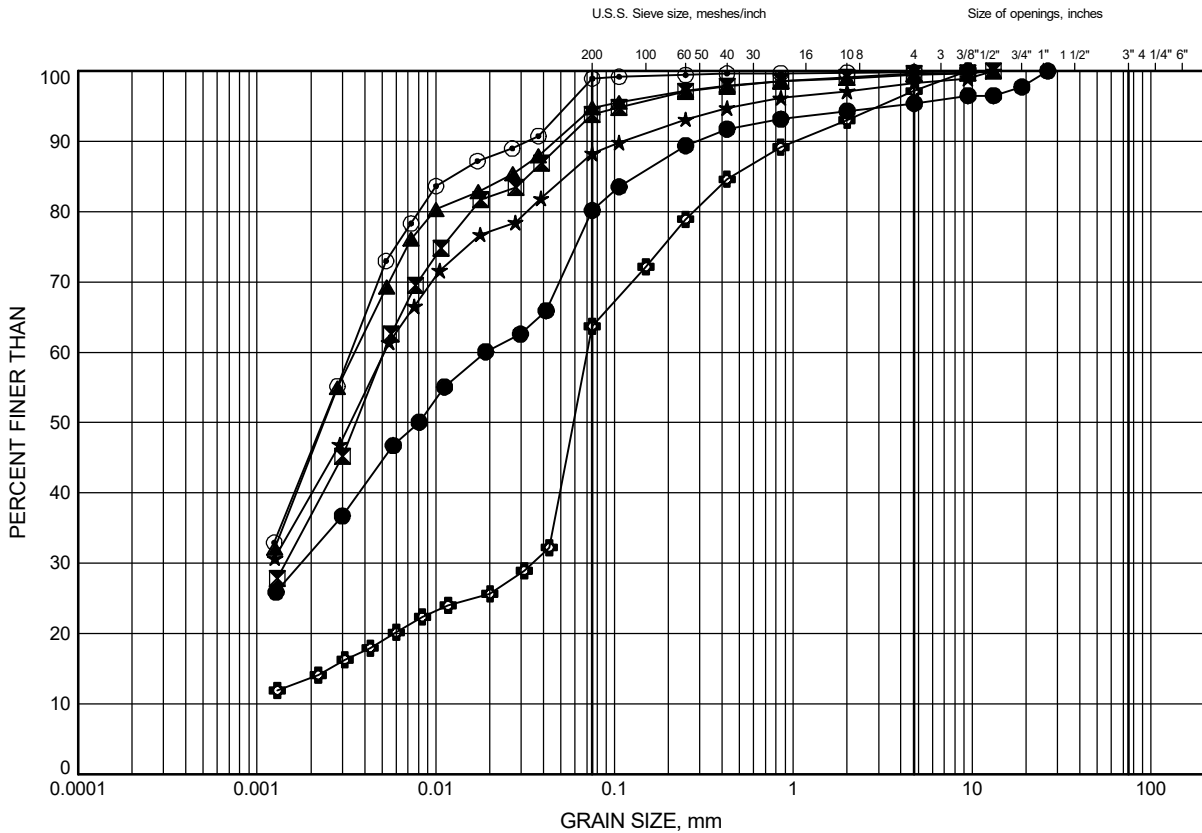


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - Clayey Silt to Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	1.8	102.0
⊠	20-01	3.4	100.4
▲	20-01	5.6	98.2
★	20-02	1.1	98.7
⊙	20-02	3.4	96.4
⊕	HF22-01	2.6	107.7

Date November 2022

GWP# 4068-14-00

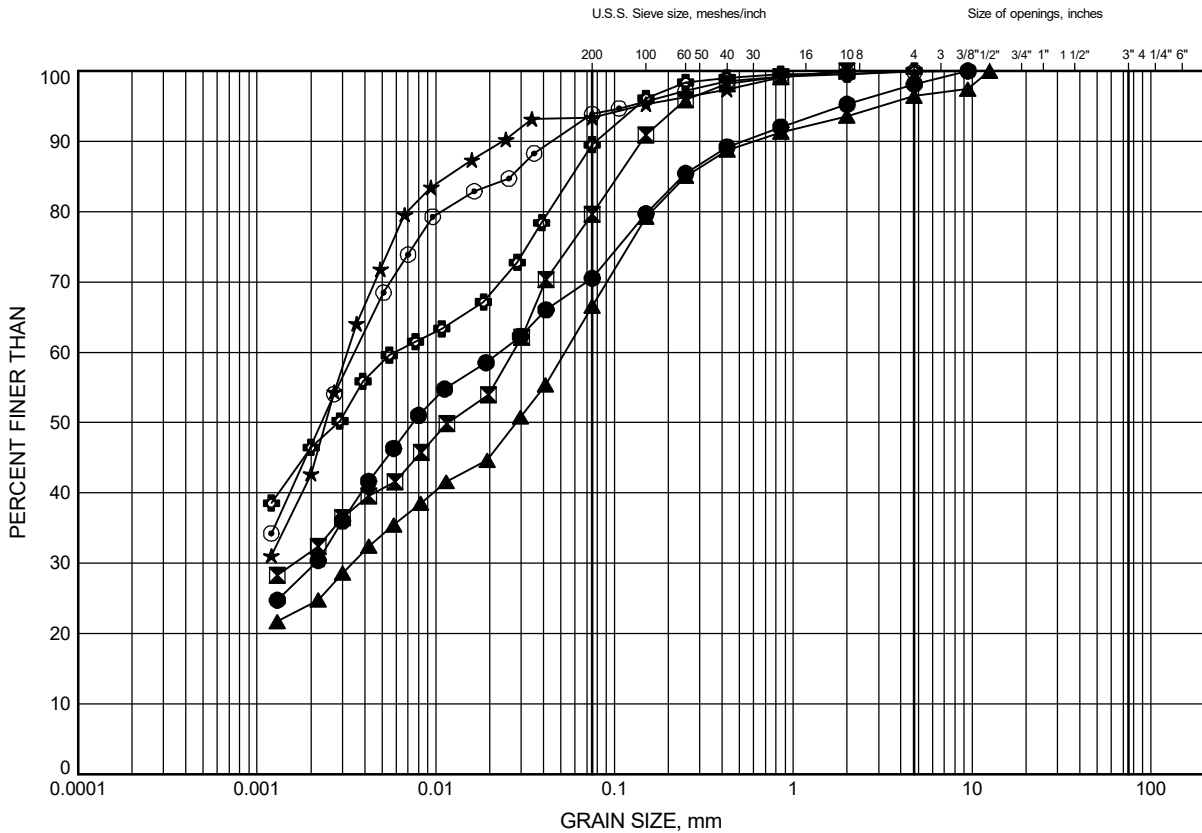


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - Clayey Silt to Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-01	3.4	106.9
⊠	HF22-02	0.8	106.6
▲	HF22-02	2.6	104.8
★	HF22-02	6.2	101.2
⊙	HF22-03	4.9	99.4
⊕	HF22-04	1.1	103.9

Date November 2022

GWP# 4068-14-00

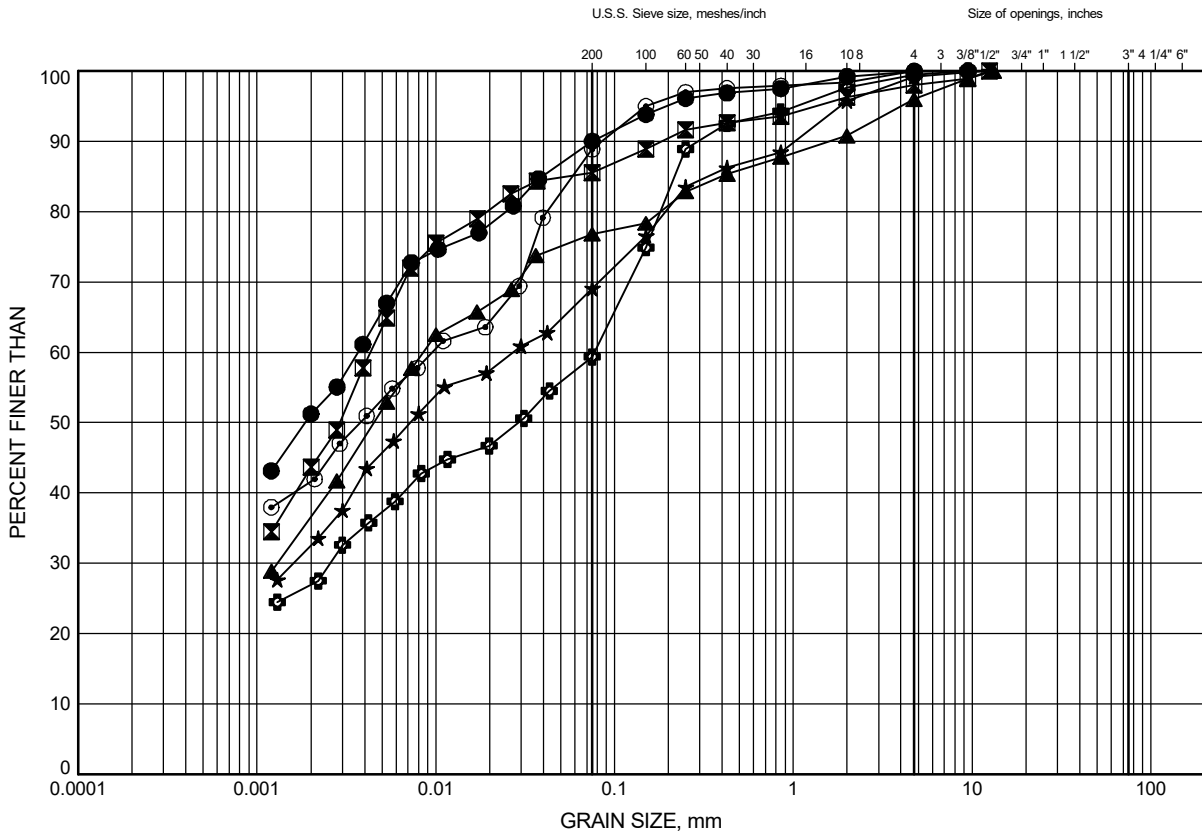


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - Clayey Silt to Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-04	4.9	100.1
⊠	HF22-04	6.4	98.6
▲	HF22-04	7.2	97.8
★	HF22-07	8.7	106.6
⊙	HF22-08	11.0	101.2
⊕	HF22-08	14.0	98.2

Date November 2022

GWP# 4068-14-00

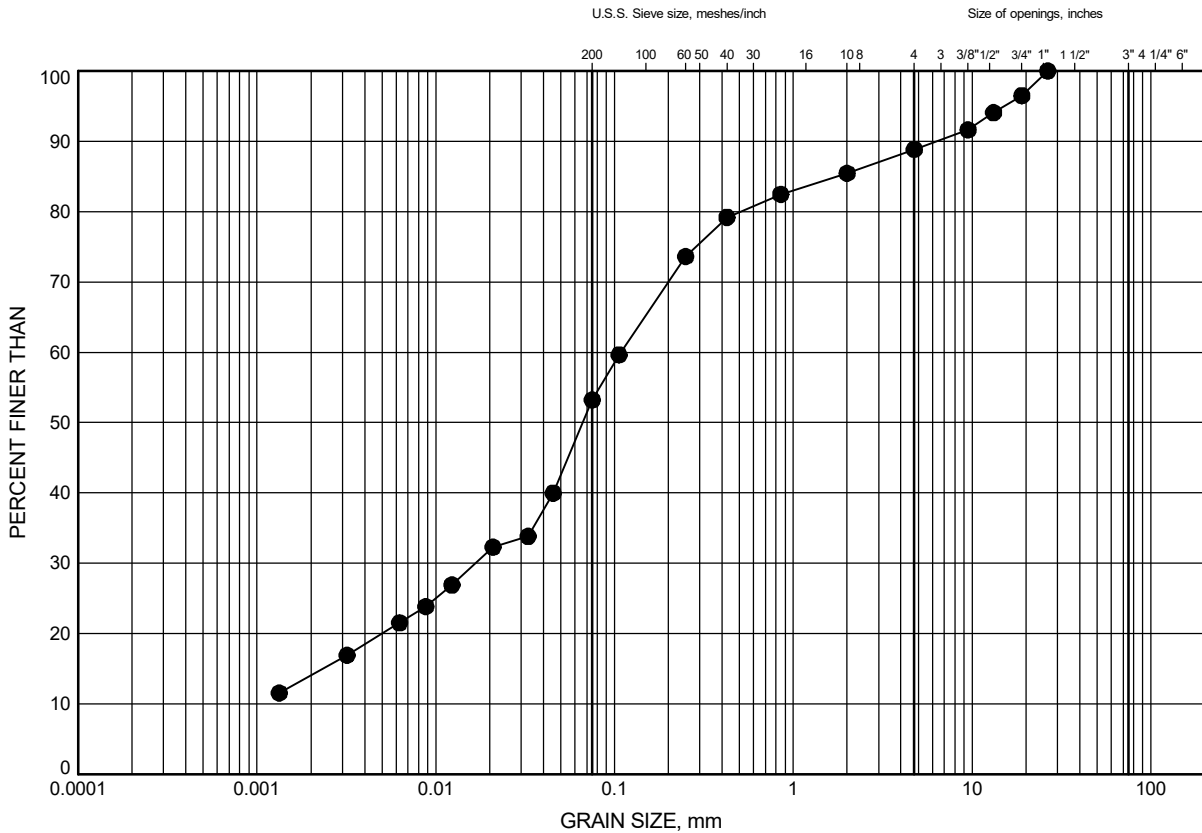


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - Sandy Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	7.2	96.6

Date November 2022

GWP# 4068-14-00

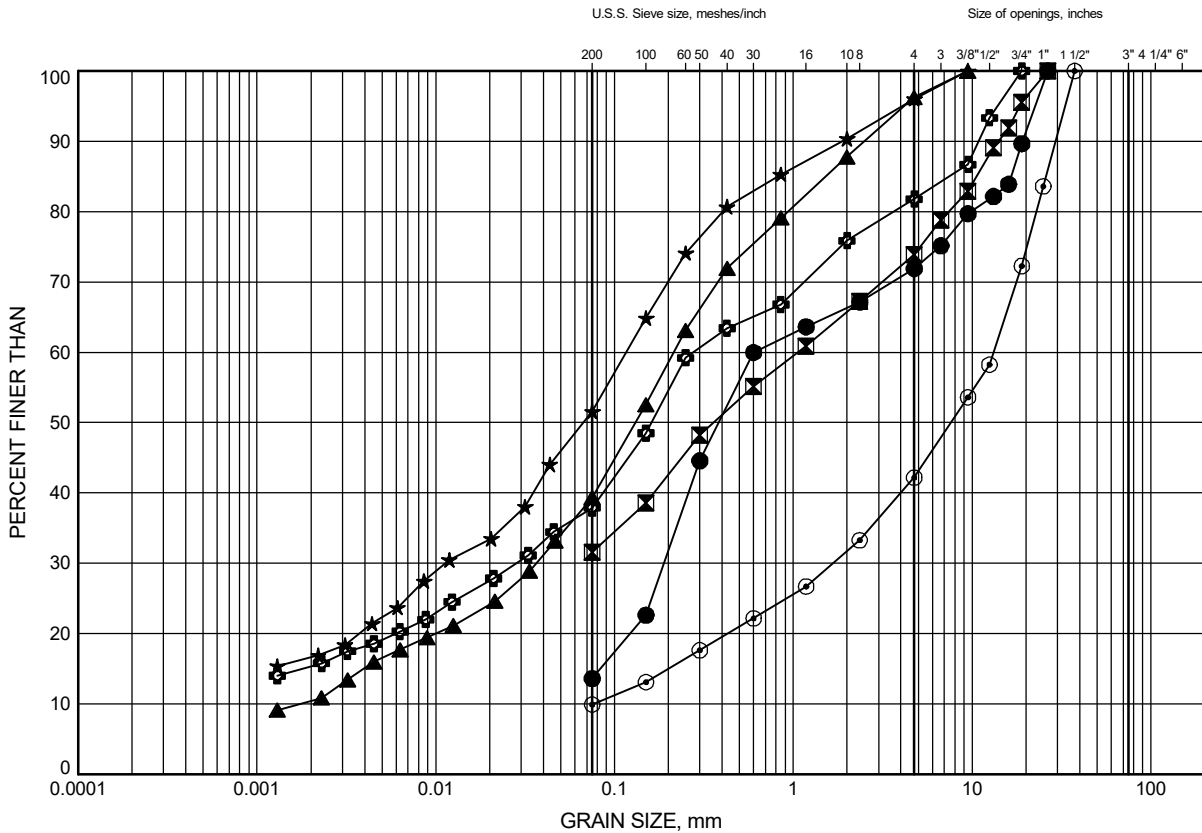


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

West of Choate - Glacial Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	7.9	95.9
⊠	20-02	6.4	93.4
▲	HF22-01	5.6	104.7
★	HF22-02	8.7	98.7
⊙	HF22-03	7.9	96.4
⊕	HF22-07	12.5	102.8

Date November 2022

GWP# 4068-14-00



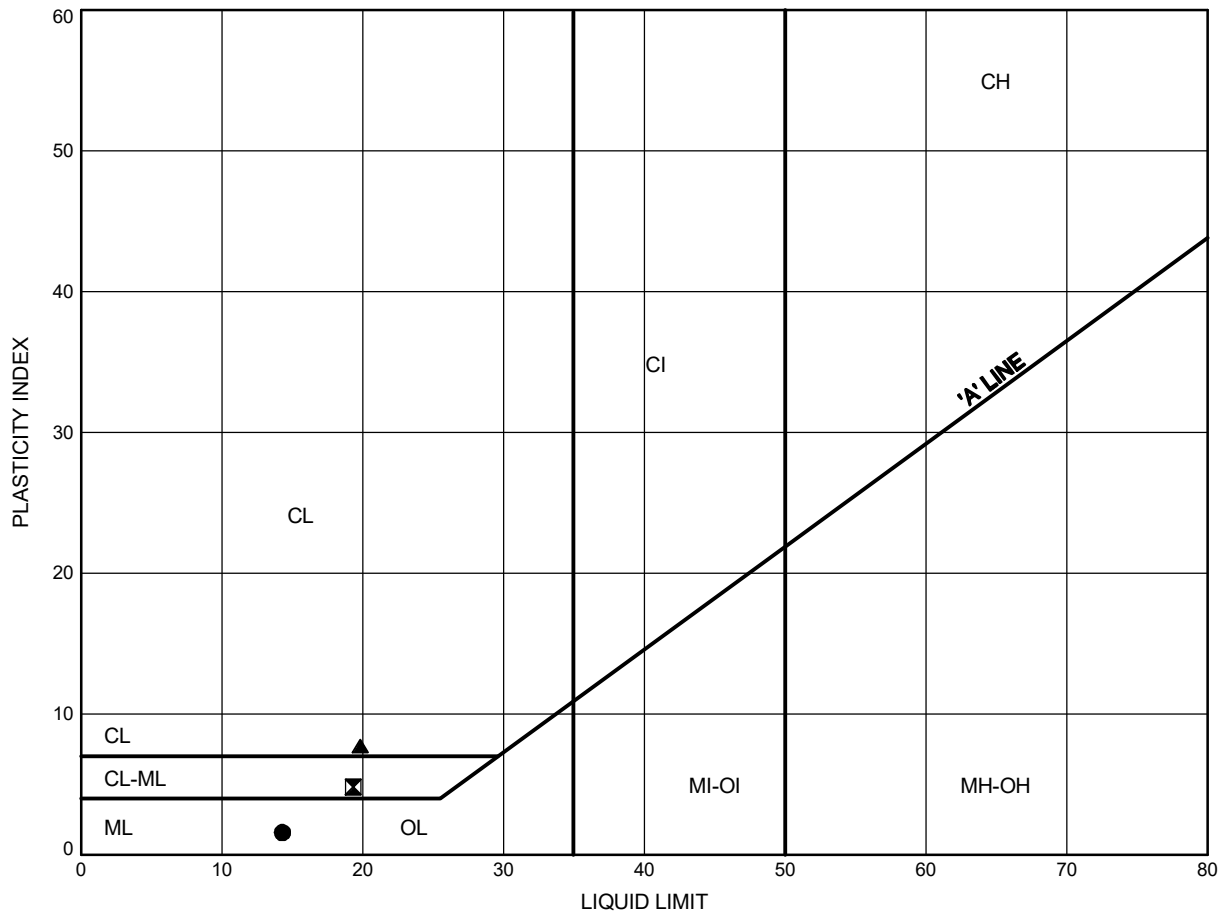
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C10

West of Choate - FILL: Lower Embankment



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-07	4.9	110.4
⊠	HF22-07	6.4	108.9
▲	HF22-08	7.9	104.3

Date November 2022

GWP# 4068-14-00



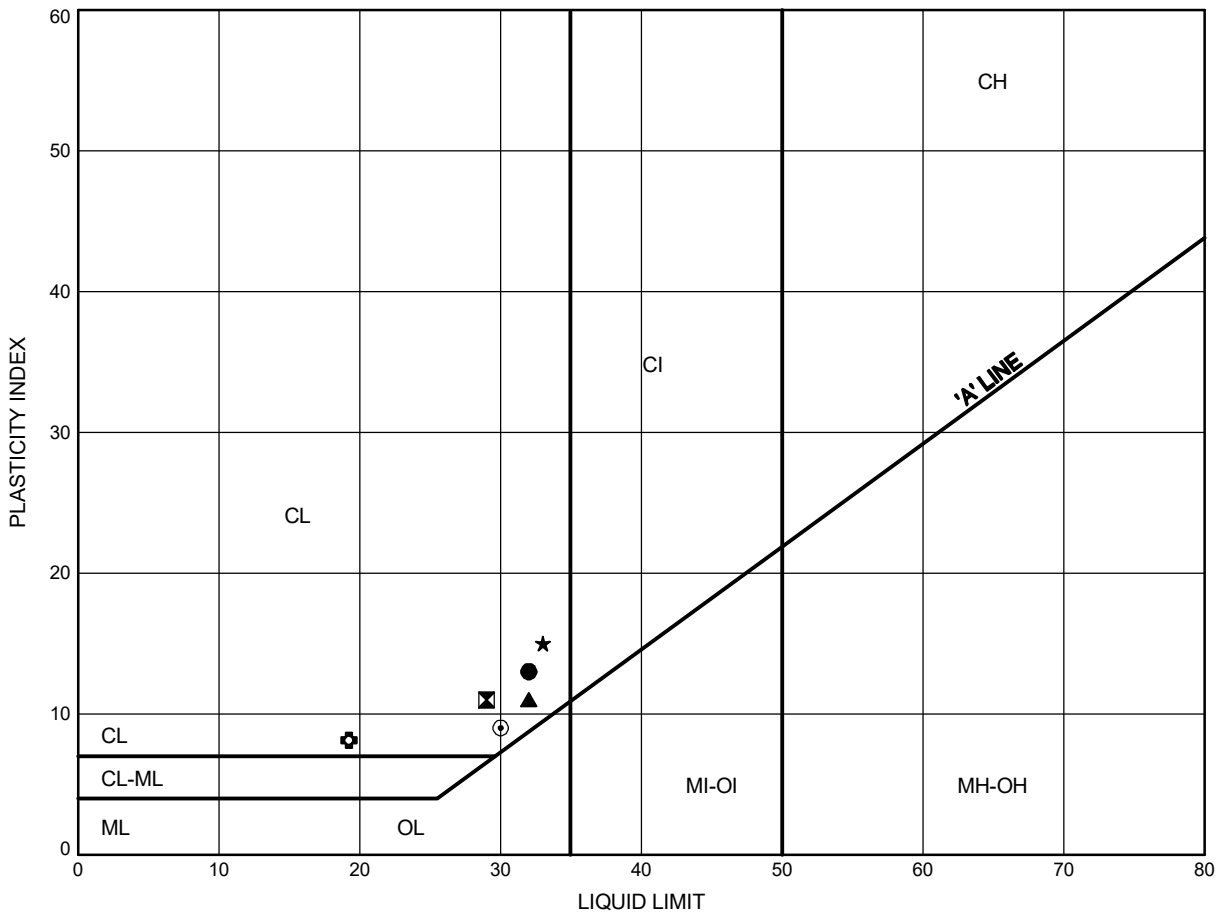
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design ATTERBERG LIMITS TEST RESULTS

FIGURE C11

West of Choate - Clayey Silt to Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	1.8	102.0
⊠	20-01	3.4	100.4
▲	20-01	5.6	98.2
★	20-02	1.1	98.7
⊙	20-02	3.4	96.4
⊕	HF22-02	0.8	106.6

Date November 2022

GWP# 4068-14-00



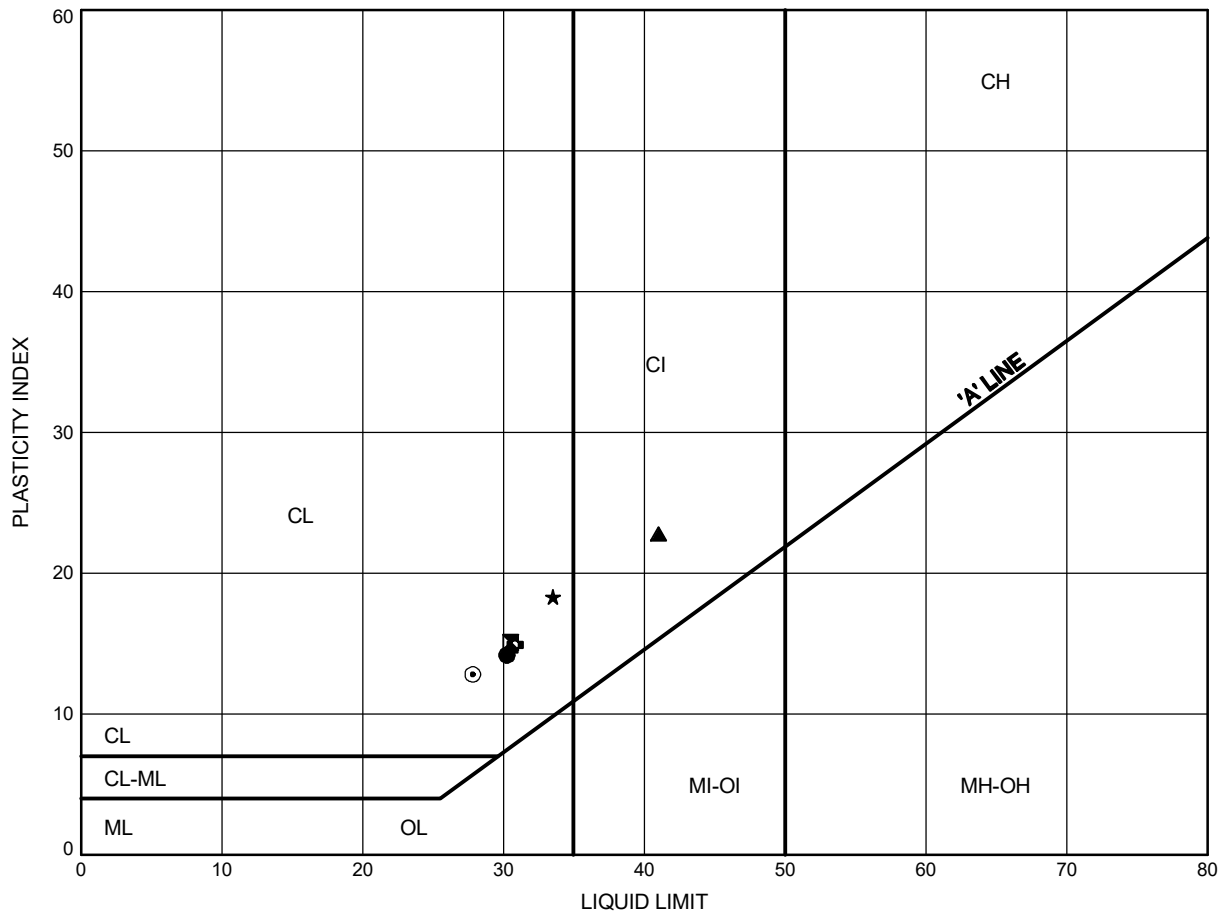
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design ATTERBERG LIMITS TEST RESULTS

FIGURE C12

West of Choate - Clayey Silt to Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-02	6.2	101.2
⊠	HF22-03	4.9	99.4
▲	HF22-04	1.1	103.9
★	HF22-04	4.9	100.1
⊙	HF22-04	6.4	98.6
⊕	HF22-04	7.2	97.8

