



THURBER ENGINEERING LTD.

**PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
GOSHEN ROAD OVERPASSES, SITE NO. 29-410
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-225

Report to:

Ministry of Transportation Ontario

Latitude: 45.445730°
Longitude: -76.584160°

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) under Assignment No. 4018-E-0009 to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

This section of the report presents the factual findings obtained from a foundation investigation completed at the future Eastbound and Westbound Overpass structures at Goshen Road and Highway 17. The existing Highway 17 alignment will become the future Highway 17 eastbound lanes. Thurber carried out the investigation under Ministry of Transportation (MTO) Assignment No. 4018-E-0009.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

Previous foundation information from preliminary investigations completed in 2003/2004 for the currently proposed structures was available under Geocres 31F-134 and 31F-141.

It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work.

2 SITE DESCRIPTION

2.1 General

The site is located approximately 50 m east of the existing at grade intersection of Highway 17 and Goshen Road on Highway 17 in McNab/Braeside Township. It is proposed that Goshen Road will cross under Highway 17 at approximate Station 11+684 of the westbound (new) alignment and Station 11+799 of the eastbound (existing) alignment with a skew of approximately 36 degrees to the perpendicular of Highway 17. At the location of the proposed structures, Highway 17 is oriented east to west and Goshen Road is oriented roughly southeast to northwest.



For project purposes, the highway and sideroad are herein described as oriented east-west and north-south, respectively.

The land adjacent to the site consists of residential properties, agricultural fields, forests and wetter areas. The terrain generally slopes down to the south and west. Rock outcrops are visible in the existing ditch line north of existing Highway 17. Rock cuts are present 250 m east and 350 m west of the site on Highway 17. The existing highway in this area is an undivided rural highway with partially paved shoulders. In the westbound direction there is a single through lane and a right turn lane for Goshen Road. In the eastbound direction there are two through lanes and a right turn lane onto Goshen Road.

Goshen Road is a paved two lane roadway with gravel shoulders.

2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Algonquin Highlands. The Algonquin Highlands are characterized primarily by rough rounded bedrock knobs and ridges. The bedrock is generally shallow, however the depth to bedrock can vary greatly over short distances. Base mapping by the Ontario Geological Survey indicates the bedrock in the area consists of gneisses and migmatites derived from early felsic plutonic rock such as granodiorite, tonalite, monzogranite, syenogranite. Mapping also suggests that multiple faults intersect at or near the site.

Photographs showing the existing conditions in the area of the site at the time of the field investigation are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field-testing program was carried out in two separate mobilizations. Truck accessible locations were drilled between August 29 and September 18, 2019. The off-road locations were drilled between July 6 and July 14, 2020. The field investigation consisted of advancing 13 boreholes identified as Boreholes GOS19-01 through GOS19-12 and GOS19-04W. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations. Traffic control was provided where required for lane closures to complete the on-road boreholes and access to the off-road boreholes.

Previously drilled Boreholes GOS-1 through GOS-4 were completed by Thurber in September and October 2003 as part of a preliminary investigation for the structures required for the twinning of Highway 17. Data from these boreholes has been fully incorporated into this report.

The locations of the 2019 and 2020 boreholes were surveyed by Thurber for both location and elevation with a Trimble Catalyst DA1 antenna with centimeter accuracy. The nearby benchmark, HCP 138 was checked as a reference during the surveys. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A,



the individual Record of Borehole sheets in Appendix B, and in Table 3-1 below. The site is located within MTM Zone 9.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
GOS19-05	North Cut 9+900	5 034 069.5 (45.446525)	298 128.7 (-76.585284)	167.1	10.7
GOS19-06	North Cut 9+925	5 034 052.3 (45.446371)	298 146.7 (-76.585054)	167.0	9.2
GOS19-01	Westbound West Approach	5 034 031.8 (45.446186)	298 158.4 (-76.584904)	166.9	13.5
GOS19-11	Westbound West Approach	5 034 022.8 (45.446105)	298 163.3 (-76.584842)	166.8	7.6
GOS-2	Westbound West Approach	5 034 015.8 (45.446042)	298 171.4 (-76.584738)	166.8	6.8
GOS-1	Westbound East Approach	5 034 036.7 (45.446230)	298 171.9 (-76.584732)	169.0	15.9
GOS19-12	Westbound East Approach	5 034 030.3 (45.446172)	298 178.4 (-76.584649)	169.1	12.5
GOS19-02	Westbound East Approach	5 034 023.0 (45.446106)	298 183.7 (-76.584581)	169.2	14.9
GOS19-07	Median Cut 10+000	5 034 002.5 (45.445922)	298 201.8 (-76.584349)	169.2	9.9
GOS19-08	Median Cut 10+000	5 033 993.8 (45.445845)	298 192.5 (-76.584467)	168.5	6.5
GOS19-03	Eastbound West Approach	5 033 975.0 (45.445675)	298 209.0 (-76.584256)	167.4	4.5
GOS-4	Eastbound West Approach	5 033 957.6 (45.445519)	298 222.5 (-76.584084)	167.2	5.9
GOS-3	Eastbound East Approach	5 033 977.5 (45.445698)	298 222.0 (-76.584090)	167.5	4.7
GOS19-04	Eastbound East Approach	5 033 961.5 (45.445554)	298 235.8 (-76.583914)	168.0	9.6
GOS19-04W	Eastbound Structure	5 033 952.0 (45.445471)	298 228.6 (-76.584001)	167.0	6.4
GOS19-09	South Cut 10+075	5 033 940.0 (45.445361)	298 244.1 (-76.583801)	167.3	8.5
GOS19-10	South Cut 10+100	5 033 923.0 (45.445201)	298 262.4 (-76.583601)	166.5	7.7

The current investigation was carried out using truck-mounted CME 55 and track-mounted CME 75 drill rigs equipped with hollow-stem augers and/or rotary diamond drilling equipment.



Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Select boreholes were advanced approximately 3.0 m to 7.2 m into bedrock, with NQ or HQ sized coring equipment.

Monitoring wells, approximately 50 mm in diameter, were installed in Boreholes GOS19-01, GOS19-02, GOS19-04W, GOS19-06, GOS19-07 and GOS19-09 of the current investigation and piezometers, approximately 19 mm in diameter, were installed in all historical boreholes (GOS-1 through GOS-4, inclusive). The installation details are illustrated on the respective Record of Borehole sheets provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). The monitoring wells will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

4 LABORATORY TESTING

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution and Atterberg Limits was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their Fracture Index (FI), total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Unconfined compressive strength (UCS) testing was completed on selected rock core samples. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on soil samples from Boreholes GOS19-01, GOS19-03, GOS19-02, GOS19-04W.

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

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

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. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Cohesive soils from the 2019 and 2020 boreholes are described per current MTO protocols.

In general terms, the site was found to have a surficial layer of topsoil, asphalt or fill overlying native deposits of interlayered silty sand, clayey silt, sandy clay and/or sandy silt, which are underlain by a deposit of glacial till over gneiss/granitic bedrock.



5.1 Topsoil

Topsoil was encountered at surface in Boreholes GOS19-02, GOS19-04W, GOS19-07 through GOS19-10, GOS-1 and GOS-2. The topsoil thickness was found to range between 25 mm and 250 mm. Topsoil thickness may vary between borehole locations and in other parts of the site and this limited data should not be used to estimate topsoil quantity.

5.2 Asphalt

Asphalt was encountered in Borehole GOS19-03 with a thickness of approximately 200 mm.

5.3 Fill

A granular fill layer consisting of silty sand to sand with silt to sand and varying amounts of gravel to sand and gravel was encountered below the asphalt in Borehole GOS19-03, below the topsoil in Borehole GOS19-07 and at surface in Boreholes GOS19-04, GOS19-05, GOS19-06, GOS-3 and GOS-4. The granular fill ranged in thickness from approximately 0.4 to 0.9 m with a base elevation ranging from 166.2 to 168.4 m.

SPT tests conducted in the fill gave N-values of 8 and greater than 100 for 125 mm of penetration, indicating a loose to very dense relative density.

The moisture content of the granular fill samples tested ranged from 3 to 7%. The results of grain size analyses on two sample of the fill material are summarized below and are illustrated on Figure C1 in Appendix C.

Summary of Grain Size Distribution Testing – Granular Fill

Soil Particle	Percentage (%)
Gravel	28 – 44
Sand	47 – 62
Silt and Clay	9 – 10

5.4 Rock Fill

Rock fill consisting of varying amounts of gravel, rock fragments, cobbles and boulders was encountered below the granular fill in Boreholes GOS19-04, GOS-3 and GOS-4. The rock fill ranged in thickness from approximately 1.1 to 1.5 m and extended to a base elevation ranging from approximately 165.6 to 165.8m. Penetration through this layer required the use of coring techniques. One moisture content of the rock fill was approximately 6%.

5.5 Sand to Silty Sand to Sandy Silt (SP, SM, ML)

A non-cohesive deposit consisting of sand to silty sand to sandy silt with varying amounts of gravel and cobbles was encountered at surface in Borehole GOS19-01, beneath the topsoil in Boreholes GOS-1, GOS-2, GOS19-02, GOS19-04W, GOS19-08, GOS19-09 and GOS19-10 and below the granular fill in Boreholes GOS19-05, GOS19-06 and GOS19-07. Coring was required in some

boreholes to advance through cobbles. The thickness of this unit ranged from 1.4 to 5.3 m and the underside of this layer ranged from elevation 160.9 to 166.9m. Trace amounts of organics were observed in this layer in Boreholes GOS 19-08 and GOS 19-10. Cobbles were noted in Borehole GOS 19-10. A layer of clayey silt was noted within this unit in Borehole GOS19-01 and a layer of sandy silt (ML) was noted in Borehole GOS-1.

SPT tests conducted in this layer gave N-values ranging from 4 to 73 blows for 50 mm of penetration, indicating a loose to very dense relative density, although typically compact to dense.

The moisture content of this unit ranged from 3 to 30%. The results of grain size distribution testing carried out on nine samples are summarized below and illustrated on Figures C2 to C3 in Appendix C.

Summary of Grain Size Distribution Testing – Sand to Silty Sand to Sandy Silt

Soil Particle	Percentage (%)
Gravel	0 –35
Sand	50 – 92
Silt and Clay	7 - 42

5.6 Clayey Silt to Sandy Silt (CL, ML)

A native clayey silt to sandy silt deposit with varying amounts of clay and gravel was encountered within the silty sand in Borehole GOS19-01, below the sand to silty sand in Boreholes GOS19-02, GOS-1 and GOS-2, and beneath an unsampled interval in Borehole GOS 19-12. This layer ranged in thickness from 0.3 to 5.0 m with an underside elevation ranging from 161.8 to 165.1 m. A lower sand deposit was encountered in Borehole GOS-1 within the sandy silt layer and is included in Section 5.5 above.

SPT tests conducted within the clayey silt to sandy silt deposit gave N-values ranging from 12 to 41 indicating a compact to dense relative density.

The moisture content of the samples tested ranged from 14 to 40%. The results of four grain size analysis tests are summarized below and illustrated on Figure C4 in Appendix C.

Summary of Grain Size Distribution Testing – Clayey Silt to Sandy Silt

Soil Particle	Percentage (%)
Gravel	0 -2
Sand	25 – 43
Silt	48 – 63
Clay	7 - 12

The results of Atterberg Limits testing carried out on three samples indicated the deposit to be non-plastic.

5.7 Clay (Cl)

A cohesive unit clay was encountered beneath the silty sand in Borehole GOS 19-10. The thickness of the unit was 1.5 m and it extended to a base elevation of 162.7 m.

SPT tests conducted in this layer gave N-values ranging from 11 to 17, indicating a stiff to very stiff consistency.

The moisture content of this unit ranged from 27 to 28%. The results of grain size distribution testing carried out on one sample are summarized below and presented in Figure C5 in Appendix C.

Summary of Grain Size Distribution Testing – Clay

Soil Particle	Percentage (%)
Gravel	1
Sand	6
Silt	64
Clay	29

The results of Atterberg Limit Testing on one sample are summarized below and presented in Figure C9.

Summary of Atterberg Limit Testing – Sandy Clay to Clay

Parameter	Value
Liquid Limit	35
Plastic Limit	20
Plasticity Index	15

5.8 Till: Sandy Clayey Silt to Silty Sand to Sand and Gravel (SM, SC-SM, SC, ML)

A till deposit consisting of a heterogenous mixture of silt, sand, clay and gravel with occasional to frequent cobbles and boulders was encountered beneath the sandy silt in Boreholes GOS-1, GOS-2, GOS 19-02 and GOS19-12, beneath the clay in Borehole GOS19-10 and beneath the silty sand in Boreholes GOS 19-01, GOS 19-04W, GOS 19-05 through GOS 19-09. The drilling was terminated in this layer in Boreholes GOS19-05 and GOS19-06 at depths of 10.7 and 9.2 m (elev. 156.4 and 157.8m), respectively. Where fully penetrated, the thickness ranged from 0.1 to 6.2 m and the underside of this layer ranged from elevation 156.0 to 165.8 m.

The upper 2.6 m and 1.5 m of the till were observed to have increased clay content in Boreholes GOS 19-01 and GOS 19-05 respectively. A 1.2 m thick sand deposit was encountered within the till deposit in Borehole GOS-1 at a depth of 11.2 m (elev. 157.8m).

SPT tests conducted in the till gave N-values ranging from 7 to greater than 100 blows for 100 mm of penetration, indicating a loose to very dense relative density, although typically compact to dense. Refusals within this deposit are likely due to presence of cobbles and boulders. Penetration through this layer often required the use of coring techniques. Glacial tills inherently contain cobbles and boulders.

The moisture content of this unit ranged from 4 to 20%. The results of grain size distribution testing carried out on 13 samples of the till are summarized below and illustrated on Figures C6 to C8 in Appendix C.

Summary of Grain Size Distribution Testing – Glacial Till

Soil Particle	Percentage (%)	
Gravel	1 – 37	
Sand	37 – 76	
Silt	14 – 24	9 – 47
Clay		2 – 16

The results of Atterberg Limits testing carried out on the fines of five samples of this material are summarized below and are illustrated on Figure C10 in Appendix C. The laboratory results indicate that the fines are non plastic to low plastic (CL-ML to CL).

Summary of Atterberg Limit Testing – Glacial Till Fines

Parameter	Value
Liquid Limit	16 – 19
Plastic Limit	9 – 11
Plasticity Index	6 – 10

5.9 Bedrock

Bedrock was proven by coring in all boreholes except GOS19-05 and GOS19-06. The bedrock encountered consisted of slightly weathered to fresh, strong to extremely strong granite/gneiss that is predominantly grey and pink in colour. Bedrock logs are provided in Appendix B. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

Summary of Rock Core Quality Parameter	Range	Average
Total Core Recovery (TCR), %	43 – 100	96
Solid Core Recovery (SCR), %	0 – 100	71
Rock Quality Designation (RQD), %	0 – 100	66
Fracture Index	0 – >10	3

Based on the average RQD value, the bedrock is classified as fair quality. Unconfined compressive strength (UCS) testing was carried out on 21 samples of the bedrock obtained from all current boreholes except GOS19-04W, GOS19-05 and GOS19-06 (see Appendix C for results)

and 12 samples from the past boreholes (Geocres 31F-134 and 31F-141). The UCS reported from the past boreholes were inferred from the results of Point Load Testing of bedrock core samples. The measured and inferred UCS values ranged from 88 MPa to 318 MPa with an average of 161 MPa. Based on the UCS values, the bedrock is strong to extremely strong. It is noted that within the rock cores a silt seam was present in GOS 19-02, voids were observed in GOS 19-09, and fractured zones and vertical and sub-vertical fractures were present in most boreholes.