Date November 2022

GWP# 4068-14-00



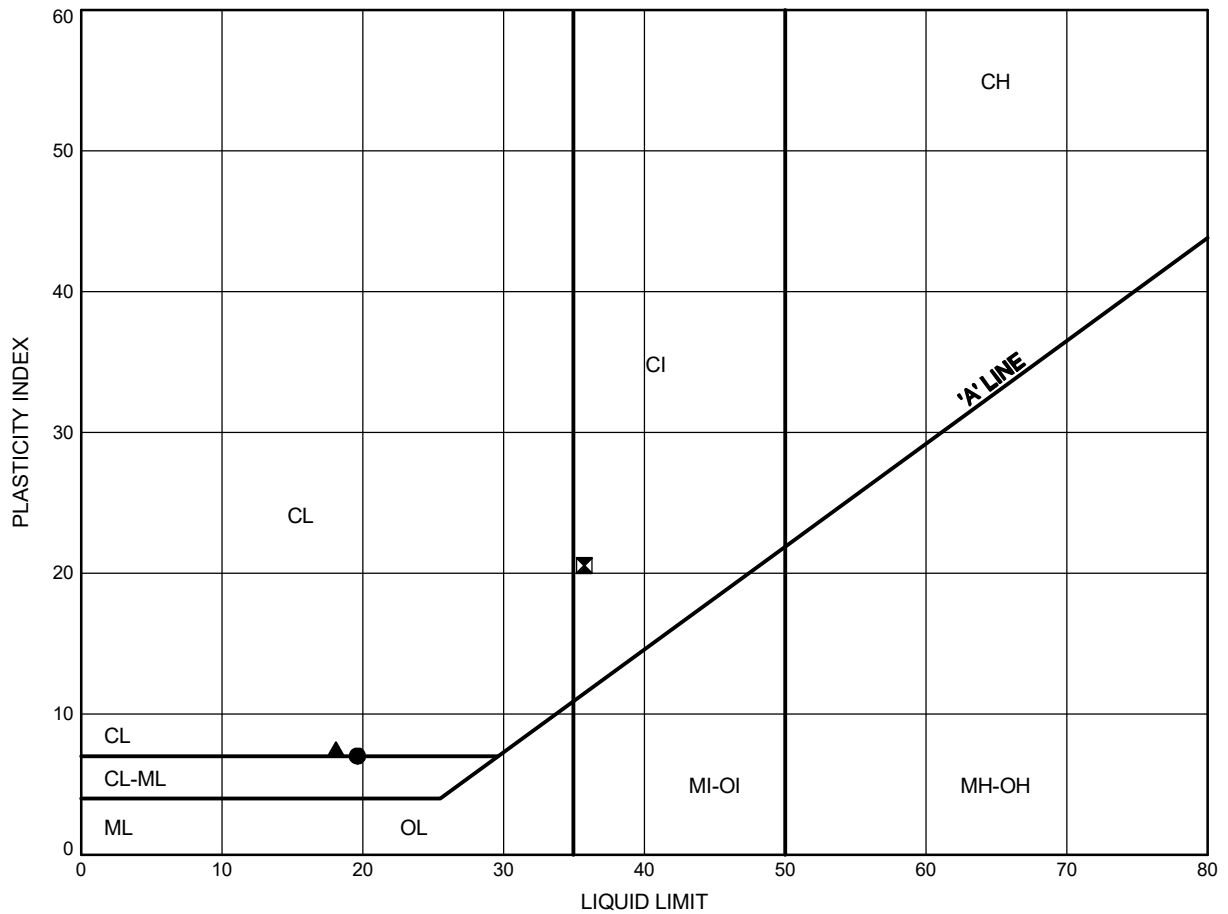
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C13

West of Choate - Clayey Silt to Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-07	8.7	106.6
⊠	HF22-08	11.0	101.2
▲	HF22-08	14.0	98.2

Date November 2022
 GWP# 4068-14-00

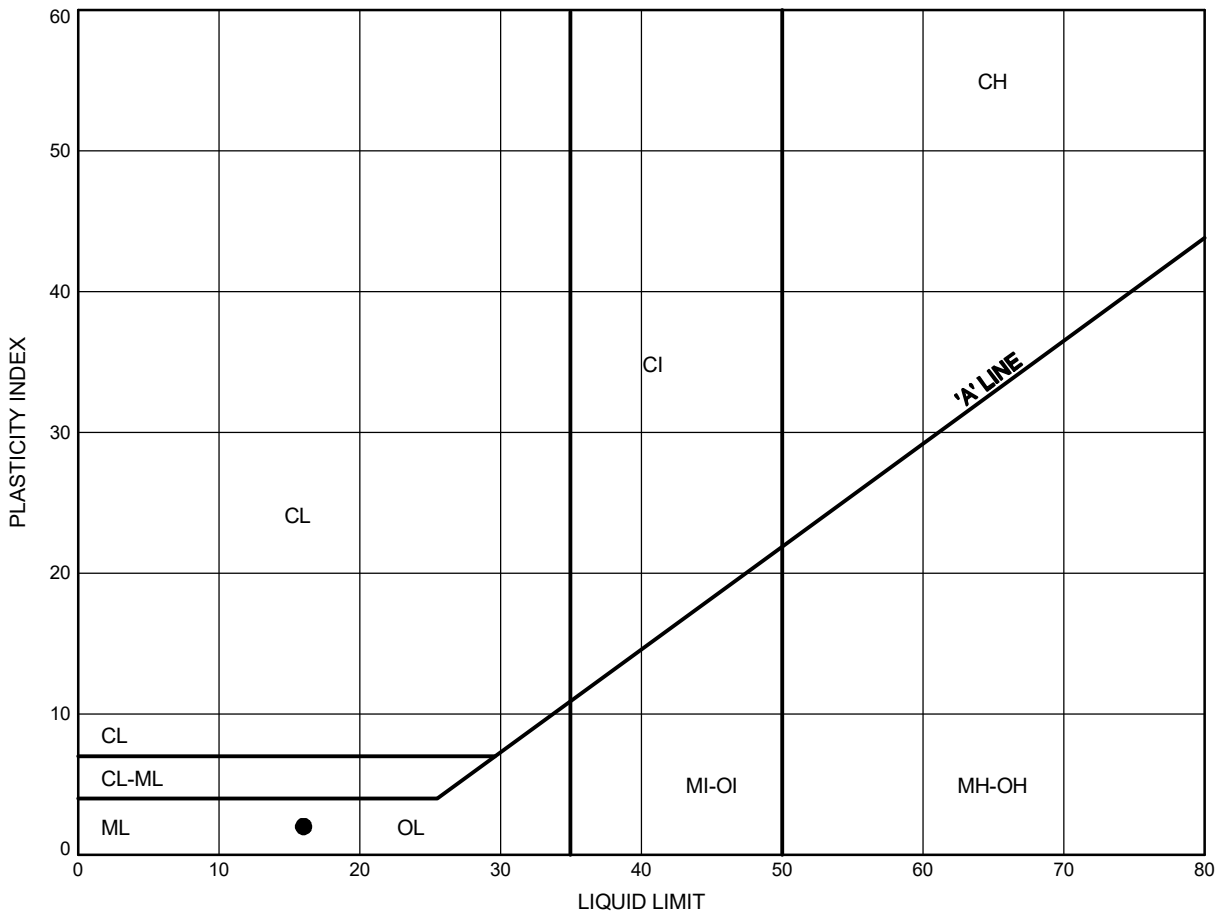


Prep'd RH
 Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C14

West of Choate - Sandy Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	7.2	96.6

Date November 2022
 GWP# 4068-14-00

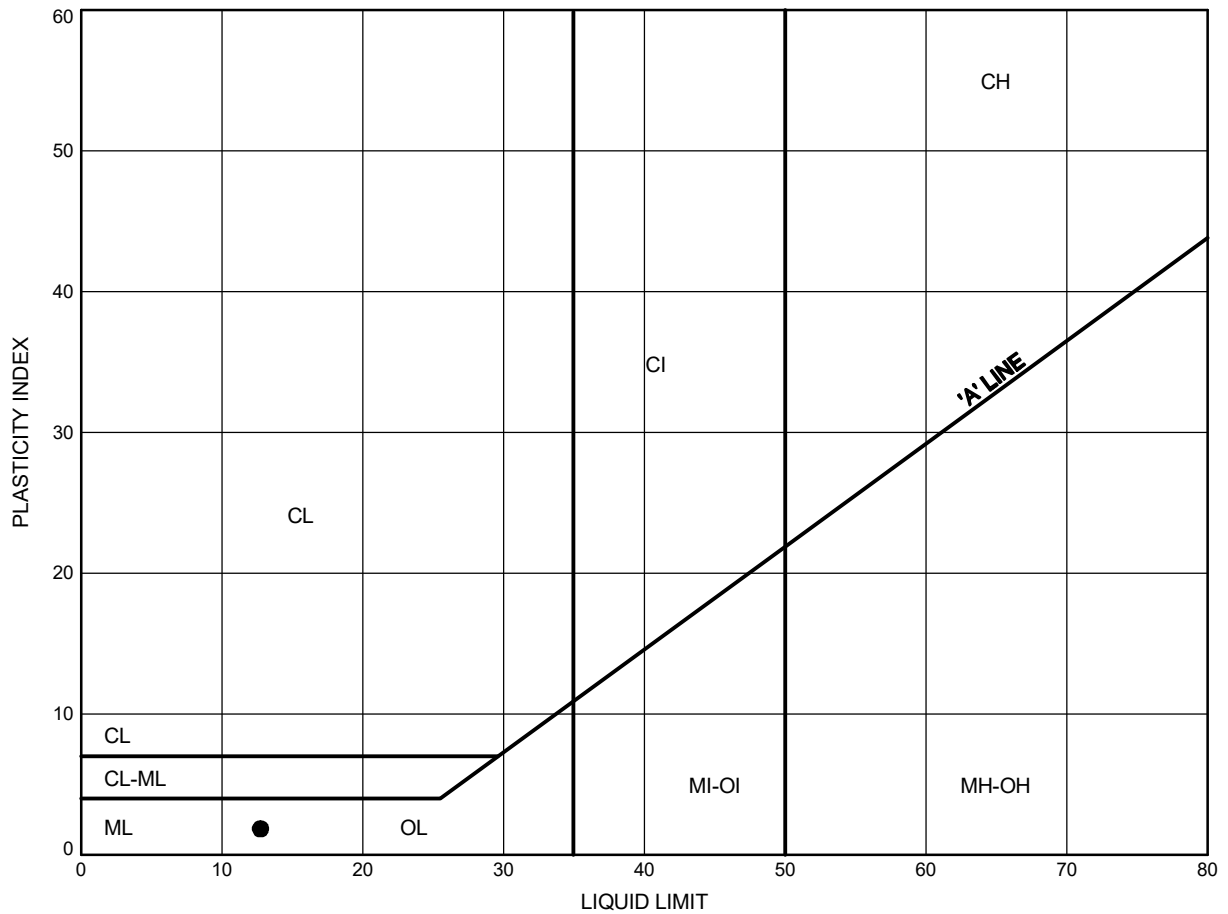


Prep'd RH
 Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C15

West of Choate - Glacial Till



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-07	12.5	102.8

Date November 2022

GWP# 4068-14-00

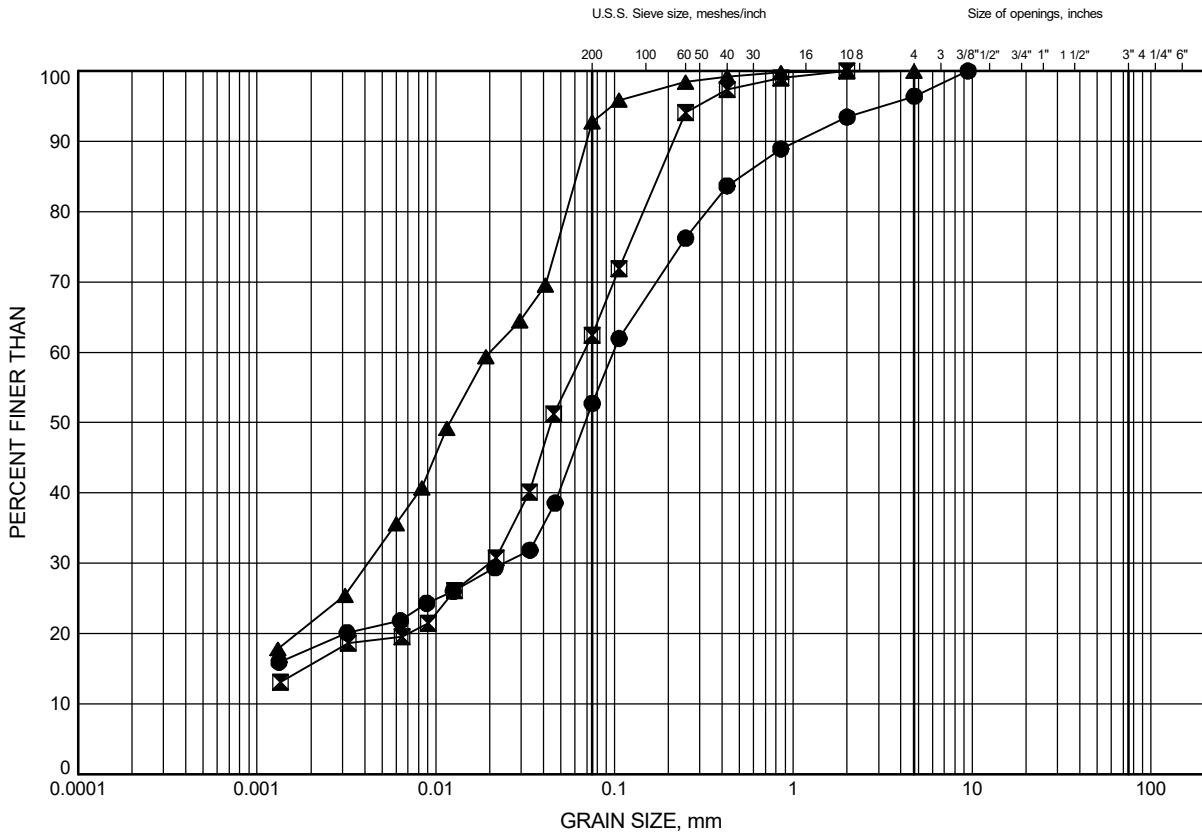


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

Choate to Ganaraska - Organic Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	1.1	95.9
⊠	20-04	0.3	95.7
▲	20-05	1.8	93.0

Date November 2022

GWP# 4068-14-00

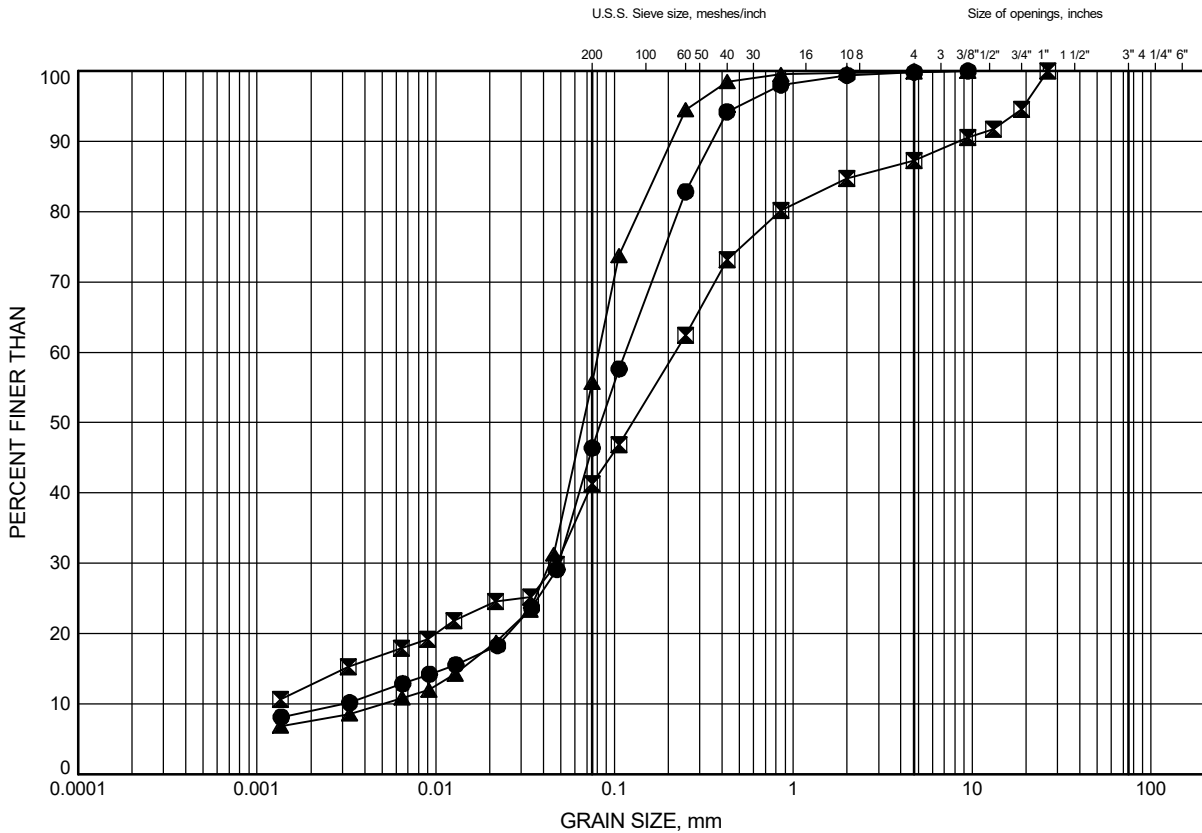


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

Choate to Ganaraska - Silty Sand to Sandy Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	2.6	94.4
⊠	20-04	1.8	94.2
▲	20-04	2.6	93.4

Date November 2022

GWP# 4068-14-00

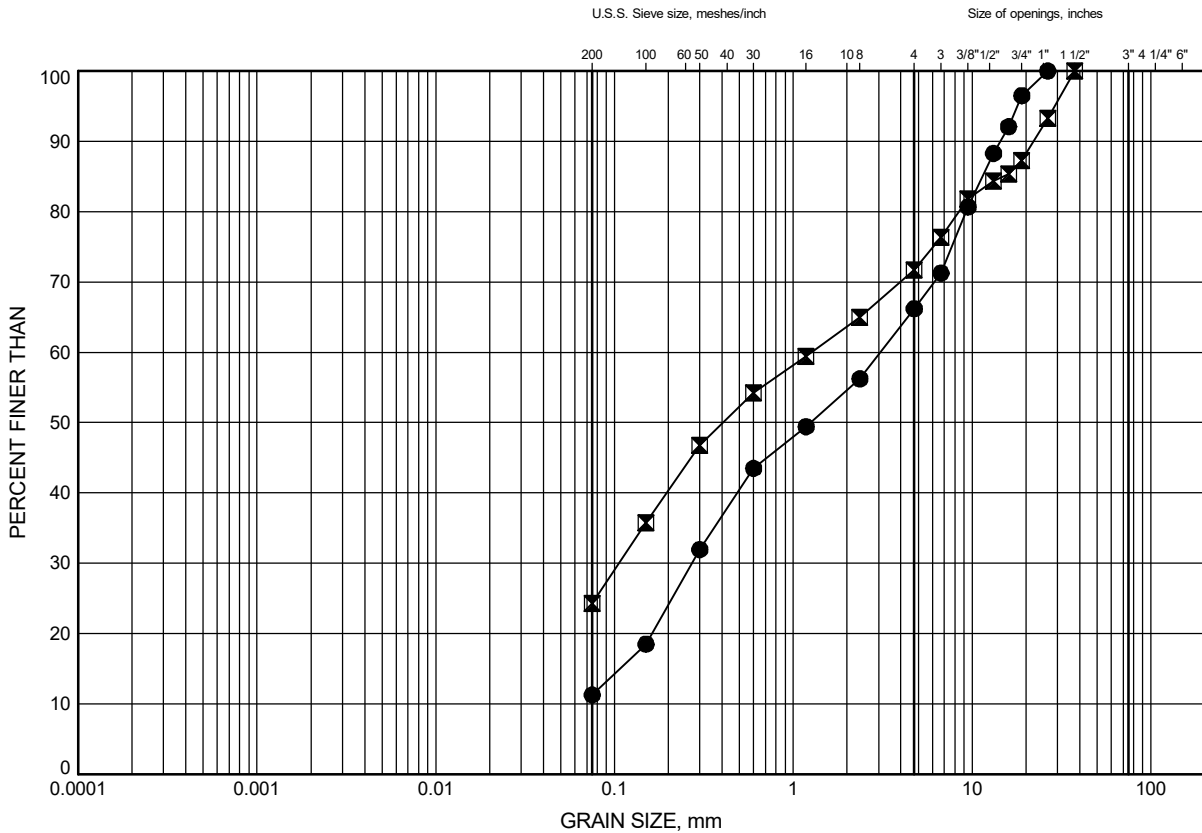


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

Choate to Ganaraska - Glacial Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	4.0	93.0
◻	20-05	3.4	91.4

Date November 2022

GWP# 4068-14-00



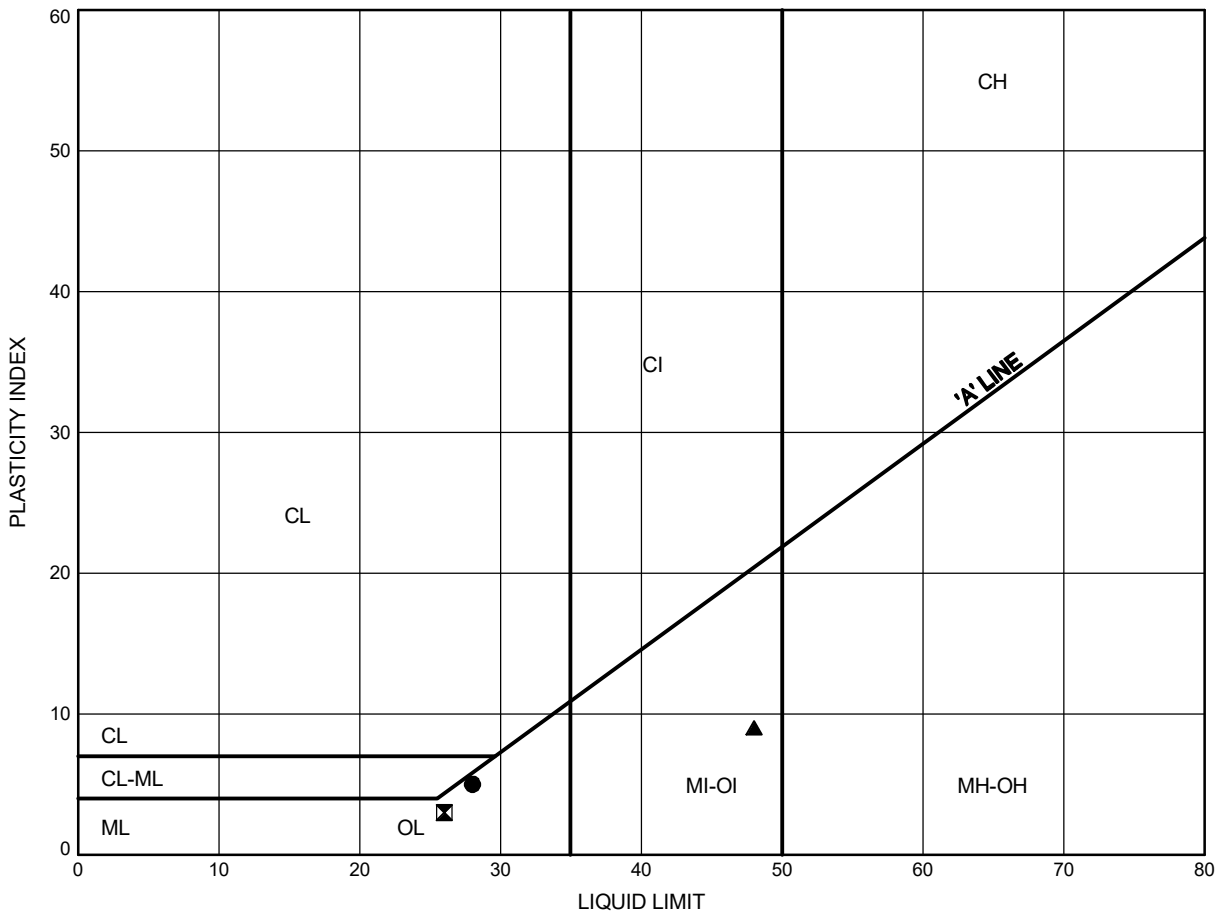
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C19

Choate to Ganaraska - Organic Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	1.1	95.9
⊠	20-04	1.1	94.9
▲	20-05	1.8	93.0

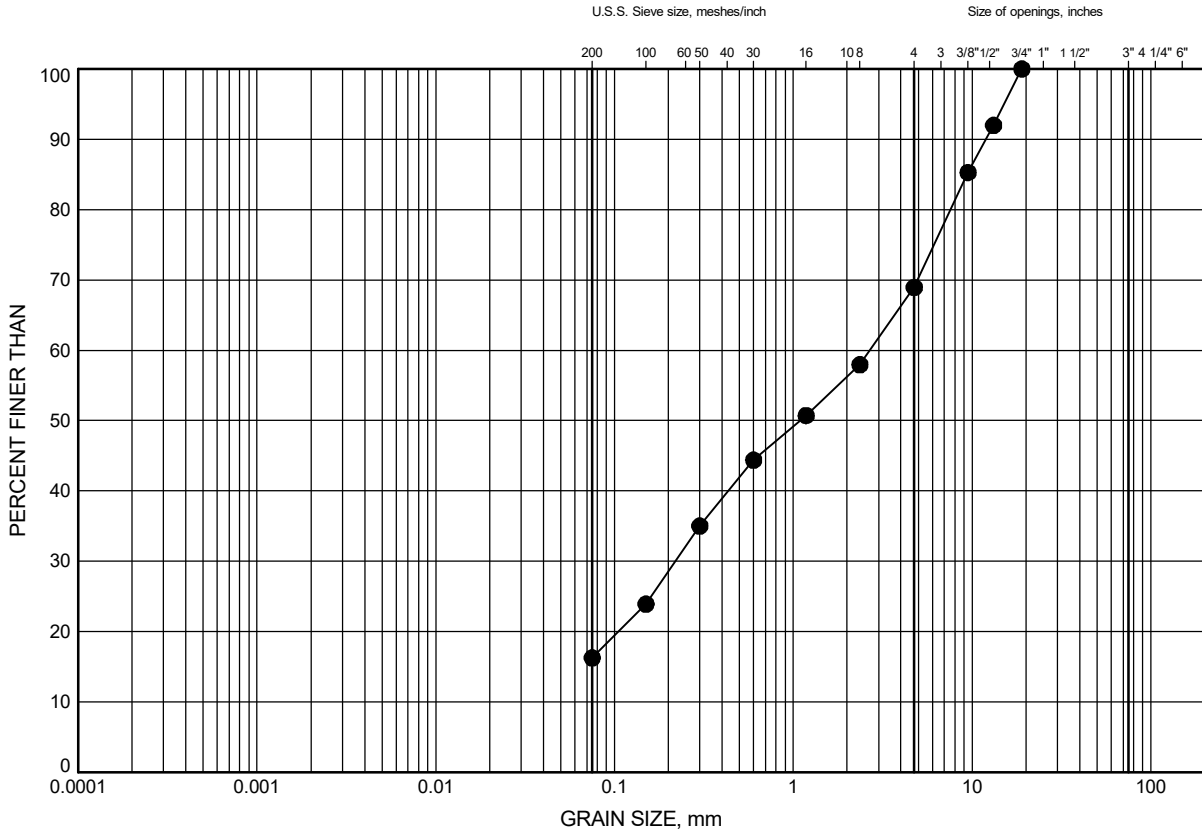
Date November 2022
 GWP# 4068-14-00



Prep'd RH
 Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - FILL: Upper Embankment



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-09	0.4	101.7

Date November 2022

GWP# 4068-14-00

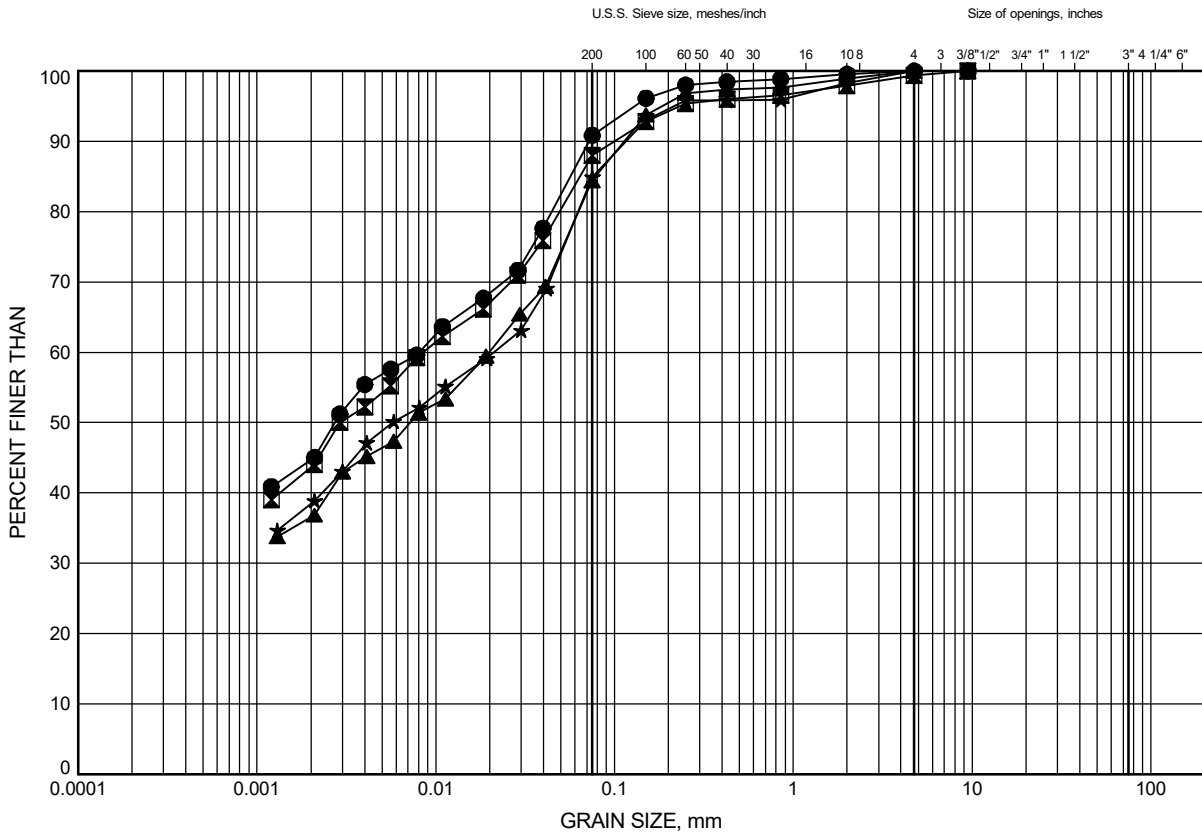


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - FILL: Lower Embankment



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-09	1.8	100.3
⊠	HF22-09	3.4	98.7
▲	HF22-09	5.6	96.5
★	HF22-09	6.4	95.7