A summary of the bedrock surface information is provided in Table 5-1 below:

Table 5-1: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
GOS-1	13.0	156.0
GOS-2	3.6	163.2
GOS-3	1.7	165.8
GOS-4	1.5	165.7
GOS19-01	10.0	156.9
GOS19-02	11.5	157.7
GOS19-03	0.8	166.6
GOS19-04	2.4	165.6
GOS19-04W	2.8	164.2
GOS19-07	4.2	165.0
GOS19-08	2.7	165.8
GOS19-09	3.1	164.2
GOS19-10	4.3	162.2
GOS19-11	4.2	162.6
GOS19-12	9.4	159.7

5.10 Groundwater

Standpipe piezometers and monitoring wells with diameters ranging from 19 mm to 50 mm were installed in six of the current boreholes and four previously drilled boreholes. Groundwater levels recorded in the piezometers are presented in Table 5-2 below:

Table 5-2: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elevation (m)	Screened Material	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
GOS-1	153.4	Bedrock	5.7	163.3	Oct 22, 2003
			4.6	164.4	Dec 18, 2003
			4.8	164.2	Feb 5, 2004
GOS-2	160.7	Bedrock	2.5	164.3	Oct 22, 2003
			2.0	164.8	Dec 18, 2003
			2.1	164.7	Feb 5, 2004

Borehole No.	Bottom of Screen Elevation (m)	Screened Material	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
GOS-3	162.8	Bedrock	2.9	164.6	Oct 22, 2003
			2.9	164.6	Dec 18, 2003
			-	Destroyed	Feb 5, 2004
GOS-4	161.3	Bedrock	2.8	164.4	Oct 22, 2003
			2.8	164.4	Dec 18, 2003
			-	Destroyed	Feb 5, 2004
GOS19-01	159.3	Till	0.6	166.3	21/04/20
			5.3	161.6	29/09/20
			3.7	163.2	Oct 18, 2021
			3.7	163.2	Oct 21, 2021
GOS19-02	160.0	Sandy Silt/Till	4.2	165.0	10/07/20
			4.7	164.5	22/07/20
			5.0	164.2	29/09/20
			4.9	164.3	16/12/20
			5.3	163.9	Sept 27, 2021
			5.3	163.9	Oct 02, 2021
			5.4	163.8	Oct 20, 2021
			5.4	163.8	Jan 20, 2022
GOS19-04W	160.6	Bedrock	5.7	161.3	22/07/20
			4.9	162.1	29/09/20
			4.1	162.9	16/12/20
			4.2	162.8	Sept 28, 2021
			4.5	162.5	Oct 02, 2021
			5.0	162.0	Jan 20, 2022
GOS19-06	157.8	Till	3.4	163.6	26/09/19
			0.6	166.4	21/04/20
			3.5	163.5	29/09/20
			3.7	163.3	Oct 22, 2021
GOS19-07	159.3	Bedrock	4.4	164.8	10/07/20
			4.5	164.7	22/07/20
			5.0	164.2	29/09/20
			4.7	164.5	15/12/20
			5.2	164.0	Sept 27, 2021
			5.2	164.0	Oct 02, 2021
			5.3	163.9	Jan 20, 2022

Borehole No.	Bottom of Screen Elevation (m)	Screened Material	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
GOS19-09	158.8	Bedrock	6.1	161.2	15/07/20
			7.2	160.1	22/07/20
			7.4	159.9	29/09/20
			6.8	160.5	16/12/20
			7.5	159.8	Sept 28, 2021
			7.6	159.7	Oct 02, 2021
			7.3	160.0	Jan 20, 2022

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

5.11 Analytical Testing

Four samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in Table 5-3. Copies of the test results are provided in Appendix C.

Table 5-3: Results of Chemical Analysis

Borehole	GOS19-01	GOS19-02	GOS19-03	GOS19-04W
Sample	SS4	SS3	SS1	SS2
Depth (m)	2.3 – 2.5	1.5 – 2.1	0.2 – 0.7	0.8 – 1.4
Chloride (µg/g)	22	22	33	17
Sulphate (µg/g)	<5	<5	19	8
Sulphide (%)	0.03	<0.04	0.04	<0.04
pH (-)	7.50	8.10	7.80	8.12
Resistivity (Ohm-cm)	6,670	11,400	2,560	2,910
Conductivity (µS/cm)	150	87	391	343



6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out with reference to geodetic elevation benchmarks provided by the MTO.

Marathon Underground of Greely, Ontario and Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, piezometer installation and borehole decommissioning. Traffic control services were provided by Beacon Lite of Ottawa, Ontario. Water supply for rock coring was provided by Bonnechere Excavating Inc., of Renfrew, Ontario. The field investigation was supervised on a full-time basis by Sean O'Bryan and Allison Chow of Thurber. Overall supervision of the investigation program was provided by Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Unconfined Compressive Strength Testing of the bedrock was carried out by Stantec's laboratory in Ottawa. Analytical testing was completed by Paracel Laboratories in Ottawa.

Overall project management and direction of the field program was provided by Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Katya Edney, P.Eng. and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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**PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
GOSHEN ROAD OVERPASSES, SITE NO. 29-410
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-225

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) under Assignment No. 4018-E-0009 to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

The site is located approximately 50 m east of the existing at-grade intersection of Highway 17 and Goshen Road on Highway 17 in McNab/Braeside Township. It is proposed that Goshen Road will cross under Highway 17 at approximate Station 11+684 of the westbound (new) alignment and Station 11+799 of the eastbound (existing) alignment with a skew of approximately 36 degrees to the perpendicular of Highway 17. At the location of the proposed structures, Highway 17 is oriented east to west and Goshen Road is oriented roughly southeast to northwest. For project purposes, the highway and sideroad are herein described as oriented east-west and north-south, respectively.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purposes or by any other parties including design-build contractors. It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work. The Preferred Proponent must make their own interpretation based on the factual data in Part 1 of the report. The information included in Part 2 is not to be relied upon for design purposes and foundation design is the sole responsibility of the Preferred Proponent. No use shall be made of Part 2 or any part thereof. The Preferred Proponent must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The following sections provide preliminary geotechnical recommendations for the construction of foundation elements for the proposed structure. The discussions and recommendations presented in this report are based on the information provided by the Ministry of Transportation of Ontario (MTO) and on the factual data obtained during the course of this investigation.



7.1 Proposed Structures

Per the Preliminary Design Report, it is understood that the proposed overpasses for this site will consist of twin single span rigid frame structures with abutments on either side of Goshen Road. The centreline for the eastbound alignment will be located on the existing highway alignment. The centreline for the new westbound lanes will be located 60 m to the north.

The finished grade of Highway 17 will approximately match the existing ground surface with an elevation of approximately 168.8 and 167.8 m for the westbound and eastbound structures, respectively. The crown of Goshen Road below Highway 17 will range in elevation from approximately 162.9 to 162.6 m sloping downwards towards the south beneath the westbound structure and elevation of 161.8 m at the eastbound structure. The cross section of Goshen Road will be approximately 10.5 m wide to allow for two 3.25 m lanes with 2.0 m shoulders. The cross section for the Highway 17 eastbound and westbound structures will be approximately 11.5 m wide to allow for two 3.75 m lanes, a 3.0 m wide outside shoulder and a 1.0 m wide inside shoulder. Wing walls will be present in each quadrant of both structures with a maximum length of 5 m on skew.

It is noted that although the preliminary drawings indicate that room for an additional future lane is being considered in the median in each direction, the structures indicated on the Preliminary GA are each only wide enough for two lanes in each direction.

Goshen Road is generally to be constructed with a rural cross-section with drainage provided by ditches draining to the south. The ditches will need to be directed through subdrains or culverts at the structures as the proposed span of 10.5 m is insufficient to allow for the ditch geometry of OPSD 200.010 or 201.010. Drainage from behind the abutments will be provided by subdrains.

7.2 Applicable Codes and Design Considerations

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

In accordance with CHBDC, the analysis and design of the structure takes into consideration the importance of the structure and the consequence associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which in this case is the Ministry of Transportation, Ontario (MTO).