Date November 2022

GWP# 4068-14-00

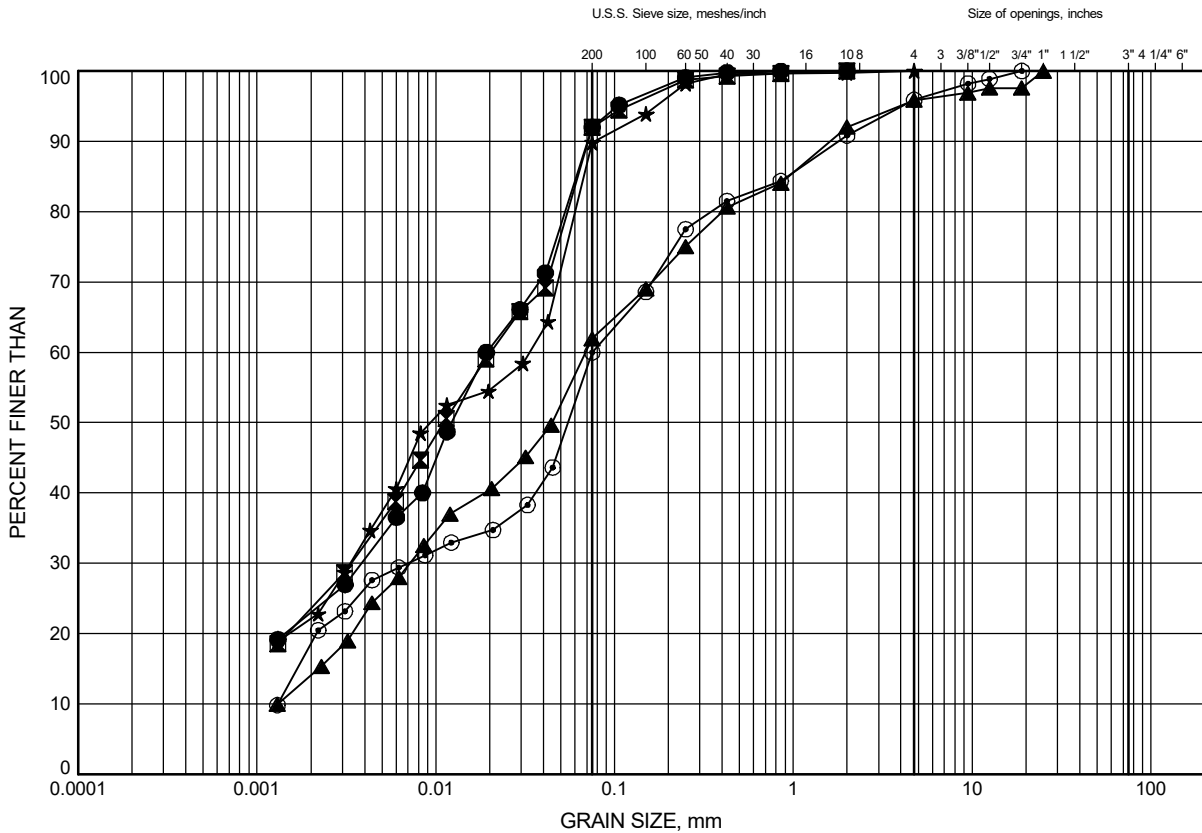


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - Organic Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	1.6	93.0
⊠	20-07	1.8	92.7
▲	HF22-05	1.8	93.2
★	HF22-05	3.4	91.6
⊙	HF22-06	1.1	94.6

Date November 2022

GWP# 4068-14-00

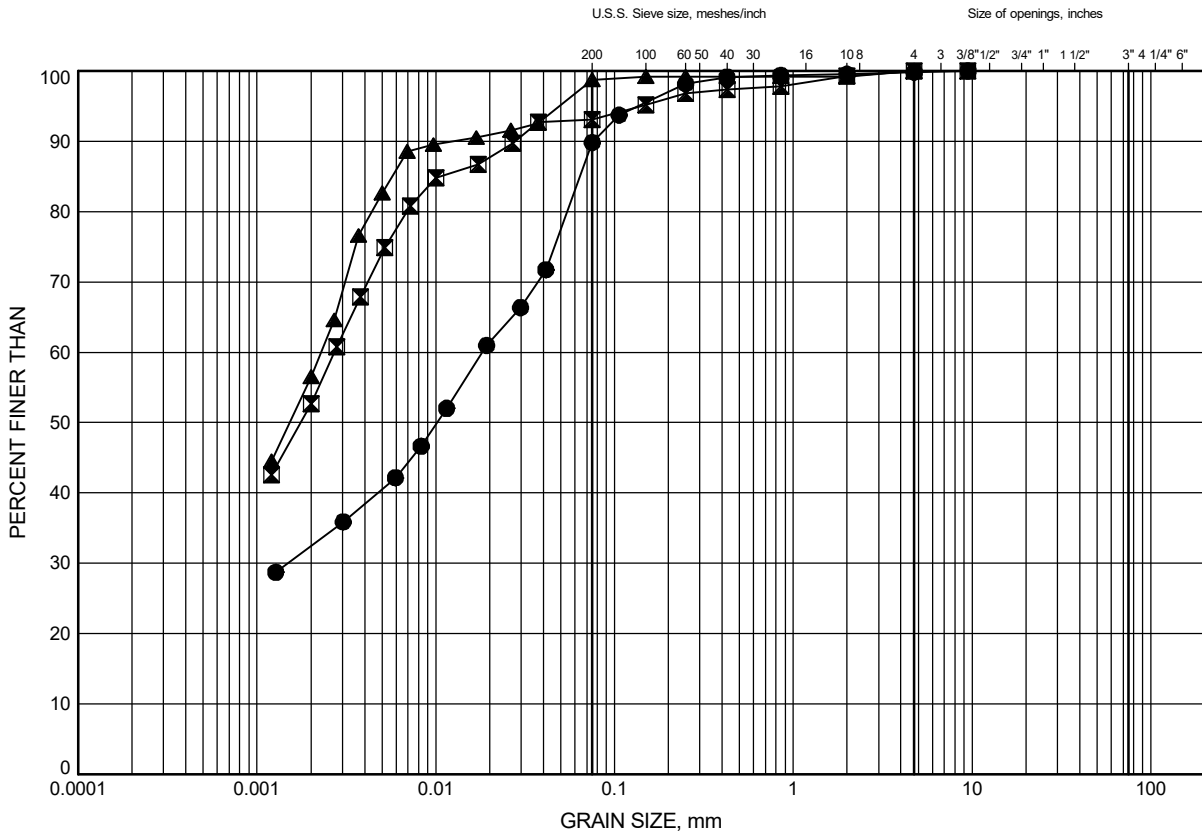


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - Clayey Silt to Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	3.3	91.3
⊠	HF22-09	7.9	94.2
▲	HF22-09	9.4	92.7

Date November 2022

GWP# 4068-14-00

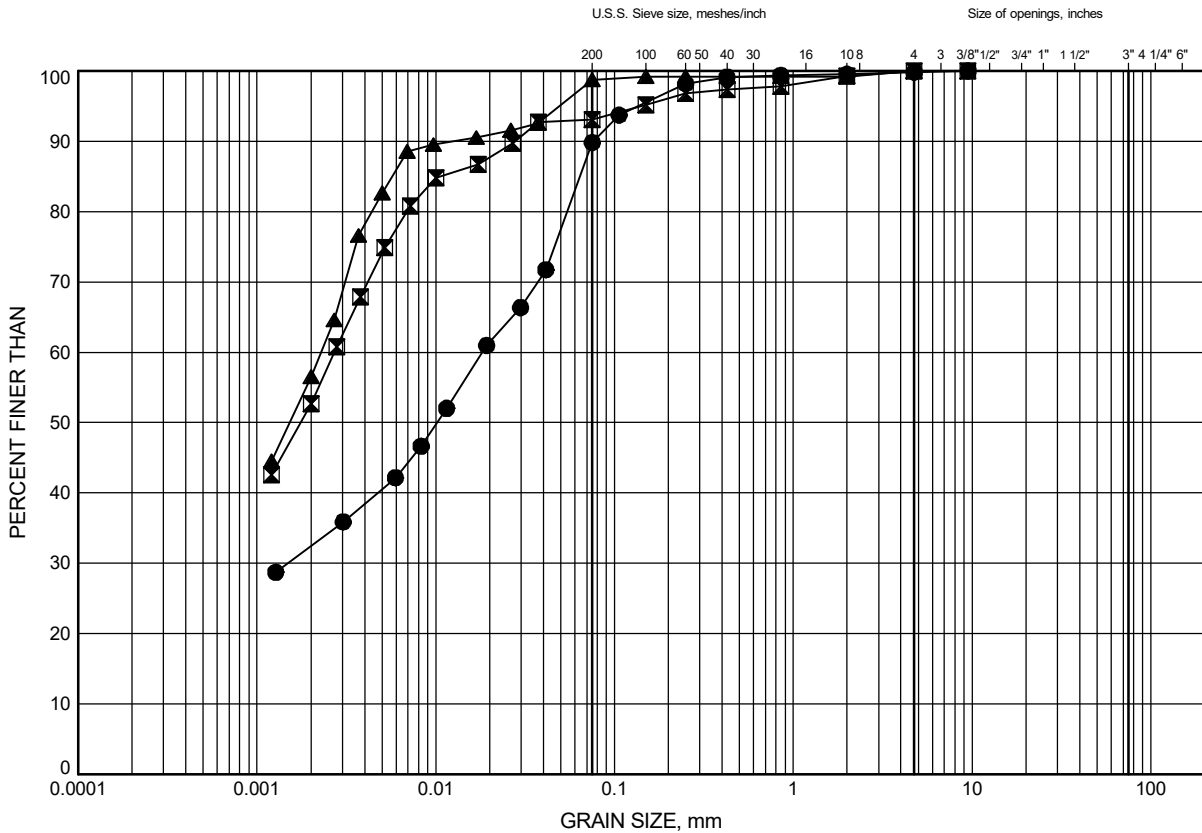


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - Clayey Silt to Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	3.3	91.3
⊠	HF22-09	7.9	94.2
▲	HF22-09	9.4	92.7

Date November 2022

GWP# 4068-14-00

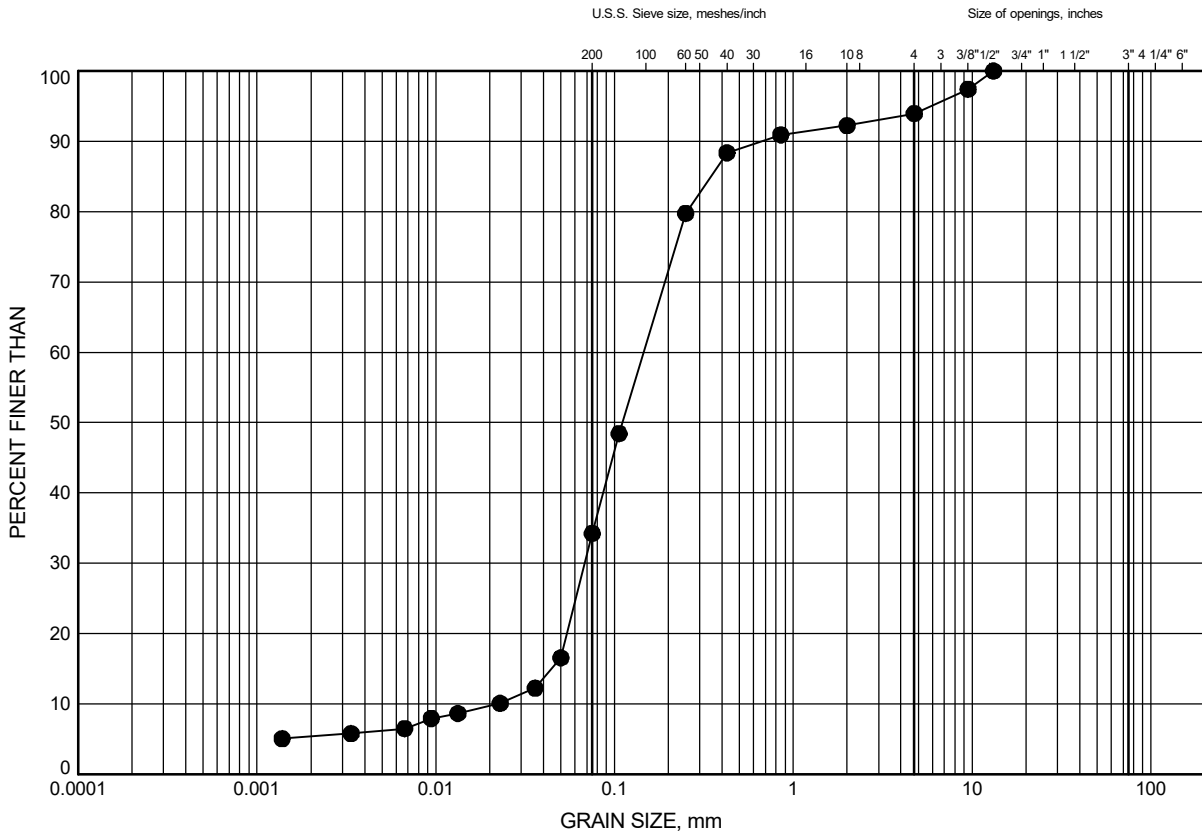


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - Silty Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-07	2.8	91.7

Date November 2022

GWP# 4068-14-00

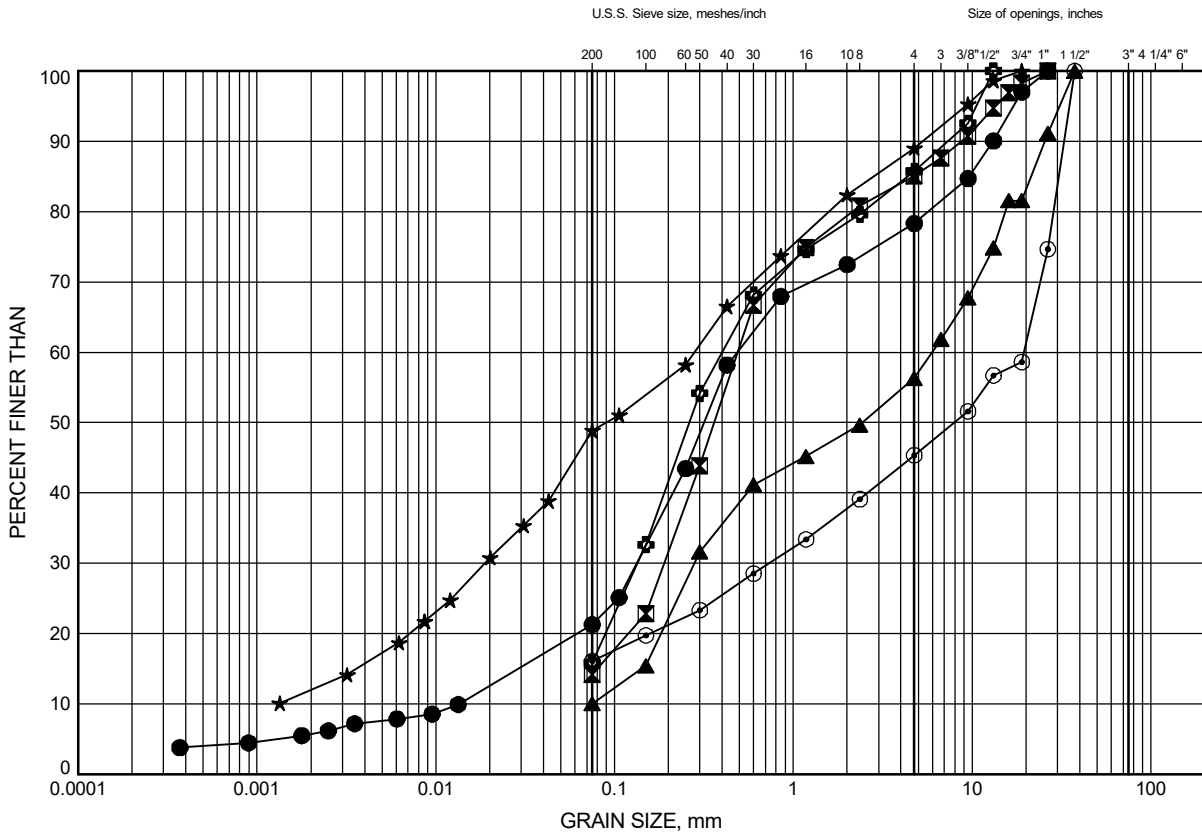


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - Glacial Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	4.0	90.6
⊠	20-06	5.8	88.8
▲	20-07	3.4	91.1
★	20-07	4.7	89.8
⊙	HF22-05	4.9	90.1
⊕	HF22-05	7.9	87.1

Date November 2022

GWP# 4068-14-00

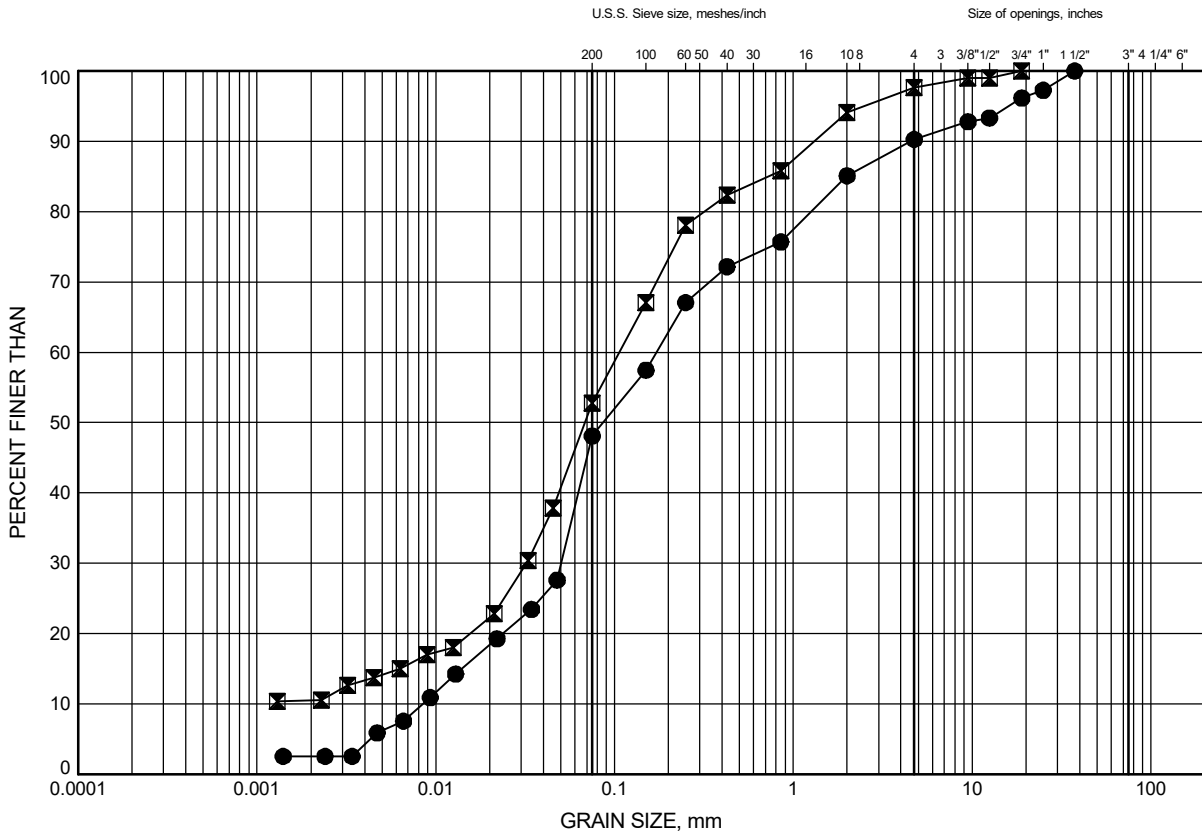


Prep'd RH

Chkd. CM

GRAIN SIZE DISTRIBUTION

East of Ganaraska - Glacial Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-06	5.2	90.5
⊠	HF22-09	14.0	88.1

Date November 2022

GWP# 4068-14-00



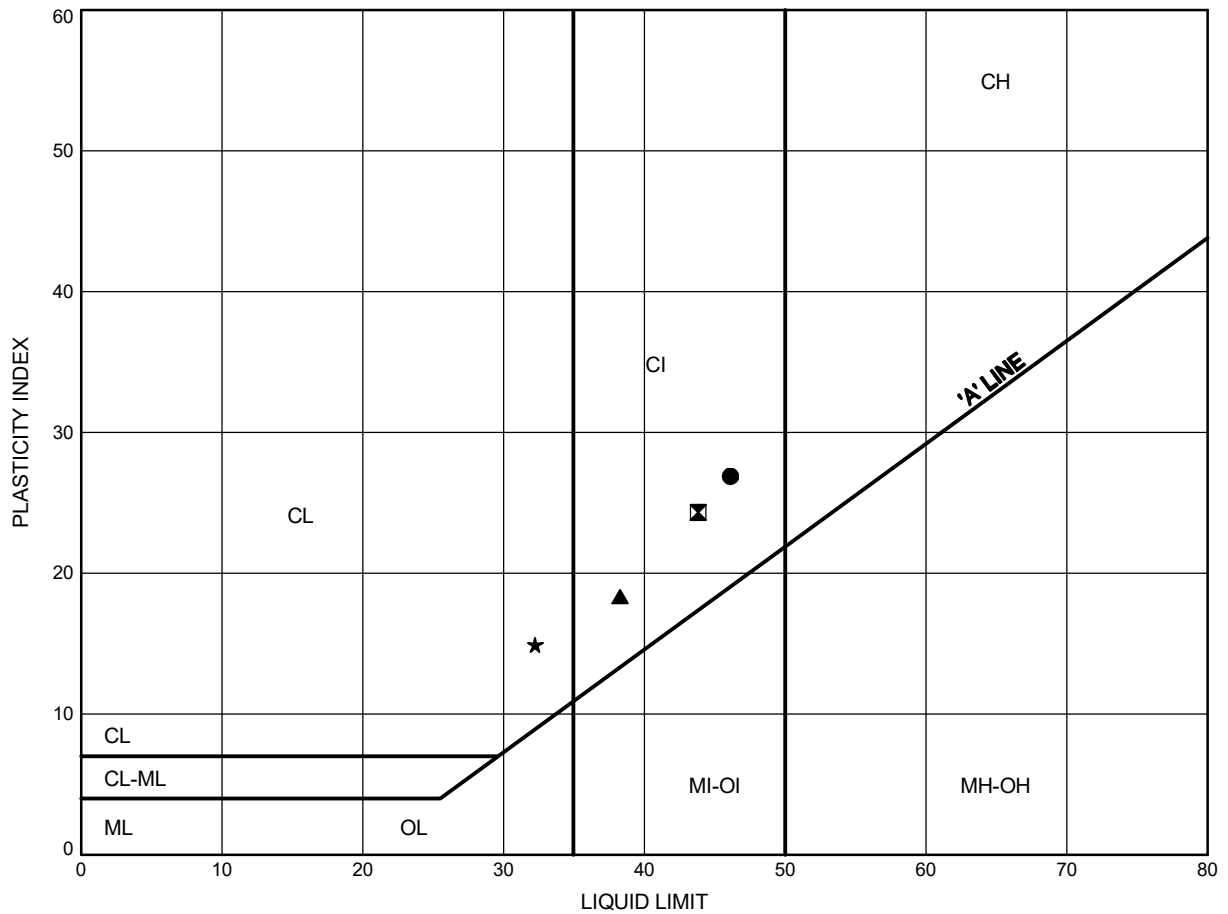
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C28

East of Ganaraska - FILL: Lower Embankment



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HF22-09	1.8	100.3
⊠	HF22-09	3.4	98.7
▲	HF22-09	5.6	96.5
★	HF22-09	6.4	95.7

Date November 2022

GWP# 4068-14-00



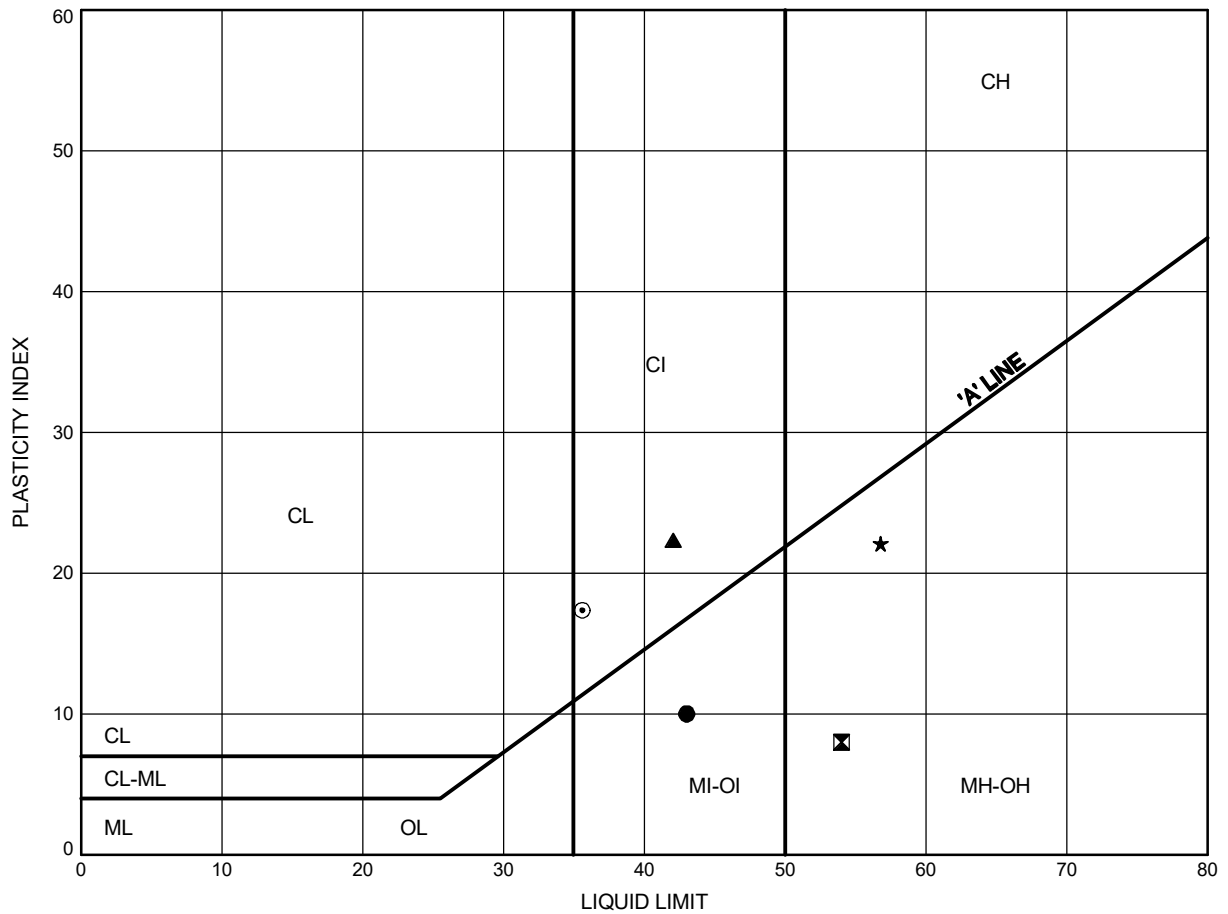
Prep'd RH

Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C29

East of Ganaraska - Organic Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	1.6	93.0
⊠	20-07	1.8	92.7
▲	HF22-05	1.8	93.2
★	HF22-05	3.4	91.6
⊙	HF22-06	1.1	94.6