It is understood that the new Highway 17 structures are being designed to the “Major Route” importance category. Goshen Road is considered to have an importance of “Other”.

Highway 17 for this project has been assigned Typical Consequence Classification, in accordance with Section 6.5.1 of the CHBDC (pending confirmation by MTO). Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing the factored geotechnical resistances. If the consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and



revised. Goshen Road has been assigned a Low Consequence Classification (pending confirmation by MTO) with a consequence factor (Ψ) of 1.15, as per Table 6.1 of the CHBDC.

The degree of site and prediction model understanding for this site has been assessed to be typical understanding (Section 6.5.3 of CHBDC).

8 SEISMIC CONSIDERATIONS

8.1 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). Seismic hazard data for this site has been obtained from the GSC's seismic hazard calculator. The data includes peak ground acceleration (PGA), peak ground velocity (PGV), and the 5% damped spectral response acceleration values ($S_a(T)$) for the reference ground condition (Site Class C) for a range of periods (T) and for a range of return periods including the 475-year, 975-year and 2475-year events. The GSC seismic hazard calculation data sheet for this site is presented in Appendix E.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class, the peak ground acceleration (PGA) and $S_a(0.2)$. The PGA for this location for a *reference* Site Class C with a 2% probability of exceedance in 50 years is 0.228g (1 in 2475 year). This value is to be scaled by the $F(PGA)$ based on the site-specific Site Class as per Section 4.4.3.3 (Table 4.8) of the CHBDC.

8.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. Based on the measured blow counts in the overburden during drilling operations for the proposed westbound structure and the location of bedrock near surface for the proposed eastbound structure, the sites have been classified as a Site Class D and B, for the proposed westbound and eastbound structures respectively, in accordance with Table 4.1 of the CHBDC (S6:19).

8.3 Seismic Liquefaction Potential

The materials beneath the anticipated founding elevation of the westbound and eastbound structures consist of compact to dense glacial till deposit and bedrock, respectively. Both deposits are not considered susceptible to liquefaction under earthquake loading associated with the seismic hazard data for this site.

9 STRUCTURE FOUNDATION ALTERNATIVES

9.1 Foundation Alternatives

At the time of preparation of this report, it is understood that the new overpass is to consist of twin single span rigid frame structures. Where possible the structures are to be supported on spread



footings placed on bedrock. The underside of the footings would be approximately 1.0 m below ground surface at the edge of the shoulder or approximately 1.1 m below the elevation of the crown of Goshen Road. This corresponds to elevations of approximately 161.5 m and 160.7 m for the westbound and eastbound structures, respectively.

Typical stabilized groundwater elevations measured in the monitoring wells ranged from 159.9 m to 164.8 m.

Eastbound Structure:

Bedrock was observed in the five boreholes drilled near the eastbound structure at elevations ranging from 164.2 m to 166.6 m, well above the anticipated underside of the footings. For the eastbound structure, spread footings placed on bedrock is the preferred foundation alternative.

Westbound Structure:

Bedrock was observed in the six boreholes drilled near the westbound structure at elevations ranging from 156.0 to 163.2 m. Only two of these boreholes (GOS-2 and GOS19-11, both located on the west side) encountered bedrock higher than the anticipated underside of footing elevation of 161.5 m. The soils noted beneath the underside of the abutment in the other four boreholes consist of glacial till of varying composition from sandy clayey silt to silty sand, compact to very dense with occasional cobbles and boulders.

The following options have been considered for the foundations of the westbound structure. The evaluation for feasible alternatives is summarized in the table provided in Appendix F in terms of their respective advantages, disadvantages, risks and consequences.

A. Driven Piles

Driven piles: pile caps require frost cover of 1.9 m thus the underside elevation of the pile cap is anticipated to be 160.7 m. Based on the observed depths from underside of abutment to bedrock of 0 m to 4.6 m, driven piles are not considered a feasible alternative due to their limited length.

B. Spread Footings on Soil and Bedrock:

Spread footings on native soils, mass concrete and bedrock: spread footings on soil require frost cover of 1.9 m which corresponds to approximate elevation of 160.7 m for the west bound structure. The founding material at the anticipated underside elevation for the east foundation of the westbound structure would generally consist of glacial till over bedrock. At the west foundation of the westbound structure the bearing material varies from glacial till in the north to bedrock in the south. For this foundation, all overburden would be removed down to elevation 160.7 m and mass concrete placed back up to a consistent underside of footing level of approximately 161.5 m. There will be differences in performance between the footings supported on till, mass concrete on till and directly on bedrock. Furthermore, the thickness of the overburden beneath the underside of the

footings of the westbound structure varies significantly which will also generate differential settlements between and along founding units. Expected settlement will likely range from 0 mm on bedrock to approximately 20 mm on glacial till for a spread footing and accordingly, placing a spread footing on both bedrock and soil is not recommended. A groundwater control system including prior dewatering utilizing a well point system would be required during construction of footings supported on till and mass concrete on till as groundwater was observed at elevations up to 164.8 m (see Section 11.3).

C. Spread Footings on Bedrock:

Spread footings on mass concrete and bedrock: alternatively, to achieve higher bearing resistances and minimize differential settlements; the overburden materials, where present, could be sub-excavated to the underlying bedrock and replaced with mass concrete. This would result in excavations to as deep as approximately elevation 156.0 m (approximately 6.6 m below the proposed Goshen Road crown elevation of 162.6 m), which will likely require temporary protection systems (see Section 11.2). It is anticipated that at least a portion of the excavated materials would be re-usable as embankment fill elsewhere on the project. Excavation equipment would need to be selected to allow progress when cobbles and boulders are encountered. A groundwater control system would be required as groundwater was observed at elevations ranging from 159.9 m to 164.8 m (see Section 11.3).

D. Combination of Spread Footings and Caissons:

Spread footings on bedrock and mass concrete combined with caissons: spread footings on soil and pile caps for caissons require frost cover of 1.9 m which corresponds to approximate elevation of 160.7 m for the west bound structure. Where bedrock is encountered above elevation 160.7 m the excavation can be backfilled with mass concrete and a spread footing set at 161.5 m utilized. Caisson foundations would be used where bedrock is deeper than elevation 160.7 m. As shown in Section EE and FF on Drawing 3, the bedrock surface is extremely variable at the westbound structure. Additional boreholes are required to further define the bedrock slope between existing boreholes to determine the transition location from spread footing to caisson foundation. The shallow groundwater level observed during the field investigation would require the use of temporary liners and synthetic slurry to counterbalance groundwater pressure during the drilling and installation of the caissons at the westbound structure. Cobbles and boulders were noted in the glacial till deposits overlying the bedrock in all boreholes located in the vicinity of the westbound structure and could present additional installation difficulties. A groundwater control system would be required as groundwater was observed at elevations ranging from 159.9 m to 164.8 m (see Section 11.3).

E. Alignment Shift to achieve Spread Footing on Bedrock:

Alignment shift: from a foundation perspective, it would be preferable to have each abutment on a consistent foundation. Based on existing information, if the westbound alignment was shifted south by approximately 10 m it could be possible to support the

entire west abutment on spread footings on rock and the entire east abutment on caissons. Additional boreholes are required to further define the bedrock slope between existing boreholes and confirm the feasibility of this alternative. Although preferred from a foundation perspective, the implications to the highway geometry would need to be assessed prior to concluding its feasibility.

9.2 Construction Methodology

At the time of preparation of this report, it is understood that a two stage construction plan has been developed. During the first stage, Highway 17 traffic will travel along the current alignment as the new westbound structure is constructed. During the second stage, Highway 17 traffic will be diverted onto the new westbound lanes while the new eastbound structure is constructed. Goshen Road will be closed during construction. The foundation recommendations presented herein have been prepared based on the assumption that construction will be carried out under full road closure conditions with no requirement for temporary roadway protection.

9.3 Recommended Foundation Approach

The preferred foundation approach is spread footings on bedrock for the eastbound structure and a combination of spread footings on bedrock and caissons (Option D) for the westbound structure. However, additional boreholes are required to further define the bedrock surface and determine the spread footing to caisson transition location.

10 FOUNDATION DESIGN RECOMMENDATIONS

The new eastbound structure may be supported on spread footings on bedrock. The new westbound structure may be supported on spread footings directly on bedrock or on mass concrete on bedrock or caissons socketed into bedrock. Spread footings can also be placed on glacial till but are not recommended due to potential issues with differential settlement. Approximate key elevations at these two structures are as follows:

- Proposed top of pavement Highway 17 westbound, assumed 168.8 m
- Proposed top of pavement Goshen Road westbound, assumed 162.6 m
- Proposed top of pavement Highway 17 eastbound, assumed 167.8 m
- Proposed top of pavement Goshen Road eastbound, assumed 161.8 m
- Approximate groundwater elevation 159.9 to 164.8 m
- Top of Glacial till (westbound structure) 161.8 to 164.6 m
- Bedrock surface (westbound structure) 156.0 to 163.2 m
- Bedrock surface (eastbound structure) 165.6 to 166.6 m

10.1 Eastbound Bridge Support: Spread Footings on Bedrock

Shallow foundations for both abutments of the eastbound bridge structure can be founded directly on the bedrock surface. The underside of the footings would be approximately 1.0 m below ground surface at the edge of the shoulder or approximately 1.1 m below the elevation of the



crown of Goshen Road. This corresponds to footing elevations of approximately 160.7 m for the eastbound structure. Frost protection is not required for footings founded on bedrock.

The top surface of the bedrock should be stripped of all overburden and be cleaned. Inspection should be carried out to confirm that the bedrock conditions, as exposed at the founding level, are consistent with the design assumption. All shattered and loosened rock fragments should be removed from the footprint of the footing and replaced with mass concrete fill with a structural strength of 30 MPa, where necessary. Where bedrock is lower than anticipated, mass concrete may be placed to raise the subgrade to the design footing level.

Rock blasting could result in uneven rock surfaces at the base of the cut. Mass concrete fill in conjunction with minor sub-excavation of loose or shattered rock may be required in order to develop a level bearing surface. After excavation, footings should be formed on undisturbed sound bedrock in accordance with the requirements of OPSS.PROV 902.

Footings bearing on sound gneiss bedrock encountered at this site may be designed for a factored geotechnical resistance of 5,000 kPa at Ultimate Limit States (ULS). The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.3 and Clause 6.10.4.

The SLS condition will not govern design for footings founded on bedrock.

Resistance to lateral forces/sliding resistance between the precast concrete and the underlying bedrock should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.7.

If the frictional component is insufficient to resist lateral forces, the horizontal resistance may be increased by dowelling into the rock mass. Dowels are considered to be comparatively short steel bars that may be assumed to provide only shear resistance.

If additional uplift resistance is needed for spread footings founded on bedrock, vertical anchors grouted into the underlying bedrock are considered to be feasible at this site. The anchors should be placed to not interfere with dowels, where present. Resistance from soil and weathered/fractured bedrock should be ignored and not included in the calculation of available anchor capacity. Based on a minimum grout strength of 30 MPa, a rock anchor installed within sound bedrock can be designed with an ultimate grout-to-bedrock bond stress of 2,400 kPa. A geotechnical resistance factor of 0.4 (ϕ_{gu}) as per Table 6.2 of the CHBDC (static analysis, typical understanding) is to be applied to the calculated value. The lower of the grout-to-anchor bond and grout-to-bedrock bond strength should be used in design. A minimum anchor length of 3 m into sound bedrock should be used in design regardless of the calculated capacity from the structural assessment. Rock anchor design, installation, proof testing and corrosion protection should be in conformance with OPSS 942. Steel anchor material selection should consider the corrosivity of the soils (see Section 10.11).

A check should be completed to verify the calculated bond strength does not exceed the effective weight of rock encompassed within an inverted cone inclined at 45 degrees from vertical acting

from the base of the bonded length of the anchor to the surface of the sound rock. Additionally, individual rock anchor capacity should be reviewed and reduced taking into consideration the proximity of other structural and foundation elements that encroach within the circumference of the inverted cone.

10.2 Westbound Bridge Support: Spread Footings on Bedrock

Shallow foundations can be founded directly on the bedrock surface for a portion of the west abutment of the westbound structure. The underside of the footings would be approximately 1.0 m below ground surface at the edge of the shoulder or approximately 1.1 m below the elevation of the crown of Goshen Road. This corresponds to elevations of approximately 161.5 m for the westbound structure. The recommendations of Section 10.1 apply.

10.3 Westbound Bridge Support: Spread Footings on Glacial Till

Spread footings on till should be founded such that they are provided with at least 1.9 m of frost cover or equivalent insulation. Although, not the preferred approach, shallow foundations for the east support of the westbound bridge structure can be founded directly on the glacial till. It is anticipated that these spread footings will be set at approximate elevation 160.6 m with a minimum 0.3 m thick Granular A bedding layer. Prior dewatering will be required to prevent heaving and boiling of underlying till soils as groundwater was observed at elevations up to 164.8 m (see Section 11.3).

Shallow footings between 3 m and 5 m in width and constructed as outlined above may be designed based on the following factored geotechnical resistances:

- Factored geotechnical resistance at ULS 450 kPa
- Factored geotechnical resistance at SLS 250 kPa

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.3 and Clause 6.10.4. The factored geotechnical resistance at SLS corresponds to total footing settlement of up to 20 mm.

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
 - $\phi_{gu} = 0.5$ (static analysis; typical degree of understanding)
 - $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)

Resistance to lateral forces/sliding resistance between the precast concrete and the underlying Granular 'A' bedding should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.45. An unfactored coefficient of friction of 0.35 can be assumed for the interface between the Granular 'A' and the glacial till.



Resistance to uplift forces may be evaluated considering the weight of overburden/fill above the spread footings founded on glacial till. The magnitude of uplift resistance will depend on the footing and abutment wall dimensions, as well as the type of backfill material. If additional uplift resistance is needed for footings founded on glacial till, vertical anchors grouted into the underlying bedrock are considered to be feasible. Preliminary recommendations on grouted anchors at this site are included in Section 10.1.

The subgrade soils may become disturbed when saturated and should be protected by prompt placement of a geotextile separator (Class II non-woven geotextile with a maximum FOS of 150 μ m: OPSS.PROV 1860) and the bedding layer placed immediately after excavation and inspection.

In order to provide a more uniform foundation subgrade condition for the spread footing, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A requirements should be placed on the undisturbed subgrade and compacted per OPSS.PROV 501.

10.4 Westbound Bridge Support: Caisson Deep Foundations

Portions of the west abutment and the entire east abutment of the westbound bridge could be founded on rock socketed caissons. The glacial till at the proposed westbound structure contains cobbles and boulders. The caissons would have to be constructed by installing a steel casing into the top of the bedrock using drilling methods that would allow reliable penetration through potential cobbles, boulders and other obstructions that may be encountered in the fill and till layers. A socket would then be drilled into the bedrock, cleaned, and the casing and socket would be filled with concrete in a single pour after installation of reinforcing steel. Coring equipment must be able to seat the casing into sloping bedrock and also penetrate into the bedrock without fracturing the sidewalls. The tension/uplift resistances provided are based on full contact of the caisson concrete with the socket sidewalls. Depth of socket should be measured downward from the lower bedrock elevation for a sloping bedrock scenario. Caissons should be installed in accordance with OPSS.PROV 903. The strength and hardness of the gneiss granitic bedrock at this site must be considered when selecting equipment to excavate the rock socket.