Date November 2022
 GWP# 4068-14-00

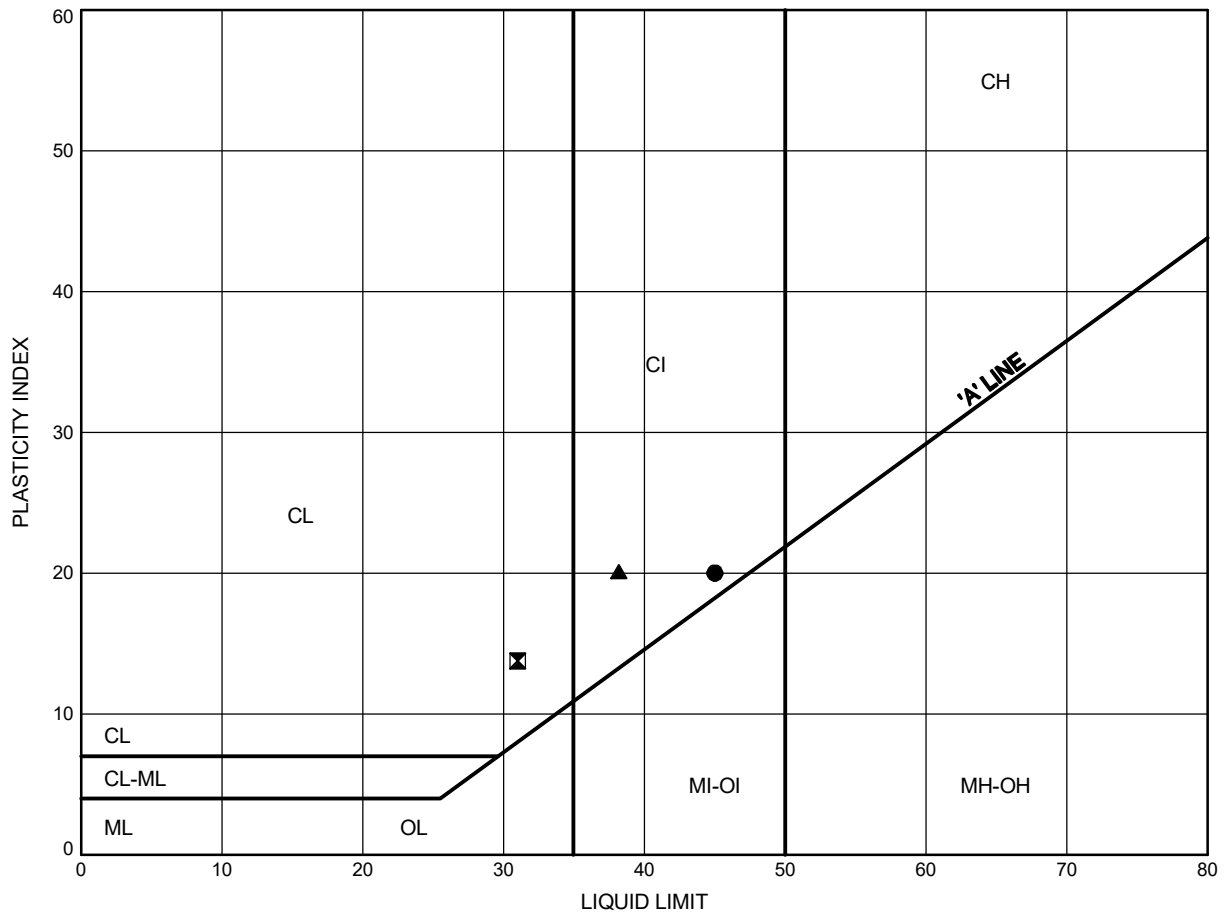


Prep'd RH
 Chkd. CM

Highway 401 Choate and Ganaraska Detailed Design
ATTERBERG LIMITS TEST RESULTS

FIGURE C30

East of Ganaraska - Clayey Silt to Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	3.3	91.3
⊠	HF22-09	7.9	94.2
▲	HF22-09	9.4	92.7

Date November 2022
 GWP# 4068-14-00



Prep'd RH
 Chkd. CM

Project: 28171

Hwy 401 Port Hope

Borehole: 20-01

Sample: TW-4

Depth: 3.4m (100.4m)

Client: Ontario Ministry of Transportation

One-Dimensional Consolidation

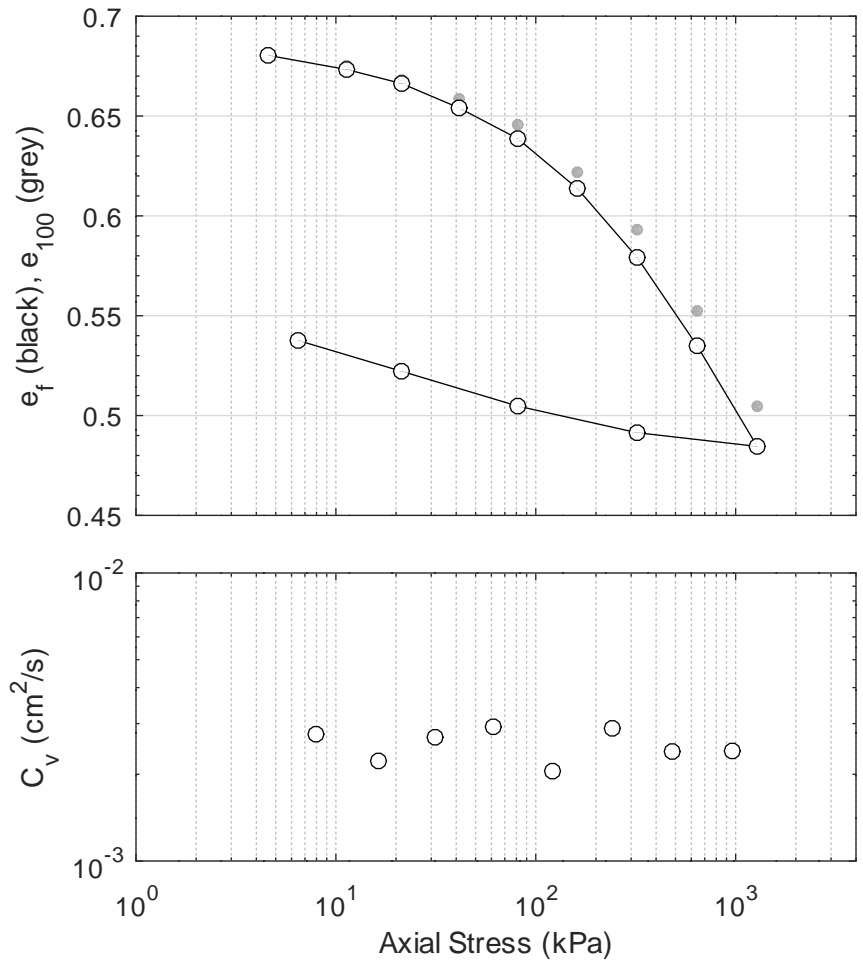
ASTM D2435-11

TRIMMING: the specimen was manually trimmed to the size of the consolidation ring, then mounted in a fixed ring consolidometer

LOADING: the consolidometer was flooded with water with the seating load adjusted to limit swelling

CALCULATIONS: coefficients of consolidation were calculated by the square root time method

Start of Test				2020-08-31			
Diameter of Sample	cm	D		6.349			
Height of Sample	cm	H _o		2.536			
Height of Solids	cm	H _s		1.509			
Water Content	%	w _o		25.66			
Dry Density	g/cm ³	ρ _d		1.609			
Moist Unit Weight	kN/m ³	γ		19.81			
Void Ratio	-	e _o		0.680			
Degree of Saturation	-	S _{ro}		1.020			
Specific Gravity	-	G _s		2.703			
End of Test				2020-09-13			
Height of Sample	cm	H _f		2.321			
Water Content	%	w _f		21.26			
Void Ratio	-	e _f		0.538			



Load No.	Axial Stress	Load Duration	System Deflec.	Dial	Sample Height	Axial Strain	Void Ratio	Time U(0.99)	C _v	k _v	C _æ
	kPa	min	mm	mm	cm	%	-	min	cm ² /s	cm/s	-
0				10.000	2.536	0.00	0.680				
1	4.6	1440.3	0.006	9.995	2.536	-0.00	0.680				
2	11.3	1440.3	0.039	9.855	2.525	0.42	0.673	16.9	2.76e-03	1.69e-07	0.0006
3	21.3	1440.5	0.085	9.703	2.515	0.84	0.666	20.5	2.23e-03	9.10e-08	0.0007
4	41.3	1440.1	0.120	9.483	2.496	1.56	0.654	16.6	2.69e-03	9.58e-08	0.0014
5	81.2	1440.0	0.195	9.177	2.473	2.48	0.639	15.0	2.92e-03	6.58e-08	0.0022
6	161.3	1440.3	0.269	8.727	2.436	3.96	0.614	20.3	2.05e-03	3.73e-08	0.0029
7	321.5	1440.1	0.358	8.116	2.383	6.02	0.579	13.4	2.89e-03	3.64e-08	0.0044
8	641.5	1440.4	0.469	7.338	2.317	8.65	0.535	14.6	2.40e-03	1.94e-08	0.0058
9	1281.7	1440.0	0.577	6.469	2.241	11.65	0.485	13.3	2.41e-03	1.11e-08	0.0066
10	321.4	1440.2	0.466	6.683	2.251	11.24	0.491				
11	81.3	1440.3	0.332	7.017	2.271	10.45	0.505				
12	21.3	1440.1	0.252	7.360	2.297	9.41	0.522				
13	6.5	1440.5	0.203	7.642	2.321	8.49	0.538				

Project: 28171

Hwy 401 Port Hope

One-Dimensional Consolidation

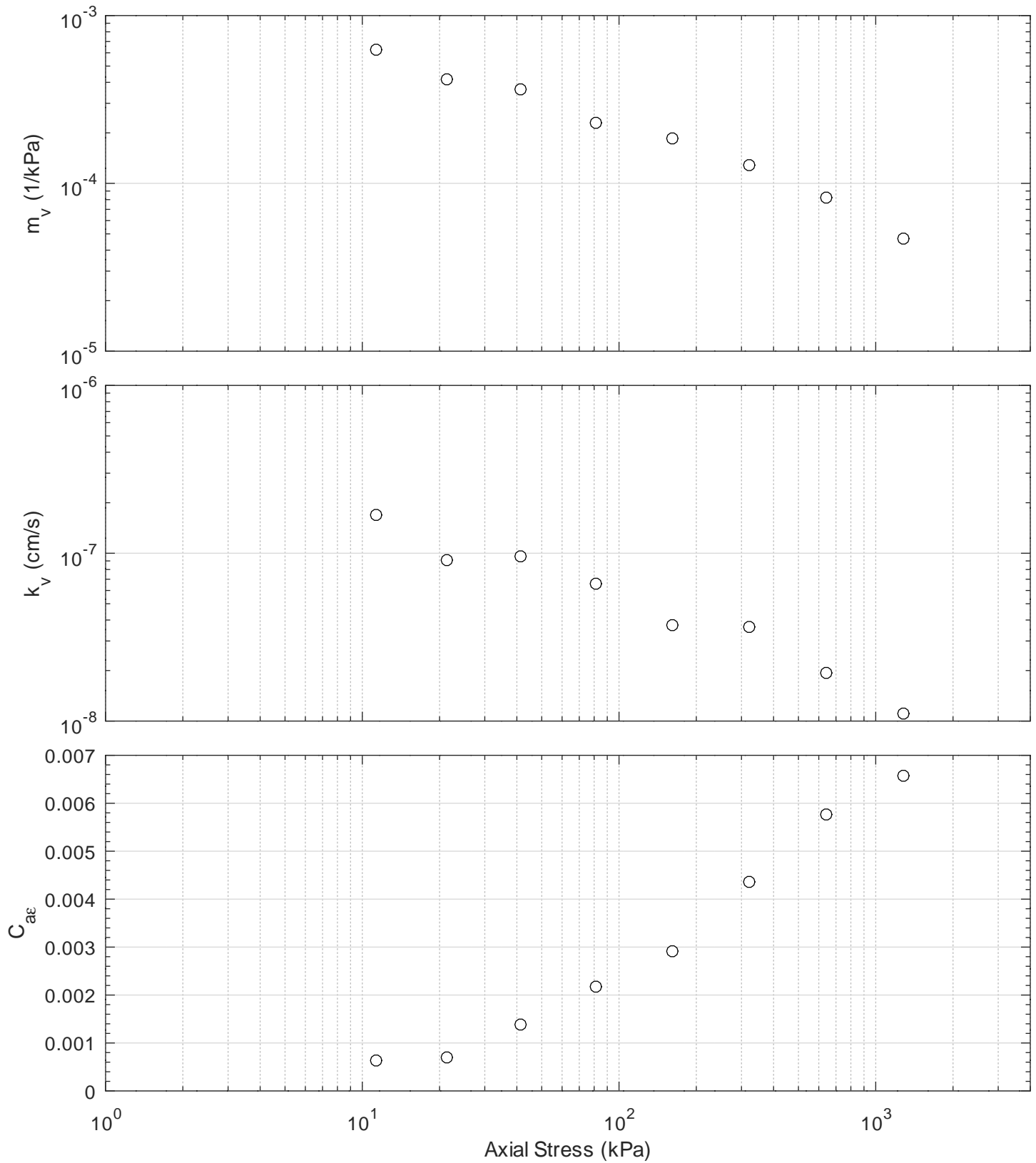
ASTM D2435-11

Borehole: 20-01

Sample: TW-4

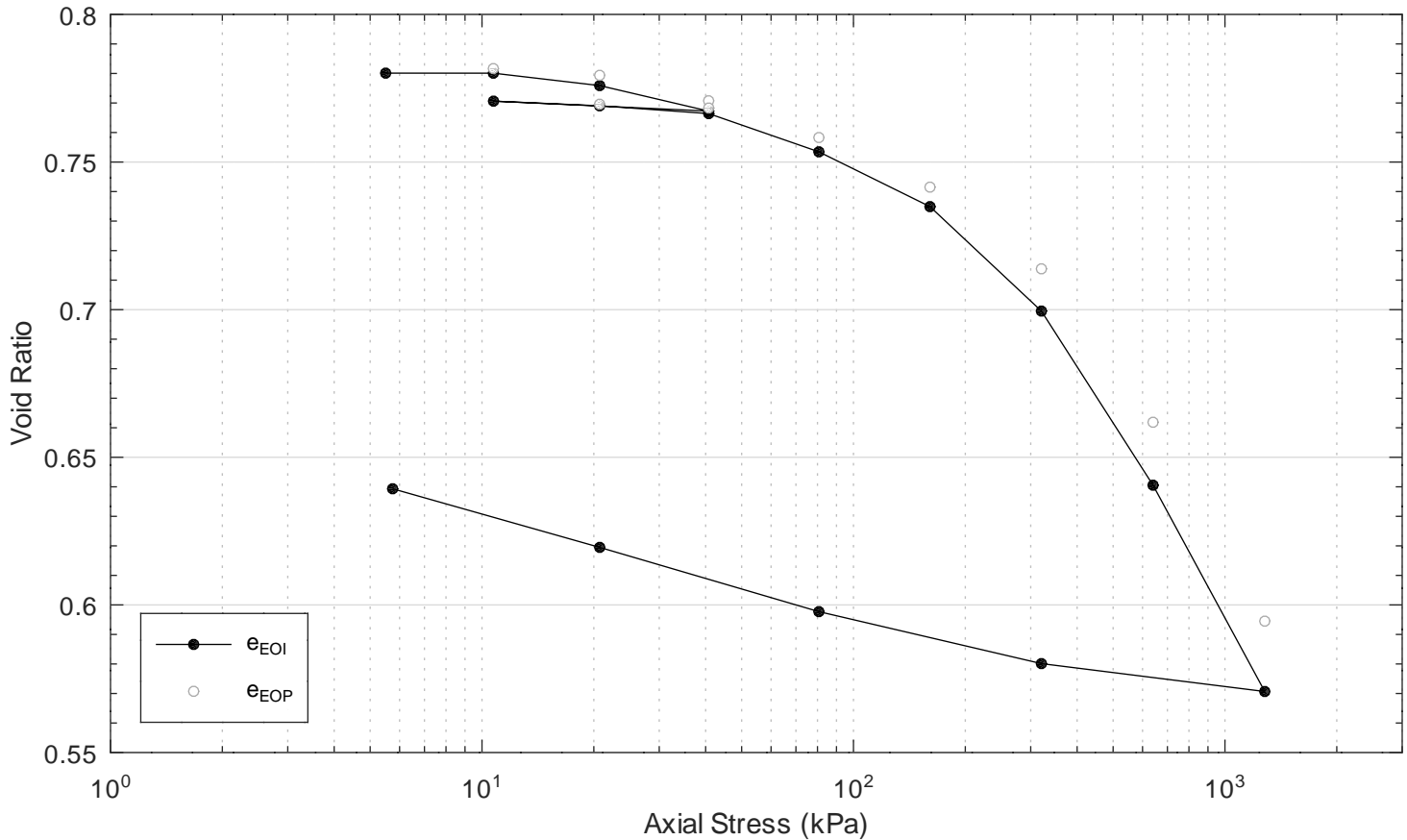
Depth: 3.4m (100.4m)

Client: Ontario Ministry of Transportation





Project: 33099
 Highway 401 Choate
 Borehole: HF22-03
 Sample: ST1
 Depth: 4.9 m
 Client: Ministry of Transportation



Start of Test		2022-06-10	
Diameter of Sample	cm	D	6.352
Height of Sample	cm	H _o	2.529
Height of Solids	cm	H _s	1.421
Water Content	%	w _o	26.85
Dry Density	g/cm ³	ρ _d	1.53
Moist Unit Weight	kN/m ³	γ	19.0
Void Ratio	-	e _o	0.779
Degree of Saturation	-	S _{ro}	0.94
Specific Gravity	-	G _s	2.721
End of Test		2022-06-27	
Height of Sample	cm	H _f	2.330
Water Content	%	w _f	24.08
Void Ratio	-	e _f	0.639

TRIMMING: the specimen was manually trimmed to the size of the consolidation ring, then mounted in a fixed ring consolidometer

LOADING: the consolidometer was flooded with water with the seating load adjusted to limit swelling

CALCULATIONS: coefficients of consolidation were calculated by the square root time method, secondary consolidation was calculated based on the available duration of the time step

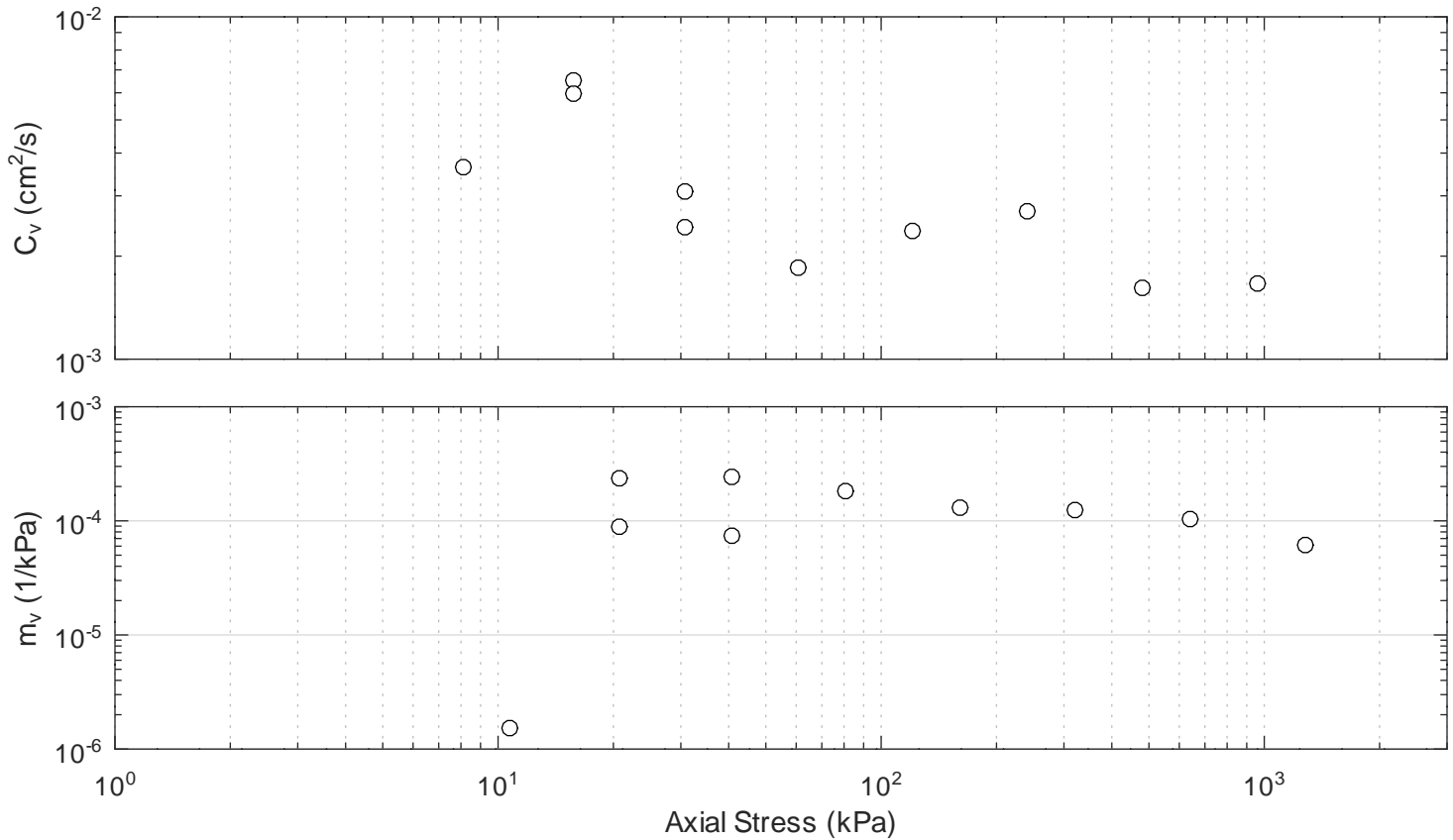
Interpreted Results

Recompression Index (reloading)	-	C _r	0.044
Compression Index	-	C _c	0.214
Recompression Index (unloading)	-	C _r	0.033
Probable Preconsolidation Pressure	kPa	p' _c	242

Check: SP Review: KS



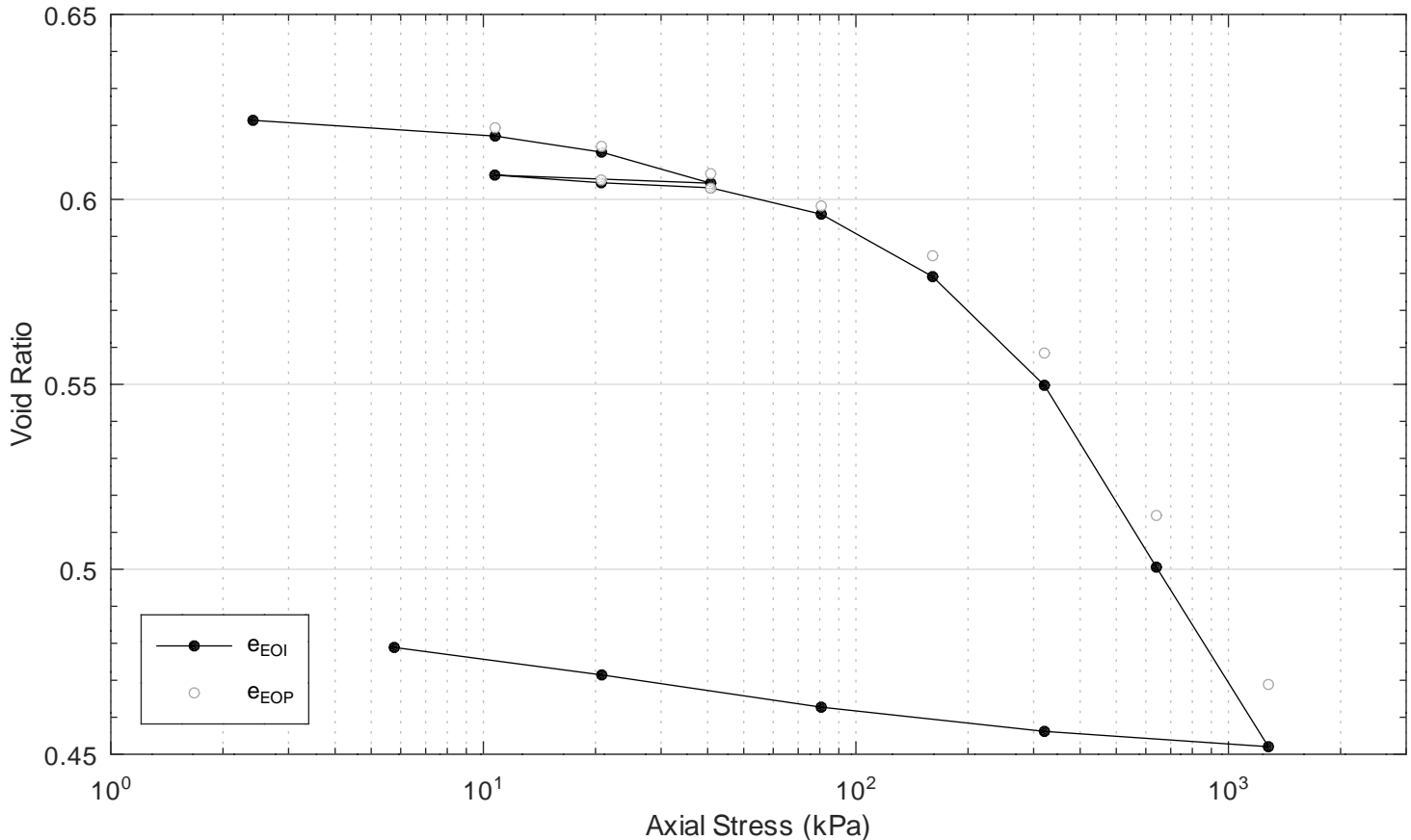
Project: 33099
 Highway 401 Choate
 Borehole: HF22-03
 Sample: ST1
 Depth: 4.9 m
 Client: Ministry of Transportation



Load No.	Axial Stress	Load Duration	System Deflec.	Dial	Sample Height	Axial Strain	Void Ratio	Void Ratio	Time U(0.99)	C_v	k_v	C_{ae}
	kPa	min	mm	mm	cm	%	(EOI)	(EOP)	min	cm ² /s	cm/s	-
0				10.000	2.529	0.00	0.779					
1	5.5	1440.4	0.006	10.003	2.530	-0.04	0.780					
2	10.7	1440.1	0.053	9.956	2.530	-0.03	0.780	0.782	13.0	3.64e-03	5.45e-10	0.0004
3	20.7	1440.4	0.098	9.851	2.524	0.20	0.776	0.779	7.1	6.52e-03	1.51e-07	0.0009
4	40.7	1440.3	0.145	9.682	2.512	0.69	0.767	0.771	18.8	2.43e-03	5.78e-08	0.0010
5	10.7	1440.1	0.117	9.757	2.516	0.50	0.771					
6	20.7	1440.3	0.123	9.730	2.514	0.59	0.769	0.770	7.8	5.96e-03	5.20e-08	0.0001
7	40.8	1440.3	0.150	9.665	2.510	0.73	0.766	0.768	15.0	3.09e-03	2.24e-08	0.0005
8	80.7	1440.1	0.222	9.409	2.492	1.46	0.753	0.758	24.1	1.85e-03	3.31e-08	0.0016
9	160.7	1440.3	0.301	9.066	2.466	2.51	0.735	0.742	18.2	2.37e-03	3.03e-08	0.0019
10	320.6	1440.2	0.403	8.462	2.415	4.49	0.700	0.714	14.8	2.70e-03	3.30e-08	0.0042
11	640.4	1440.2	0.514	7.511	2.332	7.81	0.641	0.662	21.3	1.62e-03	1.64e-08	0.0070
12	1279.9	1440.4	0.673	6.360	2.232	11.73	0.571	0.595	18.3	1.66e-03	1.00e-08	0.0079
13	320.6	1440.2	0.519	6.649	2.246	11.20	0.580					
14	80.7	1440.2	0.421	6.997	2.271	10.21	0.598					
15	20.7	1440.2	0.336	7.391	2.302	8.99	0.619					
16	5.7	2580.1	0.284	7.726	2.330	7.88	0.639					



Project: 33099
 Highway 401 Choate
 Borehole: HF22-04
 Sample: ST1
 Depth: 7.2 m
 Client: Ministry of Transportation



Start of Test 2022-06-10

Diameter of Sample	cm	D	6.351
Height of Sample	cm	H _o	2.527
Height of Solids	cm	H _s	1.561
Water Content	%	w _o	19.03
Dry Density	g/cm ³	ρ _d	1.68
Moist Unit Weight	kN/m ³	γ	19.6
Void Ratio	-	e _o	0.620
Degree of Saturation	-	S _{ro}	0.83
Specific Gravity	-	G _s	2.716

End of Test 2022-06-27

Height of Sample	cm	H _f	2.308
Water Content	%	w _f	17.54
Void Ratio	-	e _f	0.479

TRIMMING: the specimen was manually trimmed to the size of the consolidation ring, then mounted in a fixed ring consolidometer

LOADING: the consolidometer was flooded with water with the seating load adjusted to limit swelling