Given the risk of the till layer sloughing, the caisson construction method should include use of temporary or permanent casings (liners) sealed into the bedrock. Using a temporary casing that is extracted during the concrete pour to reduce material costs is feasible, if the caissons are installed in combination with drilling fluid to maintain the stability of the side walls. The use of temporary casing would require careful control of the concrete level. Alternatively, caisson casings may be left in place as permanent liners to reduce the potential for disturbance of the soil-concrete interface that may occur during removal of temporary liners. Permanent liners would assist in maintaining the integrity of the concrete caisson by reducing the risk of infiltration of soil or water prior to concrete curing. Ultimately, the contractor will be responsible for selecting the construction means and methods based on cost and risk considerations.



The Contractor shall use appropriate means to clean and inspect the caisson base. The Contractor shall apply means necessary (such as air lift pump or hydraulic pump, etc.) to clean the base of the caissons.

The base cleaning method, inspection method, and any additional measures required to satisfy the acceptance criteria must be selected by the Contractor to ensure direct contact between the concrete and un-weathered bedrock over the entire area of the base.

10.4.1 Axial Geotechnical Resistance and Founding Elevation

The axial geotechnical capacity at factored ULS for a steel casing filled with concrete and socketed a minimum of 2 caisson diameters into sound bedrock is provided in the table below. The caisson capacities include a resistance factor of 0.4 (ϕ_{gu}) for ULS as per Table 6.2 of the CHBDC (static analysis – typical understanding). The SLS condition will not govern for a caisson socketed into sound bedrock.

Table 10-1 Axial Geotechnical Resistance for Caissons

Caisson Diameter (mm)	Factored ULS (Compression) (kN)	Factored ULS (Tension) (kN)	Factored SLS (Compression) (kN)
915	9,000	2,350	will not govern
1220	16,000	4,200	will not govern

The structural resistance of the caissons must be checked by the structural designer. The depth of socket into sound bedrock should be lengthened, if required, based on the required lateral capacity requirements (recommendations provided in Section 10.4.3), moment capacity and seismic analysis to satisfy the structural assessment.

10.4.2 Downdrag

Downdrag forces (negative skin friction) acting upon the caisson are expected to be negligible as settlement is not expected due to removal of material to achieve the Goshen Road profile.

10.4.3 Lateral Resistance

10.4.3.1 Lateral Resistance in Soil

The lateral resistance provided by the soils above the bedrock may be calculated using p-y curves. The p-y curves for static conditions are shown in Appendix H to allow for calculation of the ultimate lateral capacity of an individual caisson. Reduction factors should be applied to these ultimate values in accordance with Table 6.2 of the CHBDC.

10.4.3.2 Lateral Resistance in Rock Socket

The lateral resistance in granitic gneiss bedrock at this site may be calculated using ultimate lateral resistance (p_{ult}) as follows:



$$\text{For } z \leq 3D, \quad p_{ult} = (1 + 1.4 z / D) \sigma_{rm} \quad (\text{kPa})$$

$$\text{For } z > 3D, \quad p_{ult} = 5.2 \sigma_{rm} \quad (\text{kPa})$$

Where z = depth of socket below surface of sound bedrock (m)

D = pile or caisson diameter (m)

σ_{rm} = 10 MPa, average rock mass strength within rock socket

The ultimate lateral resistance, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} L D$ (kN), where D is the pile diameter (m) and L is the length (m) of the pile segment or element used in the analysis. This represents the ultimate load at which the rock fails and will not support any additional load at greater displacement.

10.5 Wingwalls and Retaining Walls

At the time of this report, it is unknown if wingwall/retaining wall systems will be installed along Goshen Road at each structure. If required, concrete retaining walls would be supported on similar foundations to the adjacent abutment, either shallow or deep foundations, as discussed in Sections 10.1 to 10.4, respectively. For concrete retaining walls founded on spread footings, the geotechnical resistances for bearing and sliding/lateral loads provided in Sections 10.1 and 10.3 may be used for preliminary design of concrete wing wall footings of similar size founded on sound bedrock or glacial till, respectively. For concrete retaining walls founded on caissons, the geotechnical axial and lateral resistances provided in Section 10.4 may be used for preliminary design.

10.5.1 RSS Walls

If required, retained soil system (RSS) walls are considered feasible at this site. The design of proprietary RSS walls is the responsibility of the supplier. Typically, such systems do not require full frost protection as they are able to tolerate some movement due to frost heave. The RSS system should be designed in accordance with the MTO RSS Design Guidelines. Once the location and height of the wall is established, the following recommendations should be confirmed:

Performance	H
Appearance	H
Acceptance	A

A minimum 1 m thick engineered fill pad constructed on the underlying undisturbed dense native soils at the westbound structure and/or on the clean sound bedrock surface should be provided below the RSS wall as well as under the reinforced retained soil. The engineered fill pads should consist of OPSS Granular A placed and compacted in accordance with OPSS.PROV 501. Engineered fill pads should be constructed with 1H:1V sides slopes with the crest of slope a minimum of 1 m from the edge of footing and reinforced retained soil on all sides. The subgrade soils may become disturbed when saturated and should be protected by prompt placement of a geotextile separator (Class II non-woven geotextile with a maximum FOS of 150 μm :



OPSS.PROV 1860) and the engineered fill pad placed immediately after excavation and inspection.

The lateral pressure comments provided in Section 10.6 may be used in RSS design. Bearing resistances provided in Section 10.1 through 10.4 may be used for RSS design pending the founding material type. Please also refer to Section 10.10 for comments on Global Stability.

Resistance to lateral forces/sliding resistance between the precast concrete supporting the facing wall and the underlying Granular 'A' bedding should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.45.

10.6 Backfill and Lateral Earth Pressures

Structural backfill material should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 and SP 110S06 specifications. Large scale direct shear box testing on samples of Granular A and Granular B Type II from numerous nearby aggregate sources was completed for this project. The results indicate that for design of structural backfill for this project, an internal angle of friction of 40 degrees and 42 degrees can be used for quarry-sourced Granular A and Granular B Type II, respectively, in this area provided the effective vertical pressure on the material is less than 150 kPa (Geocres Memorandum 31F-213). An Operational Constraint will be required in the contract restricting the source of Granular A to quarries. Throughout this report, the term "Granular A" is defined as "Quarry-Source Granular A" unless specifically described as "Pit-Source Granular A".

The backfill must be in accordance with OPSS 902 and placed to the extents shown on OPSD 3101.150. The backfill should be compacted and compaction equipment to be used adjacent to the structure must be restricted in accordance with OPSS.PROV 501.

The design of the abutments and wingwalls/retaining walls, where required, must incorporate a subdrain as shown in OPSD 3101.150. A geosynthetic drainage blanket is recommended to be placed vertically on the back wall of the abutment leading to the subdrain to enhance drainage.

Lateral earth pressure parameters provided in Table 10-2 and Table 10-3 in the sections below are based on the assumptions that the wall is vertical and the backfill is fully drained so that there are no unbalanced hydrostatic pressures above the permanent groundwater level. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design. For other backfill and wall geometries, Thurber will need to calculate the appropriate earth pressure coefficients once the final geometry is confirmed.

10.6.1 Static Lateral Earth Pressure

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC. Under drained conditions the lateral earth pressure is generally given by the following expression:

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

where:

σ_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below) (K_a for yielding walls, K_o for non-yielding walls)
γ	=	unit weight of retained soil (see table below), use submerged unit weight below groundwater level
h	=	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 backfill are shown in Table 10-2.

Table 10-2: Static Earth Pressure Coefficients

Condition	Pit Sourced OPSS Granular A $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	Quarry Sourced OPSS Granular A $\phi = 40^\circ, \gamma = 22.8 \text{ kN/m}^3$	Quarry Sourced OPSS Granular B Type II $\phi = 42^\circ, \gamma = 22.8 \text{ kN/m}^3$
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.36	0.33
Coefficient of Active Earth Pressure, K_A (Unrestrained Wall)	0.27	0.22	0.20

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 movement required can be assessed from Table C6.6 of the Commentary to the CHBDC. Active earth pressures should be used for any wingwalls or unrestrained walls. For rigid structures, at-rest horizontal earth pressures would apply for design.

10.6.2 Combined Static and Seismic Lateral Earth Pressure – Eastbound Structure

In accordance with Clause 4.6.5 of the CHBDC (S6-14), retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C4.6.5 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe-Okabe Method with:

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

The coefficients of horizontal earth pressure for combined static and seismic loading presented in Table 10-3 may be used. The provided earth pressure coefficients are based on a reference PGA (Seismic Site Class C) with a 2% probability of exceedance in 50 years of 0.228g (Geological Survey of Canada – Fifth Generation) and a F(PGA) of 0.87 for Seismic Site Class B, as per Table 4.8 of the CHBDC.

Table 10-3: Combined Static and Seismic Earth Pressure Coefficients – EB Structure

Condition	Pit Sourced OPSS Granular A	Quarry Sourced OPSS Granular A	Quarry Sourced OPSS Granular B Type II
	$\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	$\phi = 40^\circ, \gamma = 22.8 \text{ kN/m}^3$	$\phi = 42^\circ, \gamma = 22.8 \text{ kN/m}^3$
Coefficient of Active Earth Pressure, K_{AE} (Restrained Wall)	0.39	0.33	0.30
Coefficient of Active Earth Pressure, K_{AE} (Unrestrained Wall)	0.33	0.27	0.25

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

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

where:

- σ_h = lateral earth pressure at depth d (kPa)
- d = depth below the top of the wall (m)
- K = static earth pressure coefficient
(K_A for yielding walls, K_o for non-yielding walls)
- γ = unit weight of retained soil, use submerged unit weight below groundwater level
- K_{AE} = combined static and seismic earth pressure coefficient
- H = total height of the wall (m)

10.6.3 Combined Static and Seismic Lateral Earth Pressure – Westbound Structure

In accordance with Clause 4.6.5 of the CHBDC (S6-14), retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C4.6.5 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the 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 combined static and seismic loading presented in Table 10-4 may be used. The provided earth pressure coefficients are based on a reference PGA (Seismic Site Class C) with a 2% probability of exceedance in 50 years of 0.228g (Geological Survey of Canada – Fifth Generation) and a F(PGA) of 1.13 for Seismic Site Class D, as per Table 4.8 of the CHBDC.

Table 10-4: Combined Static and Seismic Earth Pressure Coefficients – WB Structure

Condition	Pit Sourced OPSS Granular A	Quarry Sourced OPSS Granular A	Quarry Sourced OPSS Granular B Type II
	$\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	$\phi = 40^\circ, \gamma = 22.8 \text{ kN/m}^3$	$\phi = 42^\circ, \gamma = 22.8 \text{ kN/m}^3$
Coefficient of Active Earth Pressure, K_{AE} (Restrained Wall)	0.44	0.37	0.34
Coefficient of Active Earth Pressure, K_{AE} (Unrestrained Wall)	0.35	0.28	0.26

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

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

where:

σ_h	=	lateral earth pressure at depth d (kPa)
d	=	depth below the top of the wall (m)
K	=	static earth pressure coefficient (K_A for yielding walls, K_o for non-yielding walls)
γ	=	unit weight of retained soil, use submerged unit weight below groundwater level
K_{AE}	=	combined static and seismic earth pressure coefficient
H	=	total height of the wall (m)

10.7 Frost Depth

The depth of frost penetration at this site is estimated to be 1.9 m (as per OPSD 3090.101); storm sewers, footings and pile caps for the abutments and retaining walls should be founded at or below this depth or provided with equivalent insulation. It is not necessary to found RSS walls and/or spread footings directly on bedrock at a depth below frost penetration.

10.8 Earth Cuts

Permanent earth cuts proposed for Goshen Road north of the westbound structure with a maximum depth of approximately 6.2 m expected.

The Goshen Road cut at its deepest will penetrate through existing sand to sandy silt to silt and sand deposits. Below the base of the cut the soils consist of a compact sandy silt overlying compact to very dense glacial till and bedrock. SPT N-values measured beneath the base of the cut to the bedrock surface (approximately 6.6 m) indicate compact to dense material. The ground water level was measured at an approximate elevation of 164.2 m; however, it is noted that the groundwater at the westbound structure will be permanently lowered to an elevation of approximately 161.4 m based on crown elevation for Goshen Road of 162.6 m. Ditch geometry is derived from OPSD 200.010 and includes an interceptor ditch at the crest of the slope to stop surficial runoff down the slope and reduce erosion potential.

Slope stability assessments of the east and west cut slopes have been carried out using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Input parameters for the analysis are based on the SPT N values, the results of laboratory testing typical material parameter correlations, and engineering judgement. A summary table of soil parameters are shown on each stability analyses output figure provided in Appendix G. The following additional parameters were used in the analysis:

- Estimated soil stratigraphy was based on the nearest boreholes.
- Goshen Road Cut: maximum cut depth of 6.2 m.
- Cut slopes of 2H:1V were modelled.
- Site adjusted PGA value of 0.129 g, equal to $\frac{1}{2}$ of the site adjusted PGA value (0.258 g) was used for seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Section 10.6.3 above.

Copies of the output from the stability analyses are provided in Appendix G, Figures G-1 to G-6. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis. The stability analyses generated the following factor of safety values:

Table 10-5 Slope Stability Analysis Results – Goshen Road Cut Slopes

Condition	Case	Factor of Safety	
		2H:1V Cut East Slope	2H:1V Cut West Slope
Temporary (prior to groundwater drawdown)	Short Term (Undrained)	1.2 (Fig G-1)	1.2 (Fig G-4)
Permanent	Long Term (Drained)	1.6 (Fig G-2)	1.6 (Fig G-5)
Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	1.2 (Fig G-3)	1.2 (Fig G-6)



It is noted that no traffic is envisioned at the crest of the cut slopes, thus a surcharge for traffic loading has not been included. The temporary condition assessed is based on a horizontal groundwater table at 164.2 m within the slope and at ground surface where the cut extends below this elevation. For the permanent condition, the groundwater table has been modeled at 164.2 away from the cut with a gentle slope down to intersect the new ditch line.

It is further noted that Goshen Road has been assigned a Low Consequence Classification (pending confirmation by MTO) with a consequence factor, Ψ of 1.15, as per Table 6.1 of the CHBDC.

The requirements of the CHBDC do not strictly apply for cut slopes (they are provided for embankment fills) however, we have utilized this information and a Ψ of 1.15 to generate minimum Factors of Safety of 1.3 and 1.2 for cut slopes on Goshen Road in permanent and temporary conditions respectively for a typical degree of understanding. Both of the static results presented in Table 10-5 meet or exceed the target Factors of Safety.

Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum seismic resistance factor of 0.95 for force-based design and 1.0 for performance-based design. Based on these values and Ψ of 1.15, a target Factor of Safety of 1.0 for this temporary condition with a typical degree of understanding is appropriate for the pseudo-static seismic analysis. The pseudo-static result presented in Table 10-5 above, exceeds the target Factor of Safety for seismic design. It is noted that some displacement can occur where the pseudo-static Factor of Safety is less than 1.3, however, Section 6.14.2.3 of the CHBDC which describes the performance requirements for geotechnical systems under seismic loading indicates that slopes outside the bridge approach interface zone for a Seismic Performance Category of 3 and an "Other" Route geotechnical system have no seismic performance requirements for travelled lanes, therefore no further analysis is needed in this case.

An earth cut slope of 2H:1V satisfies all of the static and pseudo-static requirements.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the earth cut slopes. Normally slope vegetation should be established as soon as possible after completion of the earth cut slopes in order to control surficial erosion in general accordance with OPSS.PROV 804. The exposed soils at the Goshen Road cut are considered to be moderately erodible based on the Wischmeier Nomograph.

The finished earth cut slopes should be inspected for ongoing seepage emerging from the cut slopes. Gravel sheeting or rock protection may be required to provide drainage of the seepage to prevent erosion of the slope face.

10.9 Rock Cut

A rock cut of as much as 6 m depth will be required to achieve the proposed profile for Goshen Road. The cut should be constructed in accordance with OPSS.PROV 202 and OPSS.PROV 120 with the geometry indicated on OPSD 201.010 and the recommendations provided in the Pavement Design Report and the Rock Cut Design Report (Geocres 31F-231).