CALCULATIONS: coefficients of consolidation were calculated by the square root time method, secondary consolidation was calculated based on the available duration of the time step

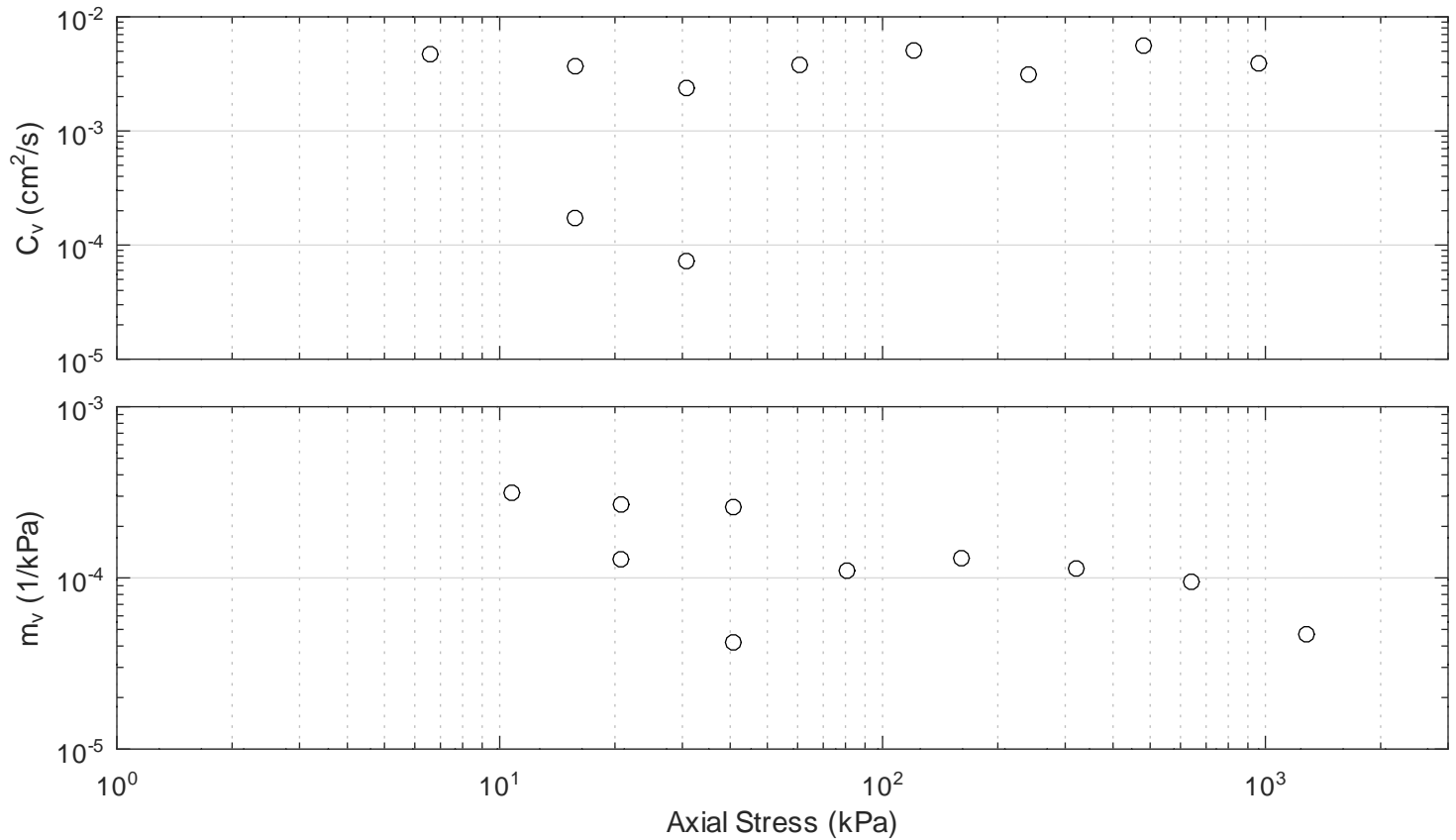
Interpreted Results

Recompression Index (reloading)	-	C _r	0.014
Compression Index	-	C _c	0.162
Recompression Index (unloading)	-	C _r	0.013
Probable Preconsolidation Pressure	kPa	p' _c	194

Check: SP Review: KS



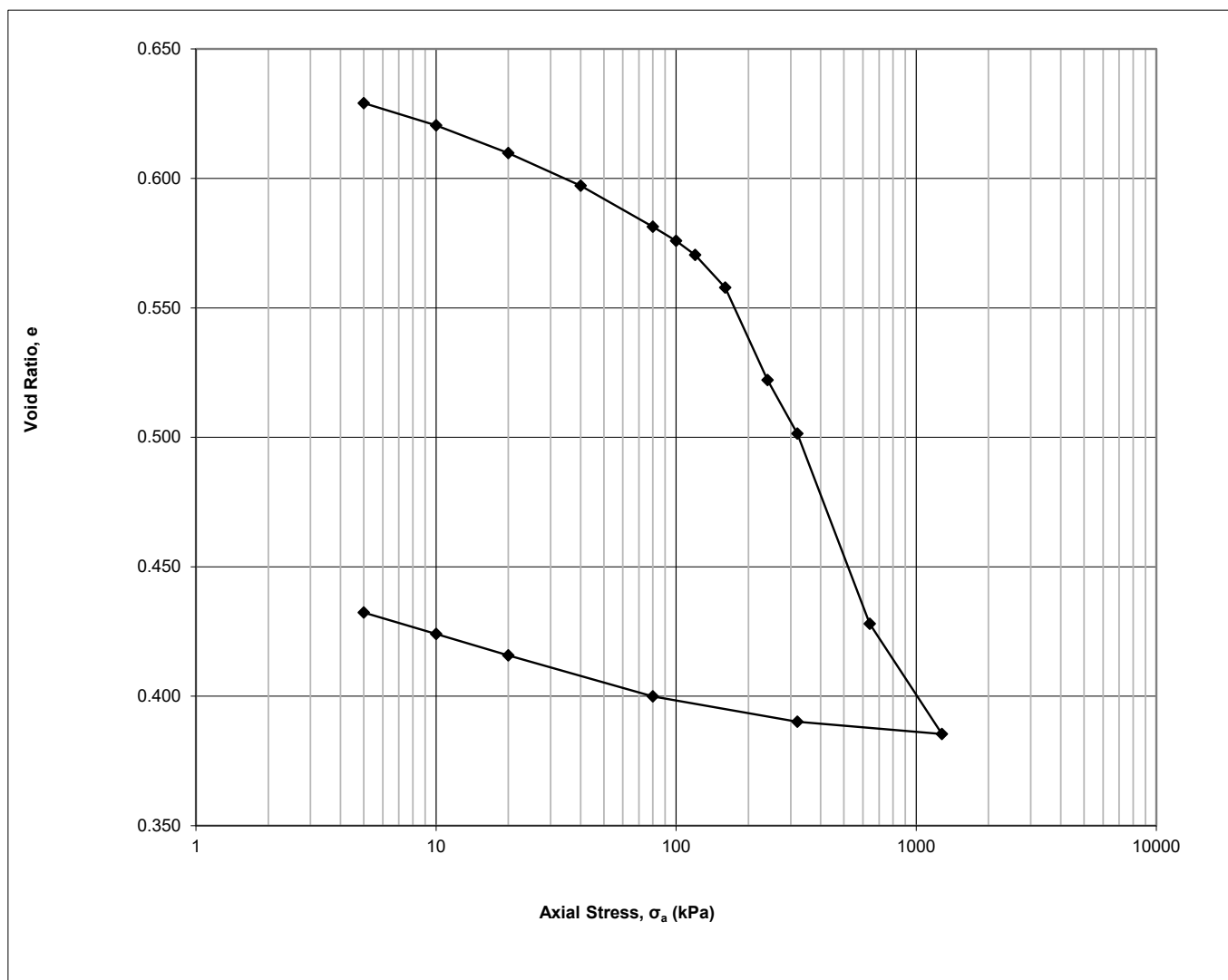
Project: 33099
 Highway 401 Choate
 Borehole: HF22-04
 Sample: ST1
 Depth: 7.2 m
 Client: Ministry of Transportation



Load No.	Axial Stress	Load Duration	System Deflec.	Dial	Sample Height	Axial Strain	Void Ratio	Void Ratio	Time U(0.99)	C_v	k_v	C_{ae}
	kPa	min	mm	mm	cm	%	(EOI)	(EOP)	min	cm ² /s	cm/s	-
0				10.000	2.527	0.00	0.620					
1	2.4	1440.5	0.021	10.007	2.530	-0.11	0.621					
2	10.8	1440.4	0.041	9.922	2.524	0.15	0.617	0.619	10.0	4.71e-03	1.45e-07	0.0006
3	20.8	1440.1	0.076	9.819	2.517	0.42	0.613	0.614	12.7	3.69e-03	9.72e-08	0.0005
4	40.8	1440.1	0.122	9.641	2.504	0.94	0.604	0.607	19.4	2.38e-03	6.05e-08	0.0008
5	10.7	1440.0	0.088	9.710	2.507	0.80	0.607					
6	20.7	1440.3	0.102	9.664	2.504	0.93	0.604	0.605	270.3	1.73e-04	2.17e-09	0.0000
7	40.8	1440.2	0.128	9.618	2.502	1.01	0.603	0.603	641.0	7.24e-05	2.98e-10	0.0001
8	80.7	1440.1	0.186	9.448	2.491	1.45	0.596	0.598	12.0	3.79e-03	4.10e-08	0.0006
9	160.7	1440.1	0.266	9.105	2.464	2.50	0.579	0.585	8.8	5.07e-03	6.48e-08	0.0015
10	320.6	1440.1	0.362	8.550	2.418	4.31	0.550	0.558	13.6	3.12e-03	3.47e-08	0.0027
11	640.5	1440.1	0.474	7.671	2.342	7.35	0.501	0.515	7.0	5.59e-03	5.21e-08	0.0039
12	1280.2	1440.1	0.622	6.766	2.266	10.34	0.452	0.469	8.8	3.91e-03	1.80e-08	0.0051
13	320.6	1440.0	0.470	6.983	2.272	10.09	0.456					
14	80.7	1440.2	0.367	7.187	2.283	9.68	0.463					
15	20.8	1440.1	0.298	7.393	2.296	9.15	0.471					
16	5.8	2580.1	0.244	7.564	2.308	8.69	0.479					

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File# 22645
122410864
BH 19-01
ST 1
20-22 ft.



One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 22645
Project Location	HWY 401-Choate Road
Borehole	BH 19-01
Sample No.	ST 1
Depth	20-22 ft.
Sample Date	February 24, 2019
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Silt and Clay, Grey, Varved, Moist- CL	
Specific Gravity of Solids	2.720
Liquid Limit %	30
Plastic Limit %	17
Plasticity Index %	13
Average water content of trimmings %	25
Additional Notes (information source, occurrence and size of large isolated particles etc.)	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	80.09
Dry Mass	g	64.30
Density	Mg/m ³	2.039
Dry Density	Mg/m ³	1.637
Water Content	%	24.56
Degree of Saturation	%	100.0
Height of Solids	mm	12.04
Initial Void Ratio		0.661

Final Specimen Conditions

Water Content	%	20.83
Final Void Ratio		0.432

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 22645
Project Location	HWY 401-Choate Road
Borehole	BH 19-01
Sample No.	ST 1
Depth	20-22 ft.
Sample Date	February 24, 2019
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started	March 14, 2019
Date Finished	March 20, 2019
Machine Number	Frame A
Cell Number	C1
Ring Number	R1
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation kPa	5
Water Used	Distilled
Test Method	A and B
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

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Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ϵ_a %	Void Ratio e
Seating	0.0	0	0.0000		0.00	0.661
1	21.7	5	0.3864		1.93	0.629
2	21.7	10	0.4901		2.45	0.620
3	23.3	20	0.6189		3.09	0.610
4	25.0	40	0.7708		3.85	0.597
5	30.0	80	0.9612		4.81	0.581
6	29.9	100	1.0268		5.13	0.576
7	33.3	120	1.0931		5.47	0.570
8	45.0	160	1.2438		6.22	0.558
9	1440.0	240	1.6741		8.37	0.522
10	1440.0	320	1.9232		9.62	0.501
11	1440.0	640	2.8077		14.04	0.428
12	192.8	1280	3.3202		16.60	0.385
13	10.1	320	3.2627		16.31	0.390
14	16.8	80	3.1452		15.73	0.400
15	33.4	20	2.9547		14.77	0.416
16	38.5	10	2.8550		14.28	0.424
17	41.8	5	2.7557		13.78	0.432

One-Dimensional Consolidation Test using Incremental Loading

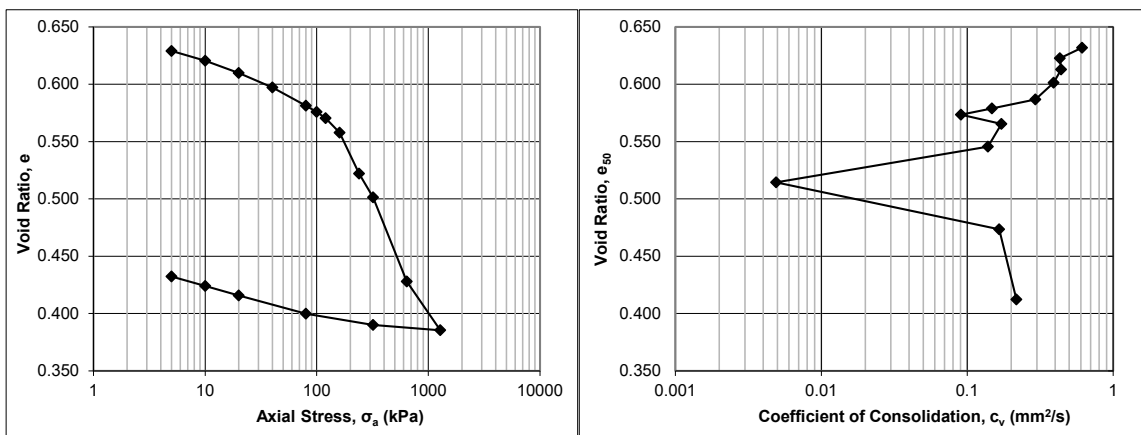
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 22645
Project Location	HWY 401-Choate Road
Borehole	BH 19-01
Sample No.	ST 1
Depth	20-22 ft.
Sample Date	February 24, 2019
Test Number	One
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress σ_a , average kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	0								
1	3	0.3524	19.6476	1.76	0.632			134	6.13E-01
2	8	0.4642	19.5358	2.32	0.623			188	4.31E-01
3	15	0.5811	19.4189	2.91	0.613			181	4.41E-01
4	30	0.7217	19.2783	3.61	0.601			202	3.91E-01
5	60	0.8957	19.1043	4.48	0.587			264	2.93E-01
6	90	0.9902	19.0098	4.95	0.579			518	1.48E-01
7	110	1.0570	18.9430	5.29	0.573			839	9.07E-02
8	140	1.1529	18.8471	5.76	0.565			439	1.71E-01
9	200	1.3906	18.6094	6.95	0.546			530	1.39E-01
10	280	1.7672	18.2328	8.84	0.514			14387	4.90E-03
11	480	2.2590	17.7410	11.29	0.474			402	1.66E-01
12	960	2.9972	17.0028	14.99	0.412			282	2.17E-01
13	800	3.2774	16.7226	16.39	0.389				
14	200	3.1932	16.8068	15.97	0.396				
15	50	3.0445	16.9555	15.22	0.408				
16	15	2.9386	17.0614	14.69	0.417				
17	8	2.8352	17.1648	14.18	0.426				





Stantec

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

July 23, 2020
File: 122410864

Attention: Thurber Engineering, File #28171

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core

The following table summarizes three rock core unconfined compressive strength results.

Project	Location	Sample Depth	Compressive Strength (MPa)	Description of Break
Highway 401 Port Hope	20-02 Run-1	21'11"	103.3	Well-formed cones at both ends
Highway 401 Port Hope	20-02 Run-3	29'11"	122.5	Well-formed cones at both ends
Highway 401 Port Hope	20-04 Run-2	16'8"	101.5	Well-formed cones at both ends

Sincerely,

Stantec Consulting Ltd

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com

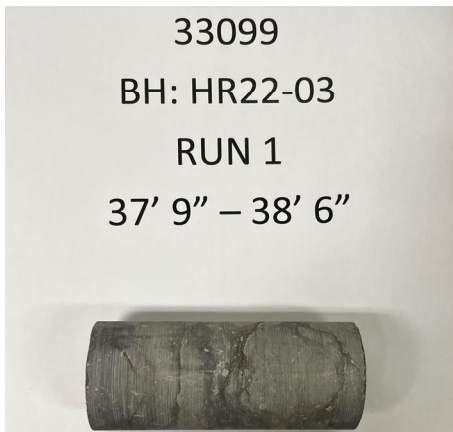
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	McIntosh Perry	FILE NUMBER:	33099
PROJECT NAME:	Hwy 401 Choate & Ganaraska	REPORT DATE:	29-Aug-22
BOREHOLE No.:	HF22-03	TEST DATE:	16-Aug-22
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	37' 9" - 38' 6"		
DESCRIPTION:	Limestone		

Avg. Height (cm):	11.1	Weight (g):	515.5
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,632
H. to Dia. Ratio**:	2.3:1	Dry Density (kg/m ³):	2,624
Cross Sectional Area (cm ²):	17.65	Moisture Content* (%):	0.3
Sample Volume (cm ³):	195.87		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	110.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	62.8 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: GF
REVIEWED BY: WM

33099 - UCS - HF22-03 Run 1 - August 17, 2022



FINAL REPORT

CA40065-APR22 R1

Client: Thurber Engineering Ltd.
Project: 33099
Project Manager: Chris Murray
Samplers: Joe (Zhou) Lin

MATRIX: SOIL

Sample Number	5	6
Sample Name	HF22-06-SS3	HF22-05-SS2
Sample Matrix	Soil	Soil
Sample Date	15/03/2022	16/03/2022

Parameter	Units	RL		Result	Result
General Chemistry					
Loss on Ignition at 550°C	%	0.1		1.88	2.48
Metals and Inorganics					
Moisture Content	%	0.1		26.0	23.1
UNDEFINED					
Total Solids	%	0.1		79.6	75.0



FINAL REPORT

CA40013-APR22 R1

Client: Thurber Engineering Ltd.

Project: 33099,

Project Manager: Chris Murray

Samplers: Joe (Zhou) Lin

MATRIX: SOIL

Sample Number	5	6
Sample Name	HF-22-06-SS4B	GR22-04-SS4
Sample Matrix	Soil	Soil
Sample Date	15/03/2022	15/03/2022

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		14	4
Soil Redox Potential	mV	no		237	169
Sulphide (Na2CO3)	%	0.04		< 0.04	< 0.04
pH	pH Units	0.05		8.51	7.15
Resistivity (calculated)	ohms.cm	-9999		1100	2210
General Chemistry					
Conductivity	uS/cm	2		905	417
Metals and Inorganics					
Moisture Content	%	0.1		20.0	38.0
Sulphate	µg/g	0.4		25	40
Other (ORP)					
Chloride	µg/g	0.4		510	290



FINAL REPORT

CA40225-JUL22 R1

Client: Thurber Engineering Ltd.

Project: 33099, Hwy 401 Choate and Ganaraska DD

Project Manager: Chris Murray

Samplers: Joe Lin

MATRIX: SOIL

Sample Number	13	14	15	16
Sample Name	DC22-13 SS3 5'-6'3"	TW22-02 SS3 5'-7"	TW22-04 SS3 5'7"	HF22-03 SS4 7'6"-9'6"
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	24/05/2022	03/06/2022	02/06/2022	18/05/2022

Parameter	Units	RL	Result	Result	Result	Result
Corrosivity Index						
Corrosivity Index	none	1	4	6	9	14
Soil Redox Potential	mV	no	272	252	255	247
Sulphide (Na ₂ CO ₃)	%	0.04	< 0.04	< 0.04	< 0.04	< 0.04
pH	pH Units	0.05	8.70	9.39	9.34	8.59
Resistivity (calculated)	ohms.cm	-9999	4390	2130	1830	1090
General Chemistry						
Conductivity	uS/cm	2	223	470	545	919
Metals and Inorganics						
Moisture Content	%	0.1	7.8	11.4	14.6	19.0
Sulphate	µg/g	0.4	7.7	12	19	28
Other (ORP)						
Chloride	µg/g	0.4	10	110	150	480



FINAL REPORT

CA40148-OCT22 R1

Client: Thurber Engineering Ltd.

Project: 33099, Choate Road

Project Manager: Scott Gittens

Samplers: Scott Gittens

MATRIX: SOIL

Sample Number	5	6
Sample Name	BH-ONT-22-2 SS#7	B-HF-2 SS#2A
Sample Matrix	Soil	Soil
Sample Date	17/10/2022	17/10/2022

Parameter	Units	RL	Result	Result
-----------	-------	----	--------	--------

Corrosivity Index

Corrosivity Index	none	1	9	1
Soil Redox Potential	mV	no	239	272
Sulphide (Na2CO3)	%	0.04	< 0.04	< 0.04
pH	pH Units	0.05	8.6	8.12
Resistivity (calculated)	ohms.cm	-9999	1930	3290

General Chemistry

Conductivity	uS/cm	2	505	304
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Metals and Inorganics

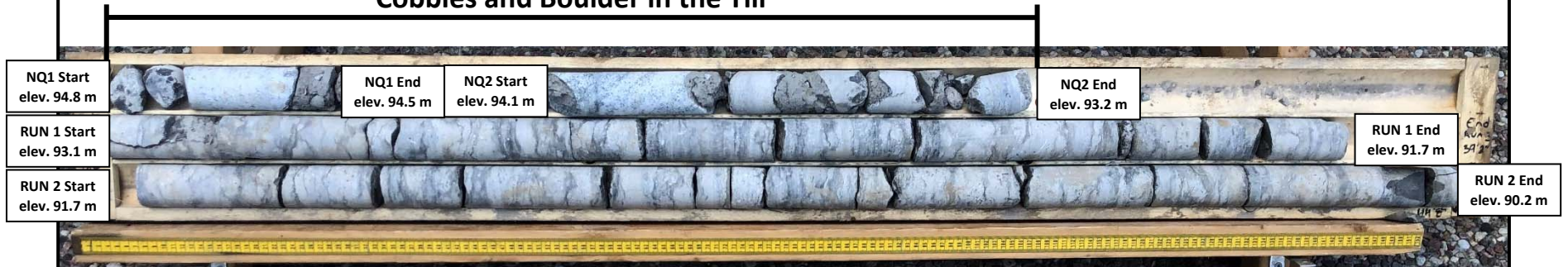
Moisture Content	%	0.1	19.0	21.3
Sulphate	µg/g	0.4	35	60

Other (ORP)

Chloride	µg/g	0.4	440	84
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Borehole 20-01
NQ1 to NQ2 and RUN 1 to 2 (of 2)
Elevation 94.8 m to 90.2 m

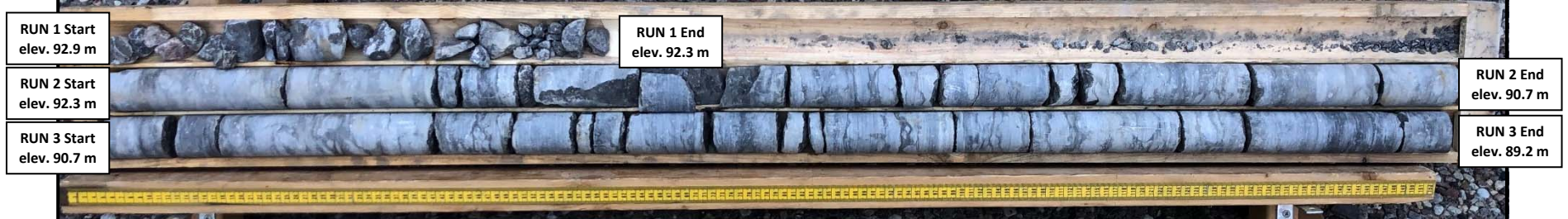
Cobbles and Boulder in the Till



Borehole 20-02
RUN 1 to 3 (of 3)
Elevation 93.2 m to 89.7 m



Borehole 20-03
RUN 1 to 3 (of 3)
Elevation 92.9 m to 89.2 m



Preliminary Foundation Investigation
Highway 401 Widening
Port Hope, Ontario

GWP: 4005-17-00
Project No.: 28171

Borehole 20-04
RUN 1 to 3 (of 3)
Elevation 92.4 m to 88.3 m



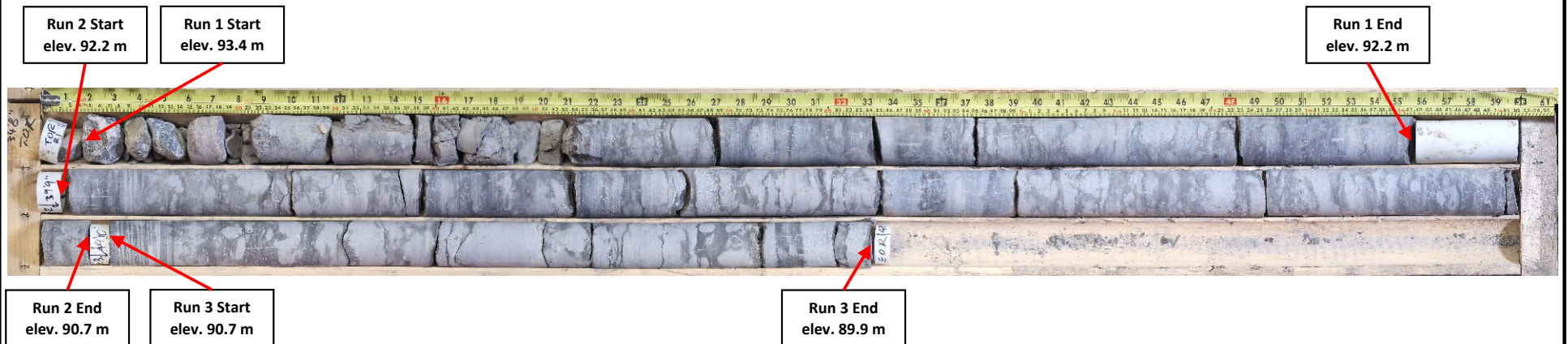
Preliminary Foundation Investigation
Highway 401 Widening
Port Hope, Ontario

GWP: 4005-17-00
Project No.: 28171

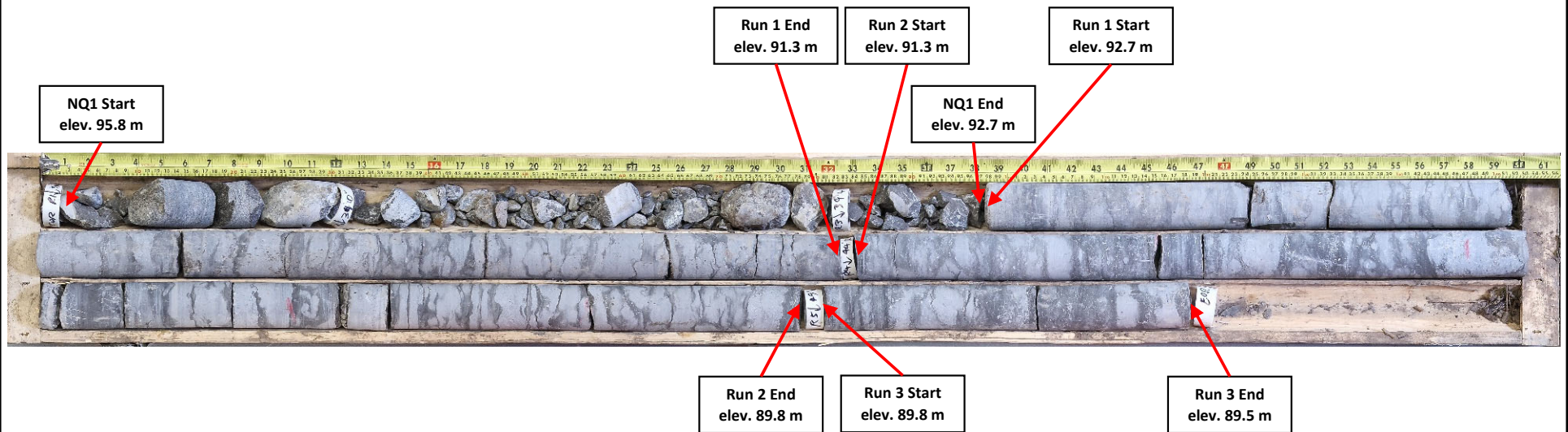
Borehole 20-05
RUN 1 to 3 (of 3)
Elevation 92.7 m to 88.9 m



Borehole HF22-03
Runs 1 to 3
Depth 10.9 to 14.4 m
Elevation 93.4 to 89.9 m



Borehole HF22-04
Runs 1 to 3
Depth 12.3 to 15.5 m
Elevation 92.7 to 89.5 m





Appendix D Site Photographs



Photo 1: North slope of the Hwy 401 embankment looking east from the Ganaraska River



Photo 2: North slope of the Hwy 401 embankment looking west from the east end of the proposed high fill



Photo 3: North slope of the Hwy 401 embankment looking east from Choate Rd



Photo 4: North slope of the Hwy 401 embankment looking west from just east of Choate Rd



Appendix E Comparison of Embankment Widening Alternatives

COMPARISON OF EMBANKMENT WIDENING ALTERNATIVES

	<i>Conventional Embankments</i>	<i>RSS Walls</i>	<i>RSS Slopes</i>	<i>Concrete Retaining Walls</i>
Description	<ul style="list-style-type: none"> An embankment widening with organic silt sub excavated within the footprint constructed using conventional embankment fill with side slopes not steeper than 2H:1V with a 2 m wide mid-height berm where the fill height is greater than 8 m. 	<ul style="list-style-type: none"> Vertical RSS walls constructed at the current north edge of the MTO right of way; a conventional embankment and 2H:1V slope has been assumed above the wall to minimize RSS wall height. 	<ul style="list-style-type: none"> RSS slopes, similar to RSS walls, are formed with a block of reinforced soil with the face inclined at 70° or less; these slopes can be designed to various angles and heights. At this site RSS slopes could be utilized to minimize embankment fill required for the widening. 	<ul style="list-style-type: none"> Vertical concrete retaining walls constructed at the current north edge of the MTO right of way; a conventional embankment and 2H:1V slope has been assumed above the wall to minimize the retaining wall height.
Advantages	<ul style="list-style-type: none"> Conventional embankment fill can be placed quickly No preload required for organic silt sections More favorable seismic site class where organic silt is present 	<ul style="list-style-type: none"> Cost effective for high walls Flexible structure with more tolerance for differential settlement 	<ul style="list-style-type: none"> Cost effective for high walls Can accommodate more differential settlement than RSS walls as RSS slopes do not have concrete face plates and are instead vegetated Ground improvement or sub-excavation and construction of granular pad could be completed in the wet. 	<ul style="list-style-type: none"> No need for reinforcement installed within the wall backfill
Disadvantages	<ul style="list-style-type: none"> Increased costs associated with removal/disposal of organic silt and replacement with granular fill. 	<ul style="list-style-type: none"> It is not recommended to construct the RSS wall on an organic silt subgrade. Sub excavation and construction of a granular pad would be required. Granular pad construction needs to be carried out in the dry. Depending on the length of reinforcement required, excavation for the reinforcing strips may extend into the existing side slope 	<ul style="list-style-type: none"> It is not recommended to construct the RSS slope on an organic silt subgrade. Sub excavation and construction of a granular pad would be required. Depending on the length of reinforcement required, excavation for the reinforcing strips may extend into the existing side slope 	<ul style="list-style-type: none"> It is not recommended to construct a shallow footed retaining wall on an organic silt subgrade. Sub excavation and construction of a granular pad would be required. Cannot accommodate much differential settlement. Depending on the height of the walls, substantial amounts of reinforcement and concrete may be required.
Risks / Consequences	<ul style="list-style-type: none"> Excavation of organic silt will need to be staged in a way to not destabilize the existing embankment. 	<ul style="list-style-type: none"> Excavation of organic silt will need to be staged in a way to not destabilize the existing embankment. 	<ul style="list-style-type: none"> Excavation of organic silt will need to be staged in a way to not destabilize the existing embankment. 	<ul style="list-style-type: none"> Excavation of organic silt will need to be staged in a way to not destabilize the existing embankment.
Relative Cost	<ul style="list-style-type: none"> Lower 	<ul style="list-style-type: none"> Higher 	<ul style="list-style-type: none"> Higher 	<ul style="list-style-type: none"> Very High
Conclusion	<ul style="list-style-type: none"> Recommended where space is available 	<ul style="list-style-type: none"> Recommended west of Ganaraska River 	<ul style="list-style-type: none"> Recommended east of Ganaraska River 	<ul style="list-style-type: none"> Feasible, but not recommended










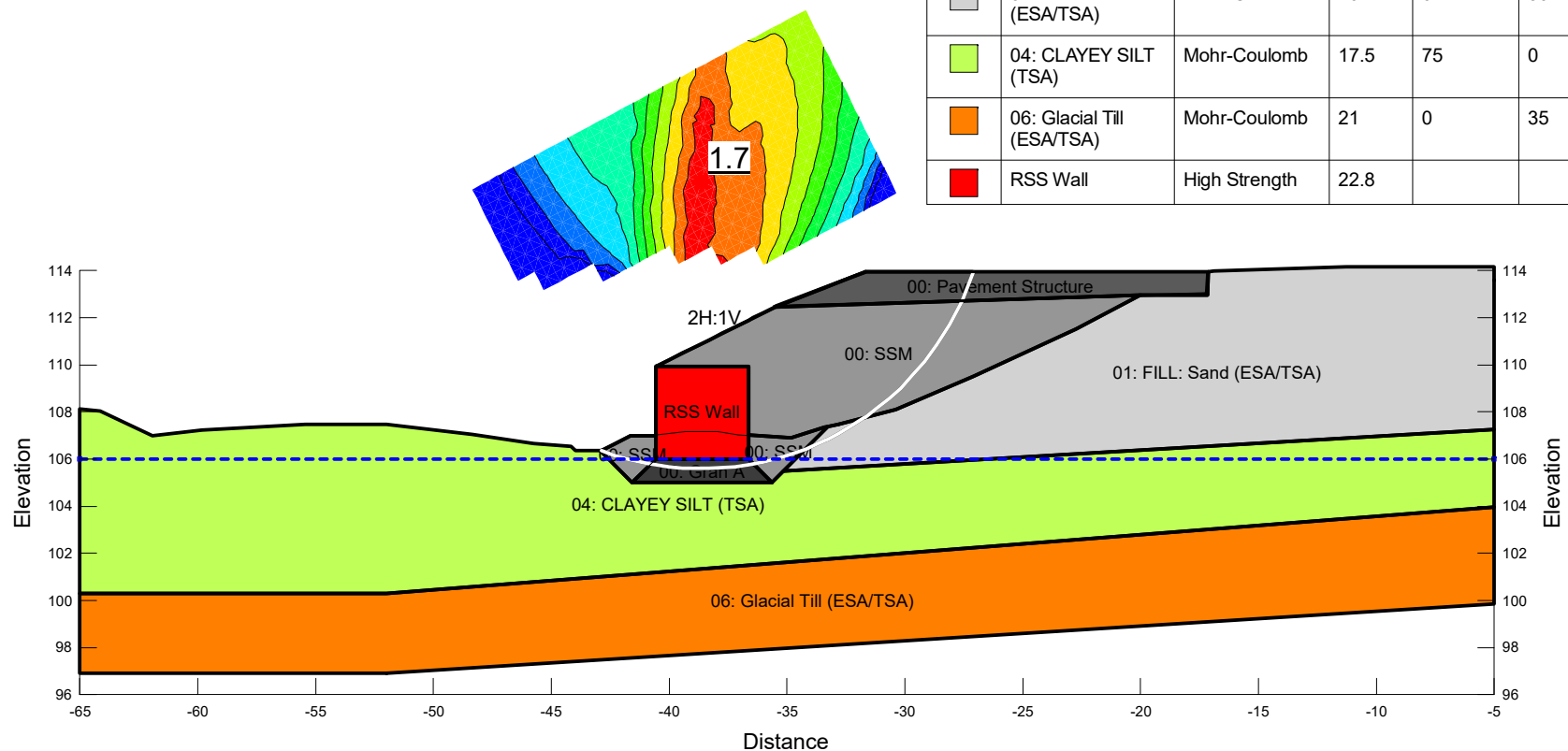
COMPARISON OF ORGANIC SILT TREATMENT OPTIONS BELOW RSS SLOPE

	<i>Sub excavation Below Groundwater Table</i>	<i>Ground Improvement such as Dense Aggregate Columns</i>
Description	<ul style="list-style-type: none"> Excavation to the base of organic silt in the wet following OPSD 203.020 and replacement with rock fill below water table and granular fill above the water table below the RSS slope footprint. 	<ul style="list-style-type: none"> Ground improvement including the potential construction of dense aggregate columns (stone columns) to increase bearing capacity and decrease settlement of the organic silt deposit below the RSS slope footprint.
Advantages	<ul style="list-style-type: none"> Conventional technique using readily available equipment. More favorable seismic site class where organic silt is present. 	<ul style="list-style-type: none"> Eliminates the need for a large sub excavation. Readily constructed for new embankments or widenings. Can be installed through the existing embankment side slope prior to excavation for RSS slope installation. Weak soil in front of the toe of slope is strengthened before temporary excavation for RSS slope. More favorable seismic site class where organic silt is present. Relatively expedient installation compared to sub excavation and replacement option.
Disadvantages	<ul style="list-style-type: none"> Large volume of removal/disposal of organic silt and replacement rock fill will be required. A deeper 1H:1V temporary slope cut into the existing embankment will be required than for stone columns. Temporary excavation will be carried out while weak soil is still present. Slow operation due to the need to work in short sections to maintain stability of existing embankment. 	<ul style="list-style-type: none"> Requires specialty contractor.
Risks / Consequences	<ul style="list-style-type: none"> Contractor must stage the excavation of organic silt in a way to not destabilize the existing embankment 	<ul style="list-style-type: none"> May induce localized settlement in area of stone column installation.
Relative Cost	<ul style="list-style-type: none"> Moderate 	<ul style="list-style-type: none"> Moderate
Conclusion	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Recommended










Appendix F Slope Stability Analysis Figures

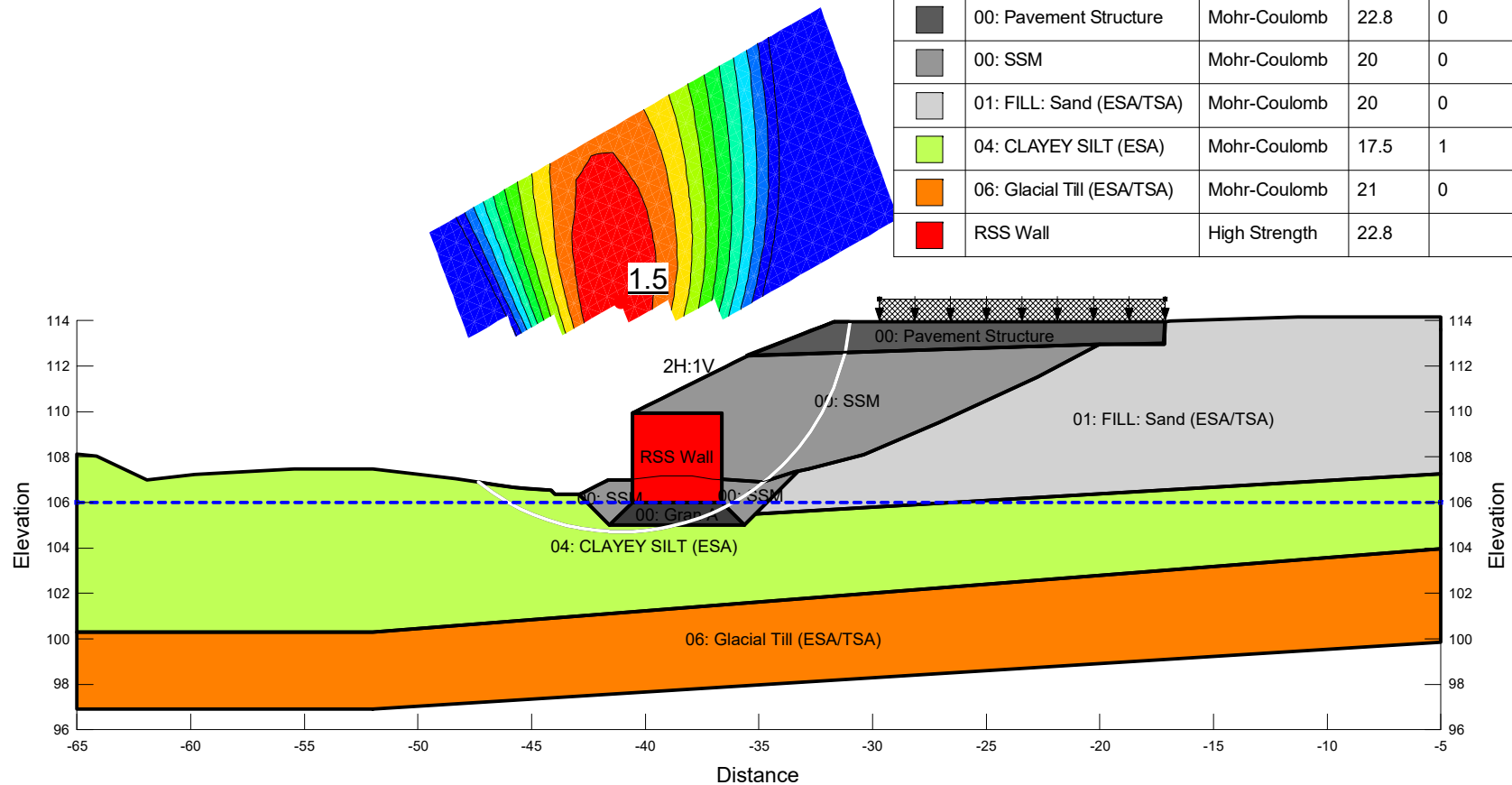
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	04: CLAYEY SILT (TSA)	Mohr-Coulomb	17.5	75	0
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	RSS Wall	High Strength	22.8		



Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis Station 22+600 - Seismic		
Seismic Coefficient H: 0.071g, V: 0g	Last Run 11/28/2022, 11:41:01 AM	Scale 1:300

Additional Details		Figure F1
Name: 1-West of Choate Road		
Comments: Slope Stability Assessment		
Method: Morgenstern-Price, Half-Sine		
Minimum Slip Surface Depth: 1.52 m		
Entry: (-42.877391, 106.356) m, Exit: (-27.104251, 113.94382) m		
Center: (-38.64493, 117.74587) m, Radius: 12.150839 m		








Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	04: CLAYEY SILT (ESA)	Mohr-Coulomb	17.5	1	29
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	RSS Wall	High Strength	22.8		

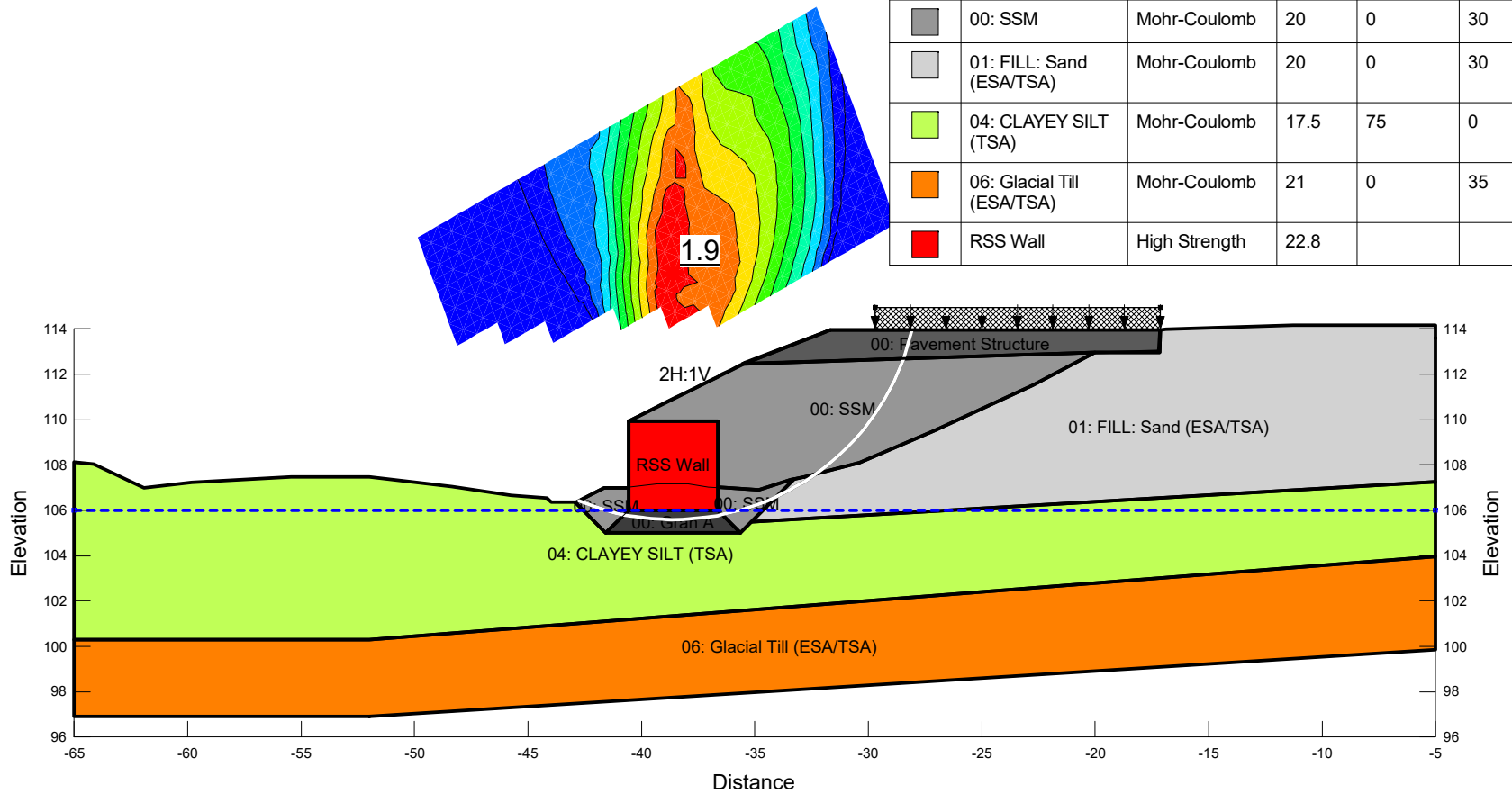


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis Station 22+600 - Static Drained		
Seismic Coefficient H: 0g, V: 0g	Last Run 11/28/2022, 11:41:13 AM	Scale 1:300

Additional Details
Name: 1-West of Choate Road
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-47.352572, 106.89036) m, Exit: (-30.991265, 113.94232) m
Center: (-41.0764, 114.83494) m, Radius: 10.12456 m

Figure F2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	04: CLAYEY SILT (TSA)	Mohr-Coulomb	17.5	75	0
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	RSS Wall	High Strength	22.8		












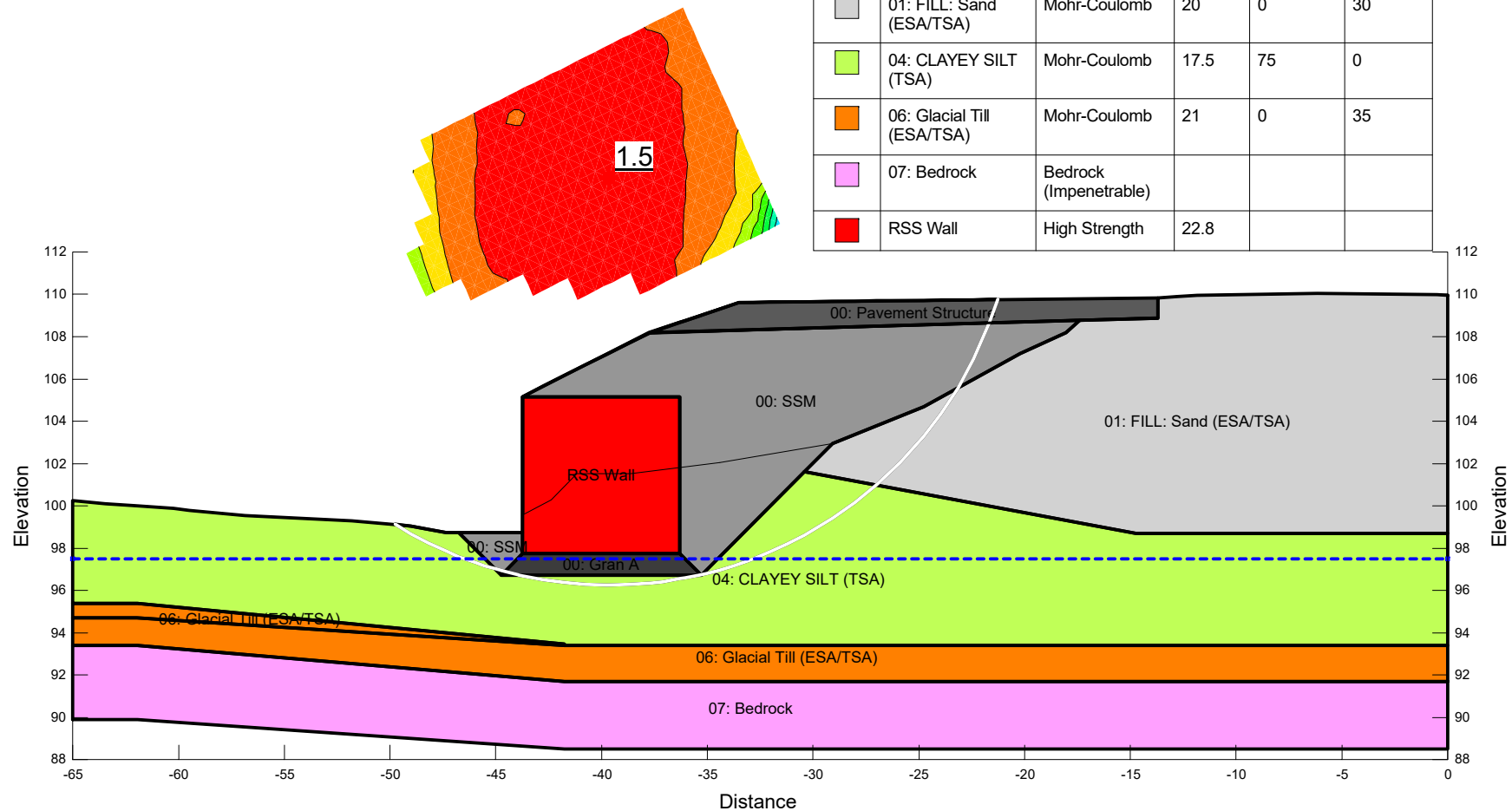
 THURBER	Project		33099- Hwy 401 Choate and Ganaraska DD		Additional Details Name: 1-West of Choate Road Comments: Slope Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (-42.763752, 106.41383) m, Exit: (-28.065155, 113.94348) m Center: (-38.617388, 116.43109) m, Radius: 10.841485 m
	Analysis		Station 22+600 - Static Undrained		
	Seismic Coefficient	Last Run	Scale		
	H: 0g, V: 0g	11/28/2022, 11:41:26 AM		1:300	

Figure F3

Figure F3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	04: CLAYEY SILT (TSA)	Mohr-Coulomb	17.5	75	0
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Wall	High Strength	22.8		



Project
33099- Hwy 401 Choate and Ganaraska DD

Analysis
Station 22+750 - Seismic

Seismic Coefficient
H: 0.071g, V: 0g









Last Run
11/28/2022, 11:40:32 AM

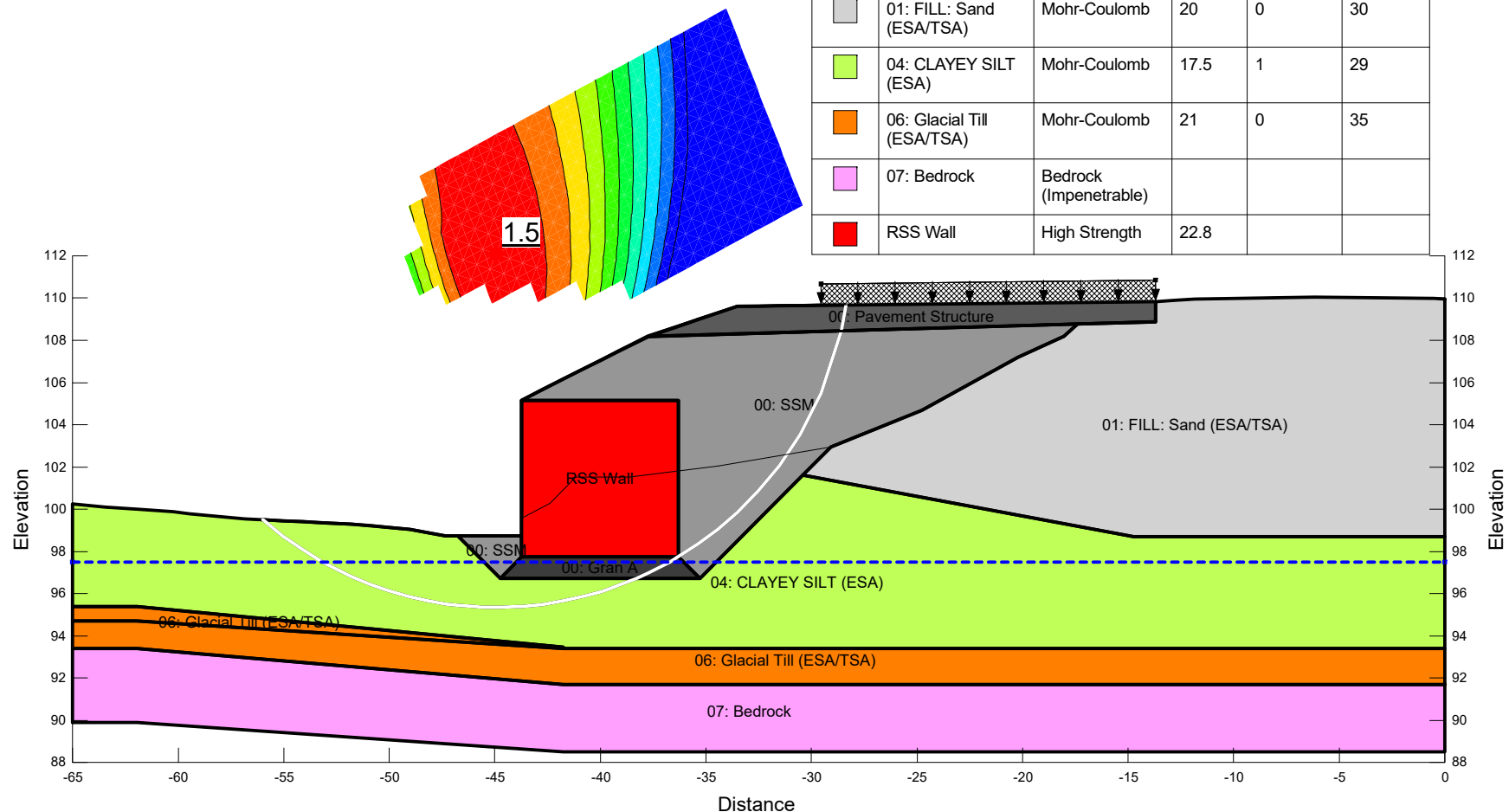
Scale
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Additional Details

Name: 2-West of Choate Road
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-49.770594, 99.11976) m, Exit: (-21.27281, 109.75678) m
Center: (-39.655478, 115.51312) m, Radius: 19.262863 m

Figure F4









Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	04: CLAYEY SILT (ESA)	Mohr-Coulomb	17.5	1	29
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Wall	High Strength	22.8		

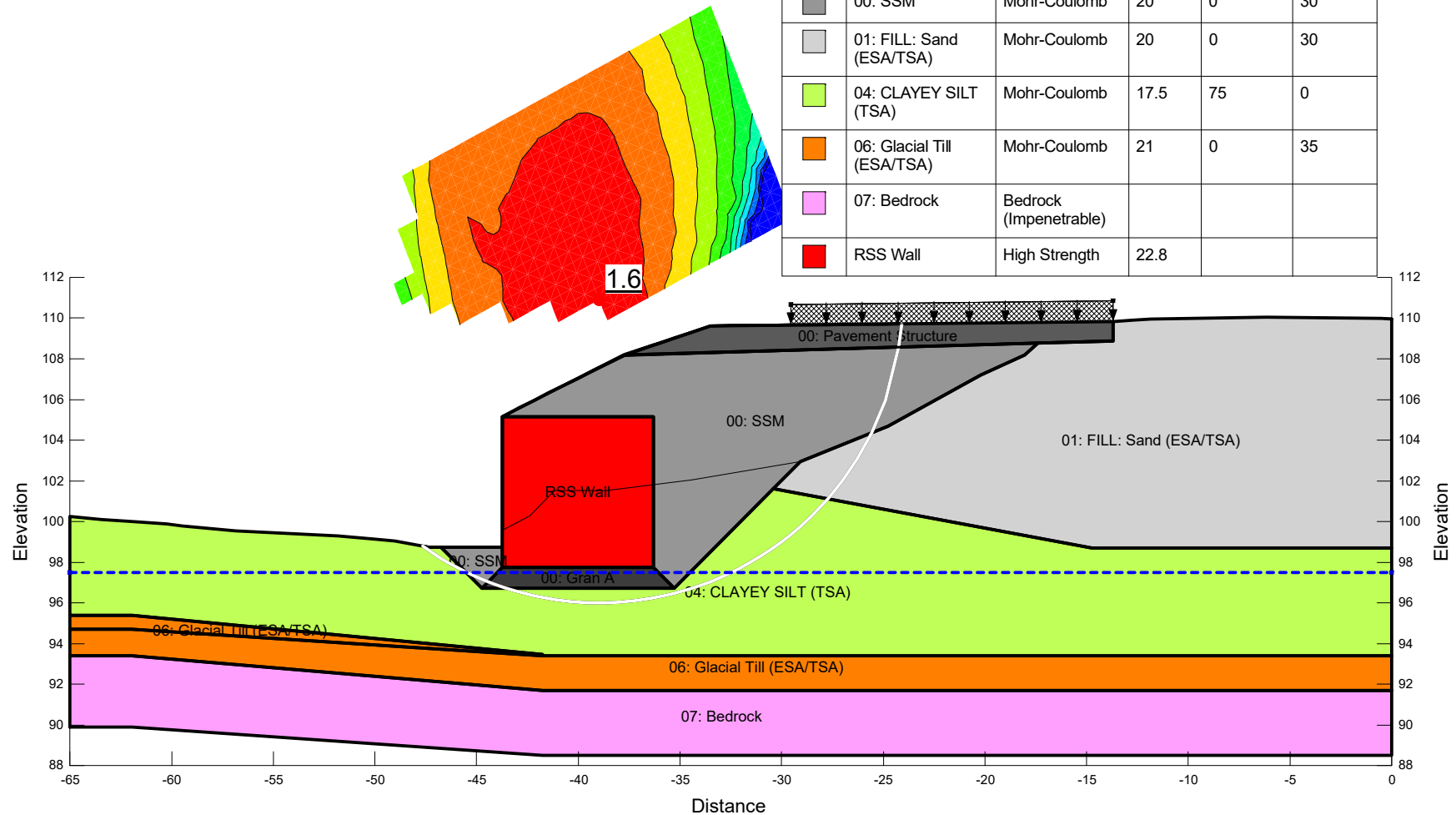


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis Station 22+750 - Static Drained		
Seismic Coefficient H: 0g, V: 0g	Last Run 11/28/2022, 11:40:41 AM	Scale 1:310

Additional Details
Name: 2-West of Choate Road
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-55.98833, 99.492432) m, Exit: (-28.360896, 109.67501) m
Center: (-44.946986, 112.10574) m, Radius: 16.763259 m

Figure F5

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	04: CLAYEY SILT (TSA)	Mohr-Coulomb	17.5	75	0
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Wall	High Strength	22.8		



Project
33099- Hwy 401 Choate and Ganaraska DD

Analysis
Station 22+750 - Static Undrained

Seismic Coefficient
H: 0g, V: 0g









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11/28/2022, 11:40:50 AM

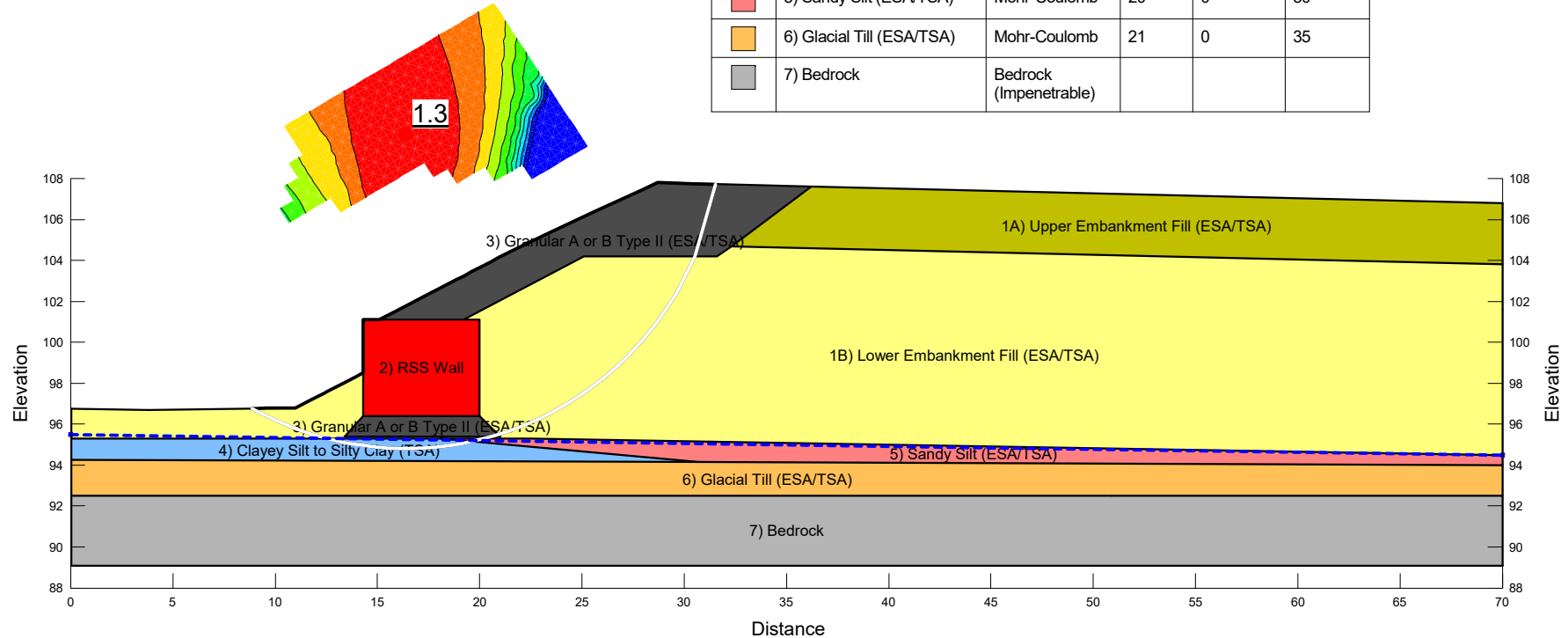
Scale
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Additional Details

Name: 2-West of Choate Road
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-47.656255, 98.787131) m, Exit: (-24.094434, 109.72423) m
Center: (-38.971124, 110.92493) m, Radius: 14.925065 m

Figure F6









Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1A) Upper Embankment Fill (ESA/TSA)	Mohr-Coulomb	21	0	32
	1B) Lower Embankment Fill (ESA/TSA)	Mohr-Coulomb	20	0	30
	2) RSS Wall	High Strength	22.8		
	3) Granular A or B Type II (ESA/TSA)	Mohr-Coulomb	22.8	0	35
	4) Clayey Silt to Silty Clay (TSA)	Mohr-Coulomb	17.5	75	0
	5) Sandy Silt (ESA/TSA)	Mohr-Coulomb	20	0	30
	6) Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	7) Bedrock	Bedrock (Impenetrable)			

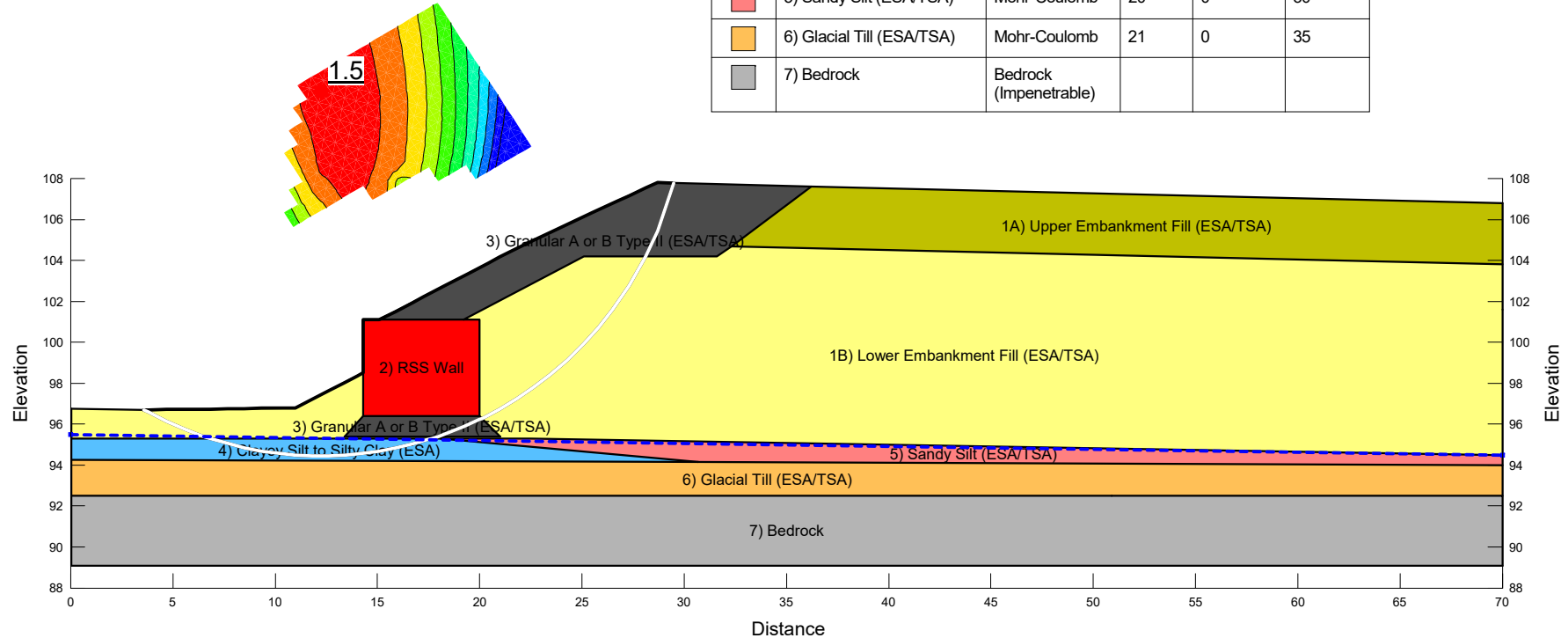


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis East Choate Road Foreslope - Seismic		
Seismic Coefficient H: 0.071g, V: 0g	Last Run 11/28/2022, 01:39:20 PM	Scale 1:325

Additional Details
 Name: 1-Choate Rd to Ganaraska River
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (8.8755991, 96.770494) m, Exit: (31.523343, 107.72471) m
 Center: (16.37, 110.165) m, Radius: 15.348577 m

Figure F7









Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1A) Upper Embankment Fill (ESA/TSA)	Mohr-Coulomb	21	0	32
	1B) Lower Embankment Fill (ESA/TSA)	Mohr-Coulomb	20	0	30
	2) RSS Wall	High Strength	22.8		
	3) Granular A or B Type II (ESA/TSA)	Mohr-Coulomb	22.8	0	35
	4) Clayey Silt to Silty Clay (ESA)	Mohr-Coulomb	17.5	1	29
	5) Sandy Silt (ESA/TSA)	Mohr-Coulomb	20	0	30
	6) Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	7) Bedrock	Bedrock (Impenetrable)			

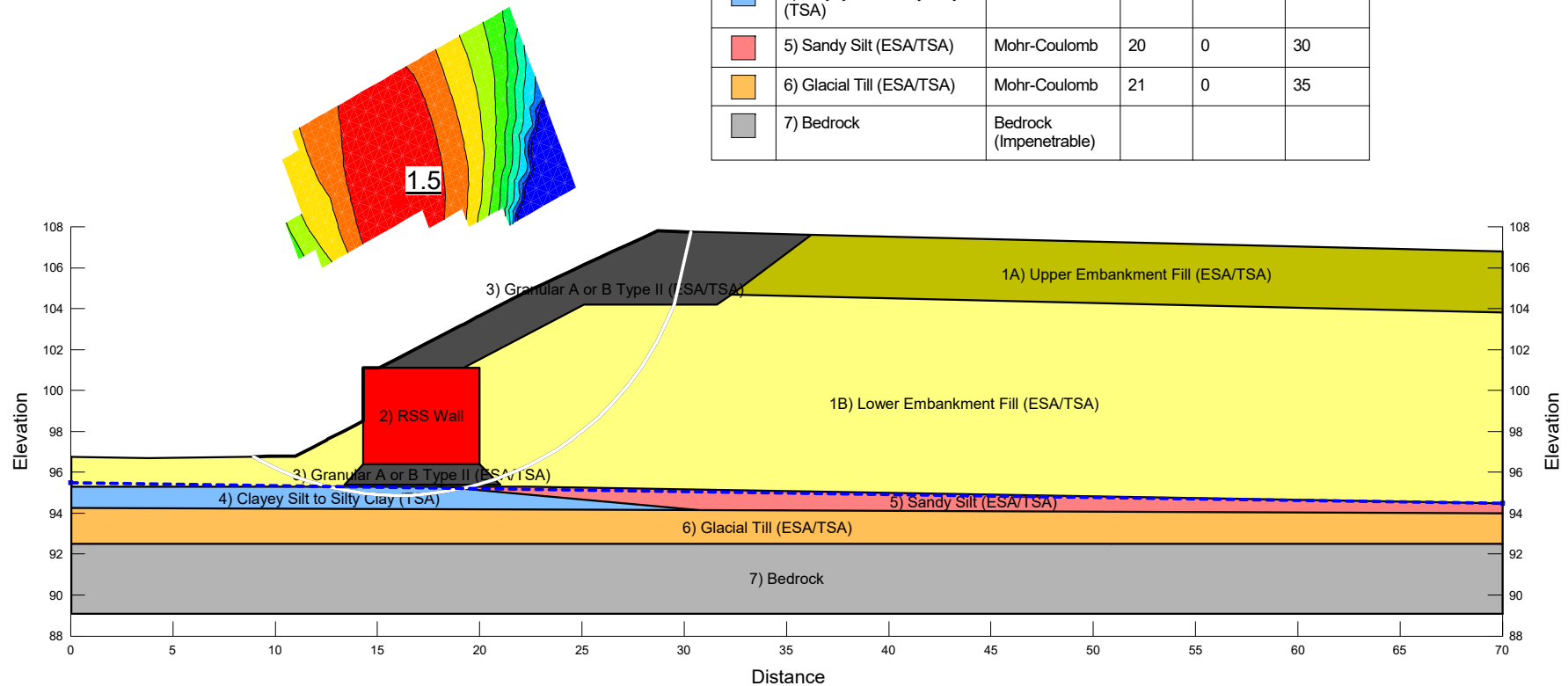


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis East Choate Road Foreslope - Static Drained		
Seismic Coefficient H: 0g, V: 0g	Last Run 11/28/2022, 01:39:25 PM	Scale 1:325

Additional Details
 Name: 1-Choate Rd to Ganaraska River
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (3.5818926, 96.703161) m, Exit: (29.482316, 107.77914) m
 Center: (12.243, 112.27093) m, Radius: 17.814887 m

Figure F8











Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1A) Upper Embankment Fill (ESA/TSA)	Mohr-Coulomb	21	0	32
	1B) Lower Embankment Fill (ESA/TSA)	Mohr-Coulomb	20	0	30
	2) RSS Wall	High Strength	22.8		
	3) Granular A or B Type II (ESA/TSA)	Mohr-Coulomb	22.8	0	35
	4) Clayey Silt to Silty Clay (TSA)	Mohr-Coulomb	17.5	75	0
	5) Sandy Silt (ESA/TSA)	Mohr-Coulomb	20	0	30
	6) Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	7) Bedrock	Bedrock (Impenetrable)			

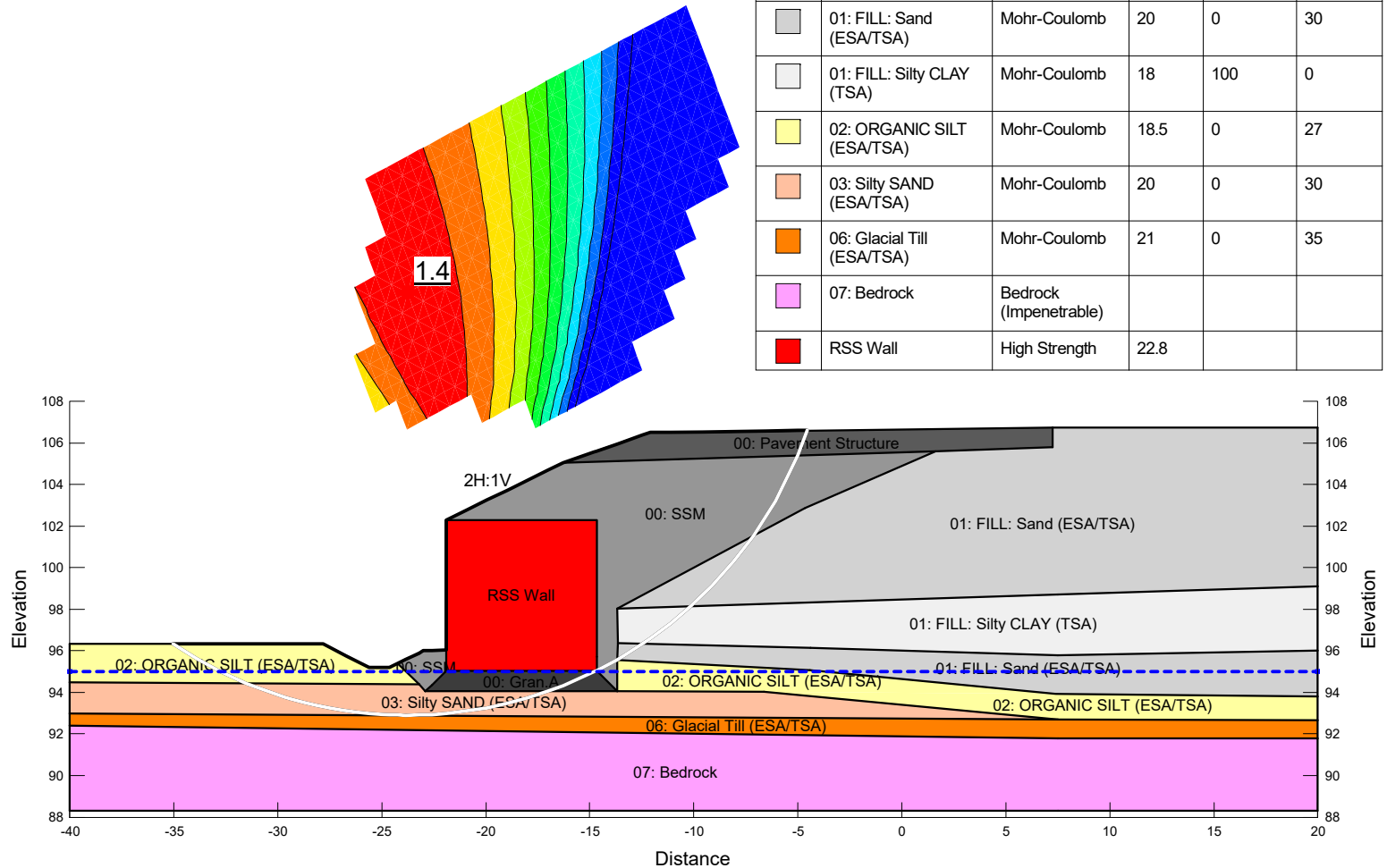


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis East Choate Road Foreslope - Static Undrained		
Seismic Coefficient H: 0g, V: 0g	Last Run 11/28/2022, 01:39:28 PM	Scale 1:325

Additional Details
Name: 1-Choate Rd to Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (8.9277983, 96.771219) m, Exit: (30.337029, 107.75635) m
Center: (16.055388, 109.23515) m, Radius: 14.357998 m

Figure F9











Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran.A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (TSA)	Mohr-Coulomb	18	100	0
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	03: Silty SAND (ESA/TSA)	Mohr-Coulomb	20	0	30
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Wall	High Strength	22.8		

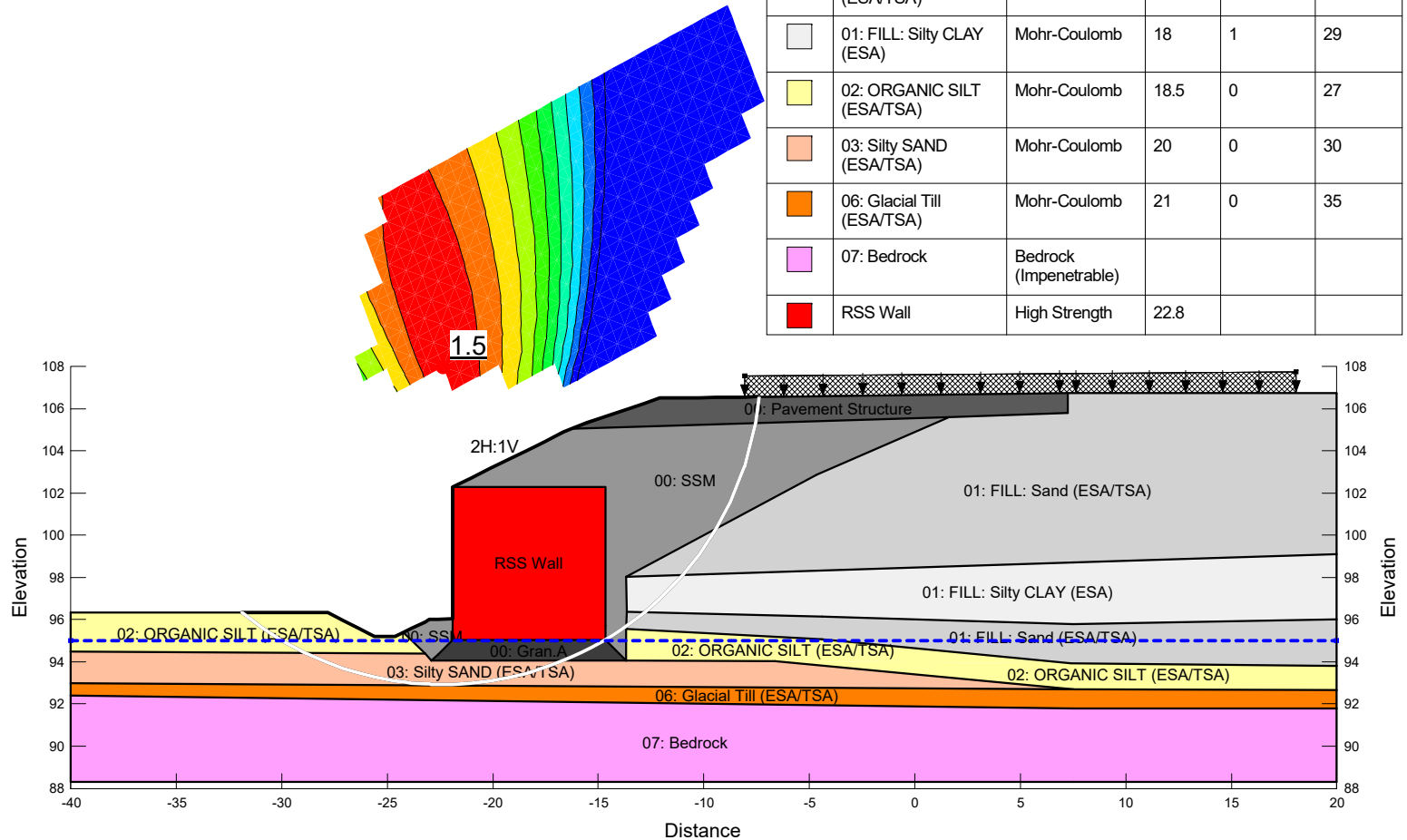


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis Station 22+850 - Seismic		
Seismic Coefficient H: 0.071g, V: 0g	Last Run 11/28/2022, 03:09:03 PM	Scale 1:325

Additional Details
 Name: 2-Choate Rd to Ganaraska River
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-35.051144, 96.323) m, Exit: (-4.5542145, 106.59794) m
 Center: (-23.769071, 113.23307) m, Radius: 20.328197 m

Figure F10











Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran.A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (ESA)	Mohr-Coulomb	18	1	29
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	03: Silty SAND (ESA/TSA)	Mohr-Coulomb	20	0	30
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Wall	High Strength	22.8		

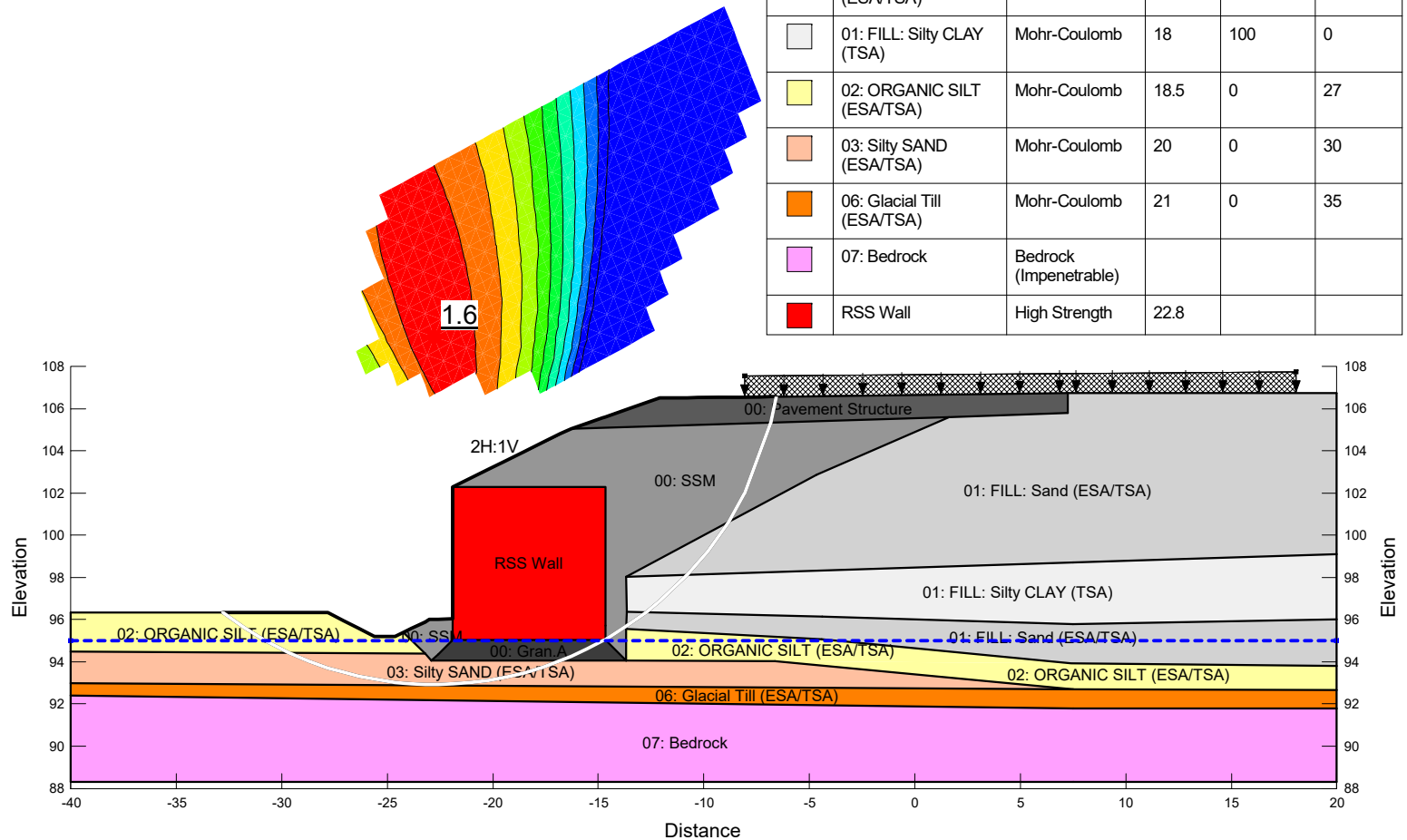


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis Station 22+850 - Static Drained		
Seismic Coefficient H: 0g, V: 0g	Last Run 11/28/2022, 03:09:10 PM	Scale 1:325

Additional Details
Name: 2-Choate Rd to Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-31.884828, 96.323) m, Exit: (-7.377921, 106.56154) m
Center: (-22.3649, 107.98522) m, Radius: 15.054448 m

Figure F11










Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Gran.A	Mohr-Coulomb	22.8	0	35
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (TSA)	Mohr-Coulomb	18	100	0
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	03: Silty SAND (ESA/TSA)	Mohr-Coulomb	20	0	30
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Wall	High Strength	22.8		

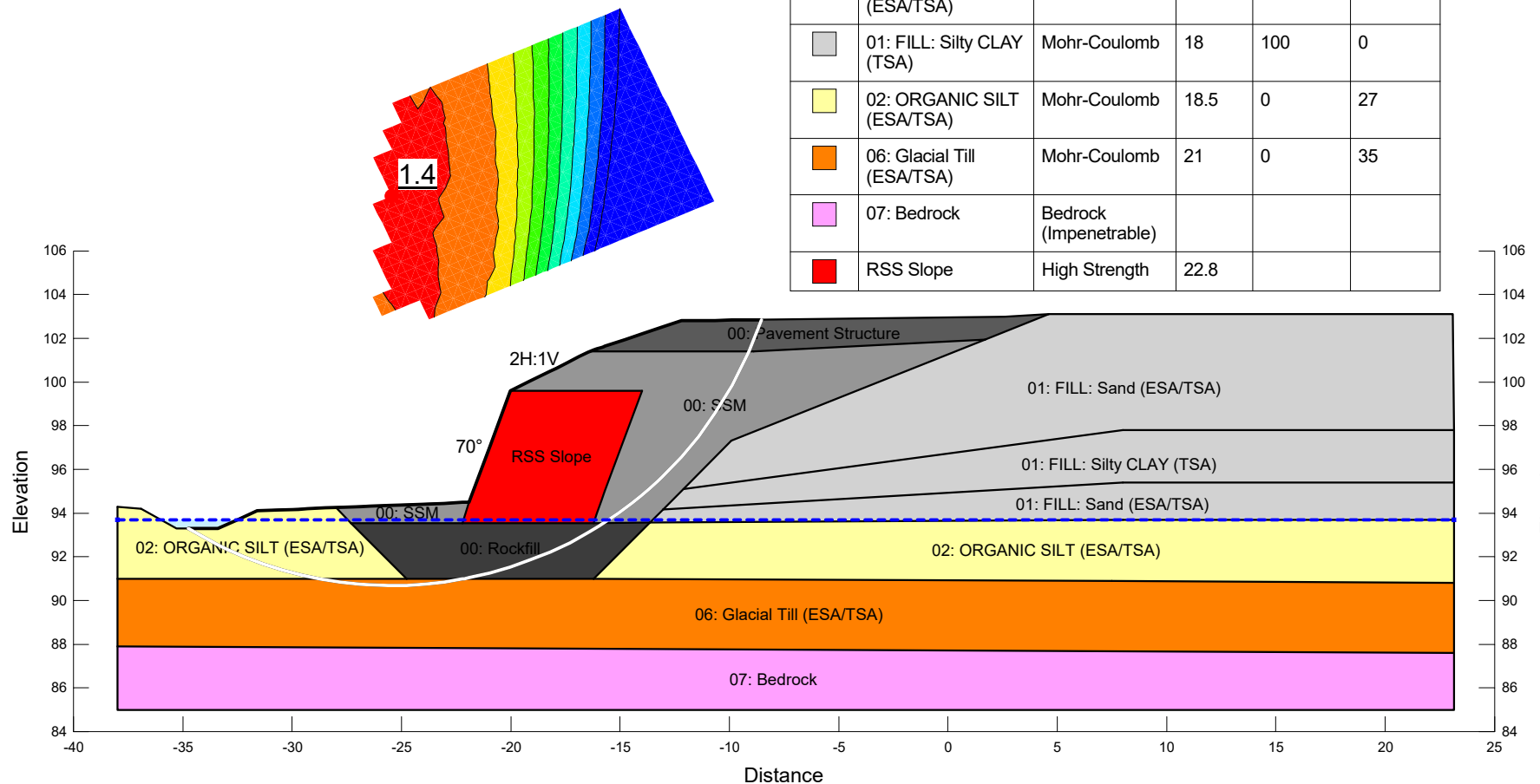


Project 33099- Hwy 401 Choate and Ganaraska DD		
Analysis Station 22+850 - Static Undrained		
Seismic Coefficient H: 0g, V: 0g	Last Run 11/28/2022, 03:09:20 PM	Scale 1:325

Additional Details
Name: 2-Choate Rd to Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-32.789977, 96.323) m, Exit: (-6.5550755, 106.57215) m
Center: (-22.776075, 109.39177) m, Radius: 16.464238 m

Figure F12

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: Rockfill	Mohr-Coulomb	18	0	42
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (TSA)	Mohr-Coulomb	18	100	0
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	07: Bedrock	Bedrock (Impenetrable)			
	RSS Slope	High Strength	22.8		



Project
33099 - Hwy 401 Choate and Ganaraska DD

Analysis
Station 22+970 - Seismic

Seismic Coefficient
H: 0.071g, V: 0g

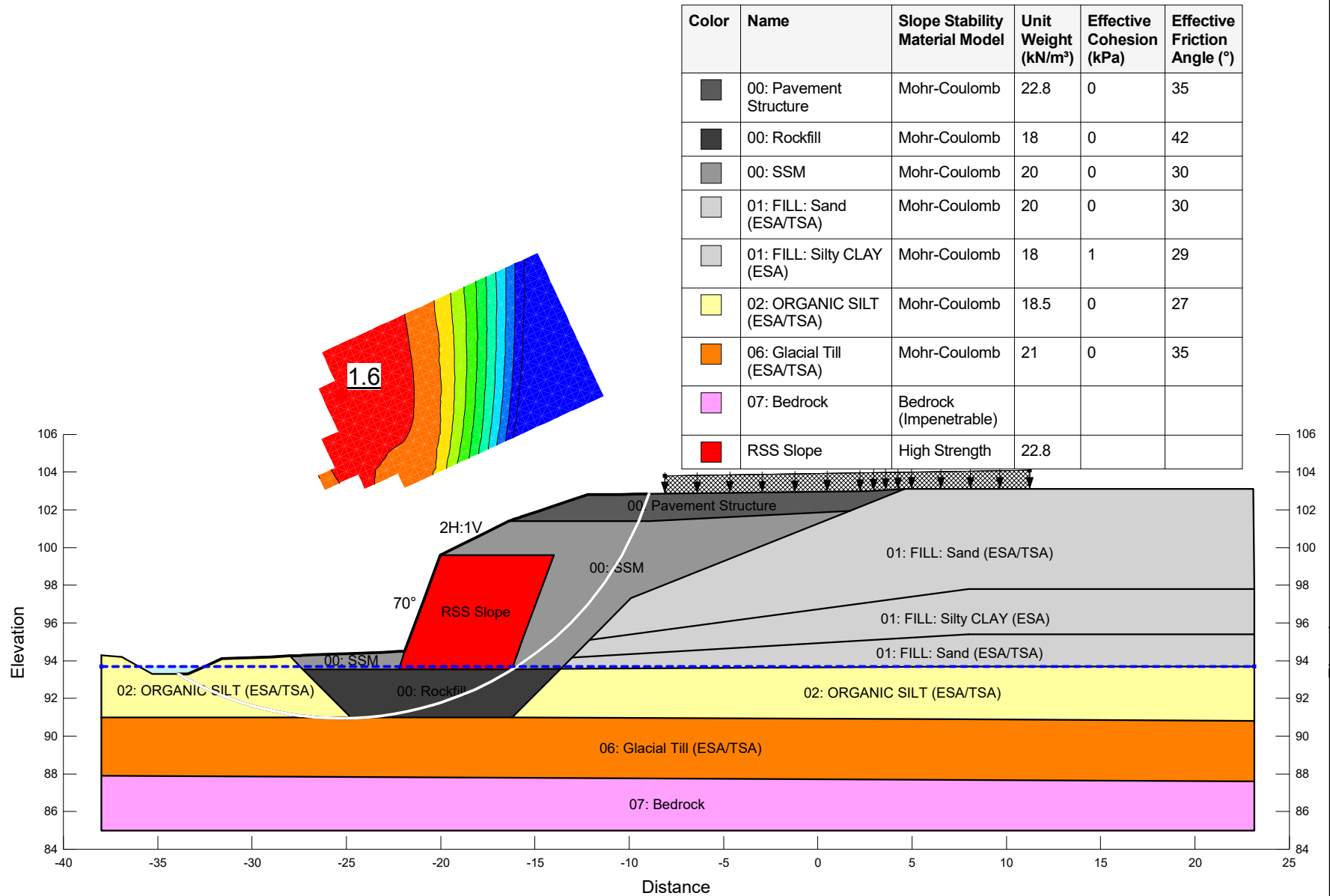
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Scale
1:300

Additional Details

Name: 2-East of Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-34.736233, 93.3) m, Exit: (-8.5364706, 102.84951) m
Center: (-25.441459, 108.51434) m, Radius: 17.82888 m

Figure F13



Project
33099 - Hwy 401 Choate and Ganaraska DD

Analysis
Station 22+970 - Static Drained

Seismic Coefficient
H: 0g, V: 0g

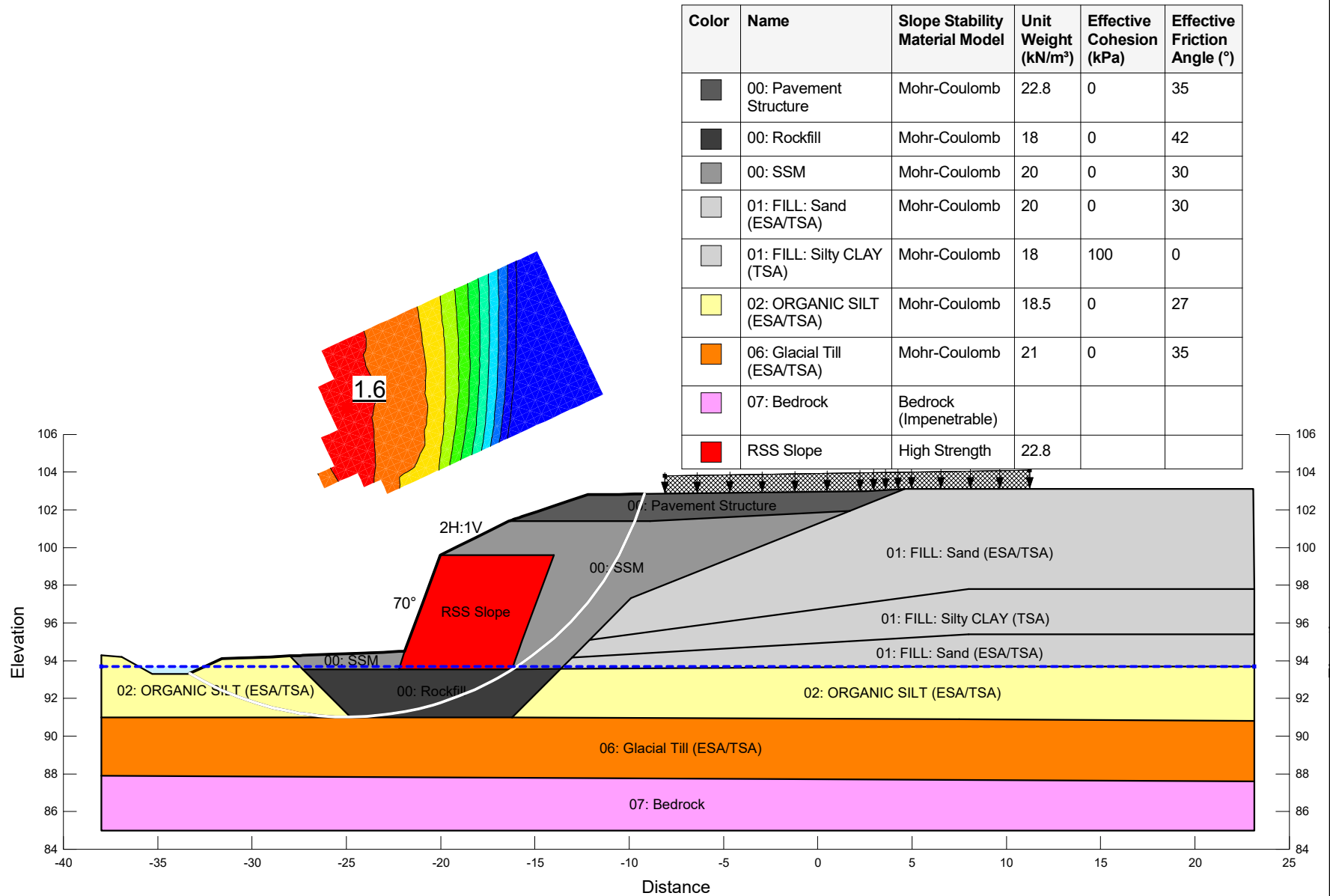
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Scale
1:300

Additional Details

Name: 2-East of Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-33.91258, 93.3) m, Exit: (-8.9409871, 102.84404) m
Center: (-25.249744, 108.07464) m, Radius: 17.127017 m

Figure F14



Project
33099 - Hwy 401 Choate and Ganaraska DD

Analysis
Station 22+970 - Static Undrained

Seismic Coefficient
H: 0g, V: 0g










Last Run
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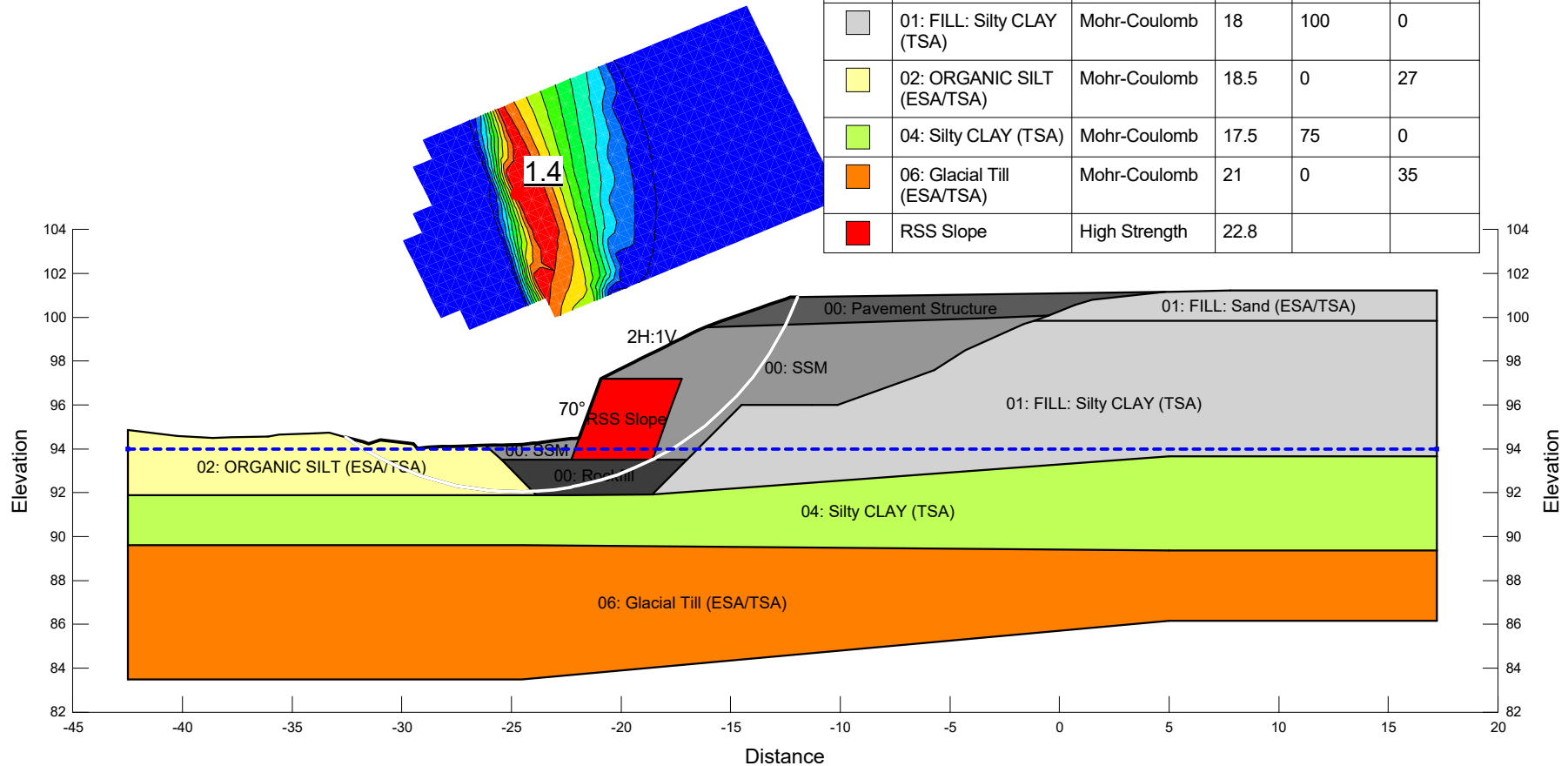
Scale
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Additional Details

Name: 2-East of Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-33.323504, 93.333998) m, Exit: (-9.1963788, 102.84059) m
Center: (-24.929744, 107.40102) m, Radius: 16.380974 m

Figure F15










Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: Rockfill	Mohr-Coulomb	18	0	42
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (TSA)	Mohr-Coulomb	18	100	0
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	04: Silty CLAY (TSA)	Mohr-Coulomb	17.5	75	0
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	RSS Slope	High Strength	22.8		

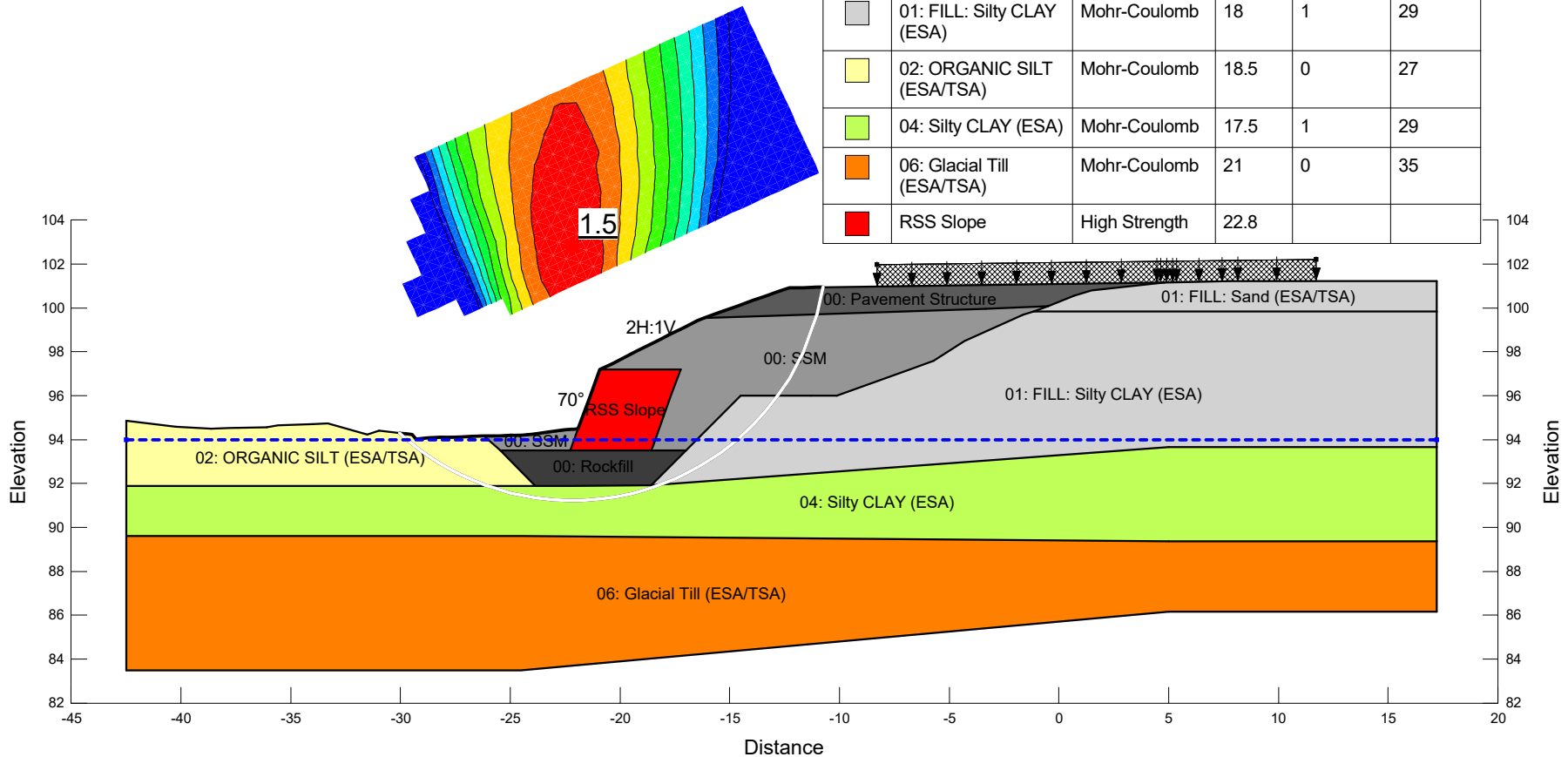


Project 33099 - Hwy 401 Choate and Ganaraska DD		
Analysis Station 23+050 - Seismic		
Seismic Coefficient H: 0.071g, V: 0g	Last Run 2022-12-07, 01:16:41 PM	Scale 1:300

Additional Details
Name: 3-East of Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-32.565692, 94.529027) m, Exit: (-11.962833, 100.92246) m
Center: (-24.721545, 105.64434) m, Radius: 13.604442 m

Figure F16

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: Rockfill	Mohr-Coulomb	18	0	42
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (ESA)	Mohr-Coulomb	18	1	29
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	04: Silty CLAY (ESA)	Mohr-Coulomb	17.5	1	29
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	RSS Slope	High Strength	22.8		



Project
33099 - Hwy 401 Choate and Ganaraska DD

Analysis
Station 23+050 - Static Drained

Seismic Coefficient
H: 0g, V: 0g










Last Run
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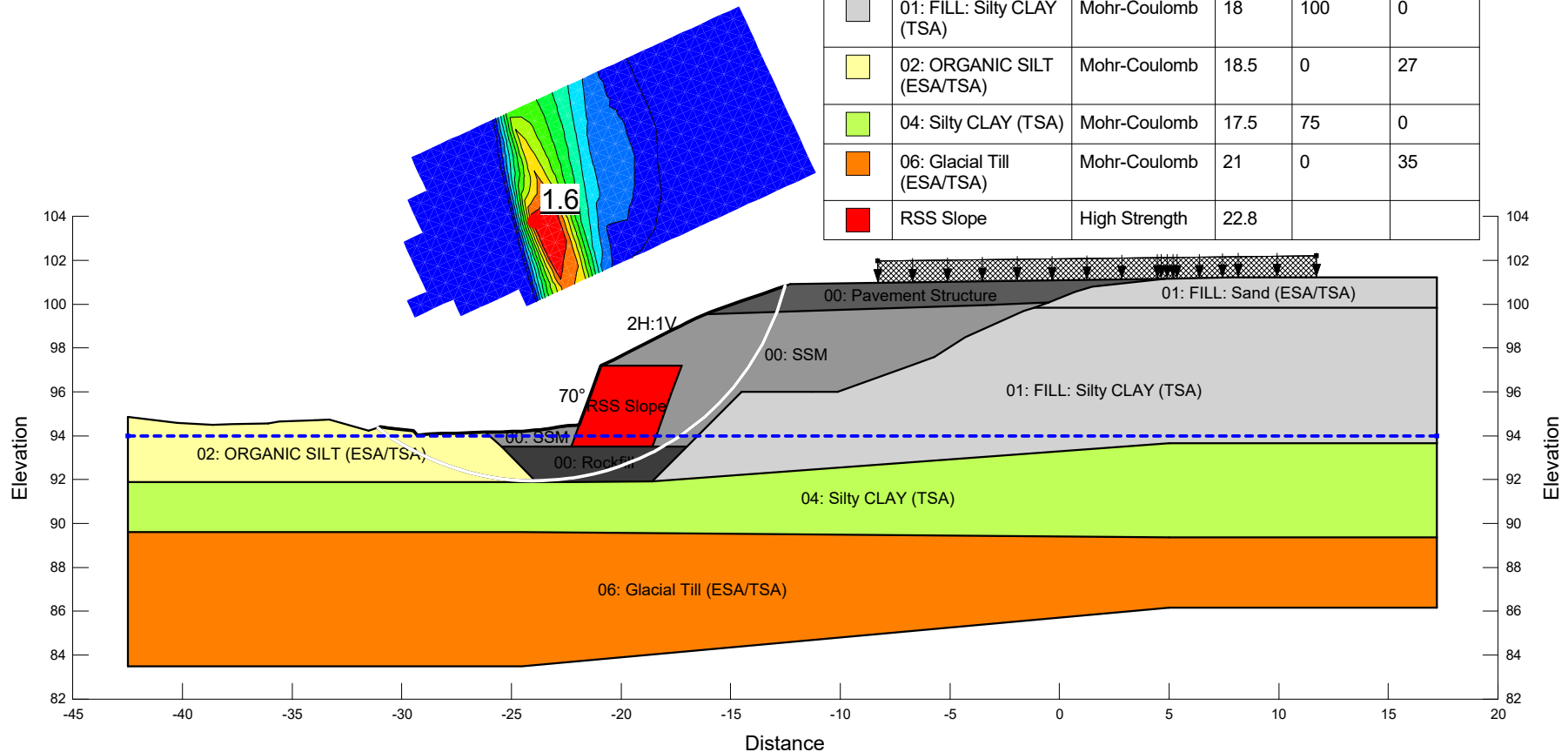
Scale
1:300

Additional Details

Name: 3-East of Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-30.027551, 94.29046) m, Exit: (-10.748799, 100.93935) m
Center: (-22.179744, 102.80964) m, Radius: 11.58294 m

Figure F17

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	00: Pavement Structure	Mohr-Coulomb	22.8	0	35
	00: Rockfill	Mohr-Coulomb	18	0	42
	00: SSM	Mohr-Coulomb	20	0	30
	01: FILL: Sand (ESA/TSA)	Mohr-Coulomb	20	0	30
	01: FILL: Silty CLAY (TSA)	Mohr-Coulomb	18	100	0
	02: ORGANIC SILT (ESA/TSA)	Mohr-Coulomb	18.5	0	27
	04: Silty CLAY (TSA)	Mohr-Coulomb	17.5	75	0
	06: Glacial Till (ESA/TSA)	Mohr-Coulomb	21	0	35
	RSS Slope	High Strength	22.8		



Project 33099 - Hwy 401 Choate and Ganaraska DD		
Analysis Station 23+050 - Static Undrained		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022-12-07, 01:17:09 PM	Scale 1:300

Additional Details
Name: 3-East of Ganaraska River
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-31.102648, 94.361878) m, Exit: (-12.508941, 100.83944) m
Center: (-23.951074, 103.75864) m, Radius: 11.808647 m

Figure F18



Appendix G GSC Seismic Hazard

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 43.970N 78.295W

User File Reference: Hwy 401 High Fill Widening

2020-08-19 19:19 UT

Requested by: Thurber Engineering

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.163	0.086	0.049	0.014
Sa (0.1)	0.204	0.114	0.069	0.021
Sa (0.2)	0.178	0.104	0.066	0.023
Sa (0.3)	0.140	0.085	0.056	0.020
Sa (0.5)	0.105	0.066	0.044	0.016
Sa (1.0)	0.059	0.038	0.025	0.008
Sa (2.0)	0.029	0.019	0.012	0.003
Sa (5.0)	0.007	0.004	0.003	0.001
Sa (10.0)	0.003	0.002	0.001	0.001
PGA (g)	0.112	0.063	0.038	0.012
PGV (m/s)	0.087	0.052	0.033	0.010

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Appendix H List of Referenced Specifications and Contract Provisions



1. The following Special Provisions and OPSS Documents referenced in this report:

- OPSS.PROV 206
- OPSS.PROV 209
- OPSS.PROV 501
- OPSS.PROV 539
- OPSS.PROV 803
- OPSS.PROV 804
- OPSS.PROV 805
- OPSS.PROV 902
- OPSS.PROV 1010
- OPSD 203.020
- OPSD 208.010
- OPSD 219.110
- OPSD 3090.101
- SP105S09
- SP110S06
- SP599S22
- FOUN0003

2. Contract Provision – Obstructions

“Obstructions should be expected within the existing fill. The obstructions may interfere with pile installation and the installation of roadway protection. The Contractor should be prepared to remove, dislodge or otherwise penetrate these obstructions to advance the piles or install the roadway protection systems to the specified tip elevation/resistance while meeting the specified deflection tolerances.”

3. Contract Provision – Foundation Excavation

“The Contractor is advised that the groundwater levels are high at this site. Preparation of the founding surfaces for the RSS slope East of the Ganaraska River will require excavation below the groundwater level. Installation of a temporary protection system and dewatering of the excavation for construction of the granular pad in the dry is considered difficult at this site.

In view of the site conditions, preparation of the founding surface is to entail sub excavation in the wet to the specified depths (stiff and compact to dense native soils) in short sections of about 5 m length followed by immediate backfilling with select rock fill to above the groundwater level, followed by placement of granular fill to the design founding level as per the Contract Drawings. All rock fill source materials shall be clean, hard, durable particles free



of earth, humus, clay or other coatings, clay lumps, shale or shaley partings and other deleterious materials. A gradation of the select rock fill is provided below:

Sieve Size	Percent Passing (%)
150 mm	100
106 mm	50 – 100
75 mm	15 – 80
26.5 mm	0 – 15
0.075 mm	0 – 2

The contractor must carry out the work in a manner which minimizes disturbance to the excavation base and ensure that the excavation does not cause slope instability of the existing embankment by controlling the length of excavation open at any one time, use of shoring, or other suitable means.

Large boulders may be encountered within the excavation depth. Removal of these boulders will require appropriate excavating equipment, and may result in areas of over-excavation requiring additional rock fill to backfill.

Selection of the equipment and methodology to excavate and prepare the founding surface remains the responsibility of the Contractor, and should be based on his interpretation of the subsurface conditions presented in the Foundation Investigation Report as well as the surface conditions exposed at the site.”

4. Contract Provision – Protection of Sensitive Foundation Soils

“The Contractor is advised that the soil that will be exposed at the RSS wall subgrade level is moisture sensitive and may become disturbed or otherwise negatively impacted when subjected to construction or personnel traffic, freeze-thaw actions, ingress or ponding water. The Contractor shall be responsible for protecting the subgrade by implementing adequate groundwater control measures and minimizing construction and personnel traffic on the founding subgrade.”