Special attention is required for rock excavation at and behind the proposed abutments and wing walls for the structures at Goshen Road. It is anticipated that a rock excavation slope of 1H:1V and with a 1.0 m wide horizontal offset between the toe of the excavated bedrock and the back of the foundation will be required in this location to protect workers from falling rock during construction of the foundations and installation of concrete formwork for the abutments. A rock face item is also required for the cut behind the abutments. Furthermore, bedrock excavation at and within 1 m horizontal distance of foundations should not incorporate a shatter zone. The final bedrock excavation near foundations should be completed mechanically to minimize disturbance to the bedrock which will support the footings. Rock blasting must be carefully designed to minimize overbreak or shattering of rock below structure foundations.

Vibration monitoring of nearby structures and utilities will be required where rock drilling and blasting is carried out.

10.10 RSS Stability

The global stability for an RSS installation north of the new westbound structure at Goshen Road was evaluated using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Please refer to the soil descriptions provided above in Section 10.8 for the Goshen Road Cut. Input parameters for the analysis are based on the SPT N values and the results of laboratory testing. The following additional parameters were used in the analysis:

- Estimated soil stratigraphy was based on the nearest boreholes.
- Goshen Road East Cut: maximum cut depth of 6.2 m.
- Goshen Road West Cut: maximum cut depth of 5.3 m.
- Retained soil to consist of OPSS Granular B Type II, 4 m in width and supported on a 1 m thick Granular A bedding layer.
- Structural backfill behind the RSS to consist of OPSS Granular A.
- Horizontal backslope behind RSS were considered.
- Site adjusted PGA value of 0.129 g, equal to ½ of the site adjusted PGA value (0.258 g) was used for seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Section 10.6.3 above.

Copies of the output from the stability analyses are provided in Appendix G, Figures G7 to G10. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis.

The stability analyses generated the following factor of safety values:

Table 10-6 Slope Stability Analysis Results – Goshen Road RSS Walls North of WBL Overpass

Condition	Case	Factor of Safety	
		East RSS	West RSS
Permanent	Long Term (Drained)	1.9 (Fig G-7)	2.3 (Fig G-9)



Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	1.5 (Fig G-8)	1.7 (Fig G-10)
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The RSS slopes are considered stable under both static and seismic conditions.

10.11 Cement Type and Corrosion Potential

Chemical analysis for determination of pH, water soluble sulphate, sulphides, chloride concentrations, resistivity and electrical conductivity was carried out on samples of the native materials. The analysis results are summarized in Section 5.11 and a copy of the test results is provided in Appendix C.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Table 5-3 were compared with Table 3.2 of the MTO Gravity Pipe Design Guideline and indicates a very low to moderate corrosive environment. The test results provided in Section 5.11 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with the soil and groundwater at the site. The sulphate results in Table 5-3 were compared with Table 3 of Canadian Standards Association Standards A23.1-19 (CSA A23.1) and indicate a negligible degree of sulphate attack potential on concrete structures at this site.

The corrosive effects of road de-icing salts should also be considered.

11 CONSTRUCTION CONSIDERATIONS

11.1 Temporary Excavations

All temporary excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the existing fills at this site may be classified as Type 3 soil. Native clay and clayey silt should be considered as Type 2 above and Type 3 below the groundwater table. Native loose to compact non-cohesive soils above the ground water level should be considered as Type 3 soils and Type 4 below the ground water level. Side slopes for excavations through more than one soil type must be entirely based on the highest soil type number. Unsupported excavations made in Type 3 soils must have side slopes no steeper than 1H:1V from the base of the excavation.

Please refer to Section 10.9 above and the Rock Cut Design Report (Geocres 31F-231) for recommendations on rock cut slopes.

Excavations for footings or pile caps must be carried out in accordance with OPSS.PROV 902 and will be carried out through the existing fill and extend into the underlying native deposits (glacial till) and bedrock. Selection of the equipment and methodology to excavate and prepare



the founding surface is the responsibility of the Contractor. Stockpiling or surface surcharge should not be allowed on embankments or the crest of cut side slopes.

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 11.2.

11.2 Temporary Protection Systems

Should Temporary Protection Systems be required for excavation support or groundwater control, they must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2. 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. The protection system should be installed at a suitable distance away from the new structures to limit the disturbance to subgrade associated with removal of the protection system following completing of construction. Alternatively, the protection system near the structures could be left in place and cut off in accordance with OPSS.PROV 903 to limit the disturbance of subgrade during removal of the TPS.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design for the structural backfill are provided in Table 10-2. The lateral earth pressure coefficients for the underlying native soils are given below for a vertical wall and a horizontal backslope:

Native clayey silt to sandy silt:

$$\begin{aligned}\gamma &= 18 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.32 \\ K_P &= 3.12\end{aligned}$$

Native sand to silty sand:

$$\begin{aligned}\gamma &= 20 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.31 \\ K_P &= 3.3\end{aligned}$$

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.

Given the presence of variable bedrock surface, cobbles, boulders and other obstructions at this site, installation of interlocking sheet piles may be difficult. A soldier pile and lagging system is a feasible option. It may be necessary to predrill for the soldier piles. Lateral support may need to be enhanced by socketing the soldier piles into bedrock and/or by using bracing or rakers. Suggested wording for an NSSP for obstructions is included in Appendix I



11.3 Surface and Groundwater Control

Foundation construction, subgrade preparation and placement and compaction of granular bedding must be carried out in the dry. The depth of excavations required to construct the storm sewer, footings or pile caps is expected to reach the groundwater level observed at the time of the investigation. Furthermore, surface runoff and perched groundwater will tend to seep into and accumulate into the excavations. The Contractor must control groundwater, perched groundwater and surface water flow at the site to permit the construction of the footings in a dry and stable excavation.

Where spread footings on glacial till are proposed, the groundwater level within the abutment footprint should be lowered, prior to excavation, to 0.5 m below the underside of the required excavation depth. It is anticipated that a vacuum well point system will need to be installed surrounding the work zone to achieve required dewatering.

It is anticipated that a sump and pump will be adequate to achieve required dewatering to the base of excavation for proposed spread footings on bedrock.

Further assessment of dewatering requirements and the need for a PTTW will be assessed in the Hydrogeological Investigation and Design Report.

11.4 Erosion Control

The Contractor should provide silt fences and erosion control blankets as per OPSS.PROV 805 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. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to limit surficial erosion. The exposed material at the Goshen Road cut consists of silty sand to sandy silt at the westbound structure and bedrock at the eastbound structure. The silty sand to sandy silt is considered to be moderately erodible based on the Wischmeier Nomograph) while bedrock is considered non-erodible.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

12 CONSTRUCTION CONCERNS

The planned construction methodology includes open cut excavations for the grade lowering of Goshen Road and the installation of foundation elements of two new overpass structures and possible associated retaining walls. Potential construction concerns include, but are not necessarily limited to:

- Variable sloping bedrock surface at the westbound structure. Additional boreholes are required to more accurately define the bedrock profile.



- Excavation difficulties due to the presence of obstructions such as potential for cobbles and boulders may be encountered in the overburden materials during excavation.
- Stability of rock cuts is uncertain based on the range of rock quality observed during the field investigation and construction oversight is recommended to assess the safety and stability of the rock cut.
- Vibration monitoring of nearby structures and utilities will be required where rock drilling and blasting is carried out.
- Control of groundwater seepage prior to construction, during excavation and permanent drainage in the cut sections.

The successful performance of the structure installations will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required as per OPSS.PROV 902 during construction to confirm that the foundation recommendations are correctly implemented, and material specifications are met.



13 CLOSURE

Engineering analysis and preparation of this report was carried out by Mrs. Katya Edney, P.Eng and Dr. Fred Griffiths, P.Eng.. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:

Katya Walker, M.Eng, P.Eng.
Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.
Senior Geotechnical Engineer,
Senior Associate

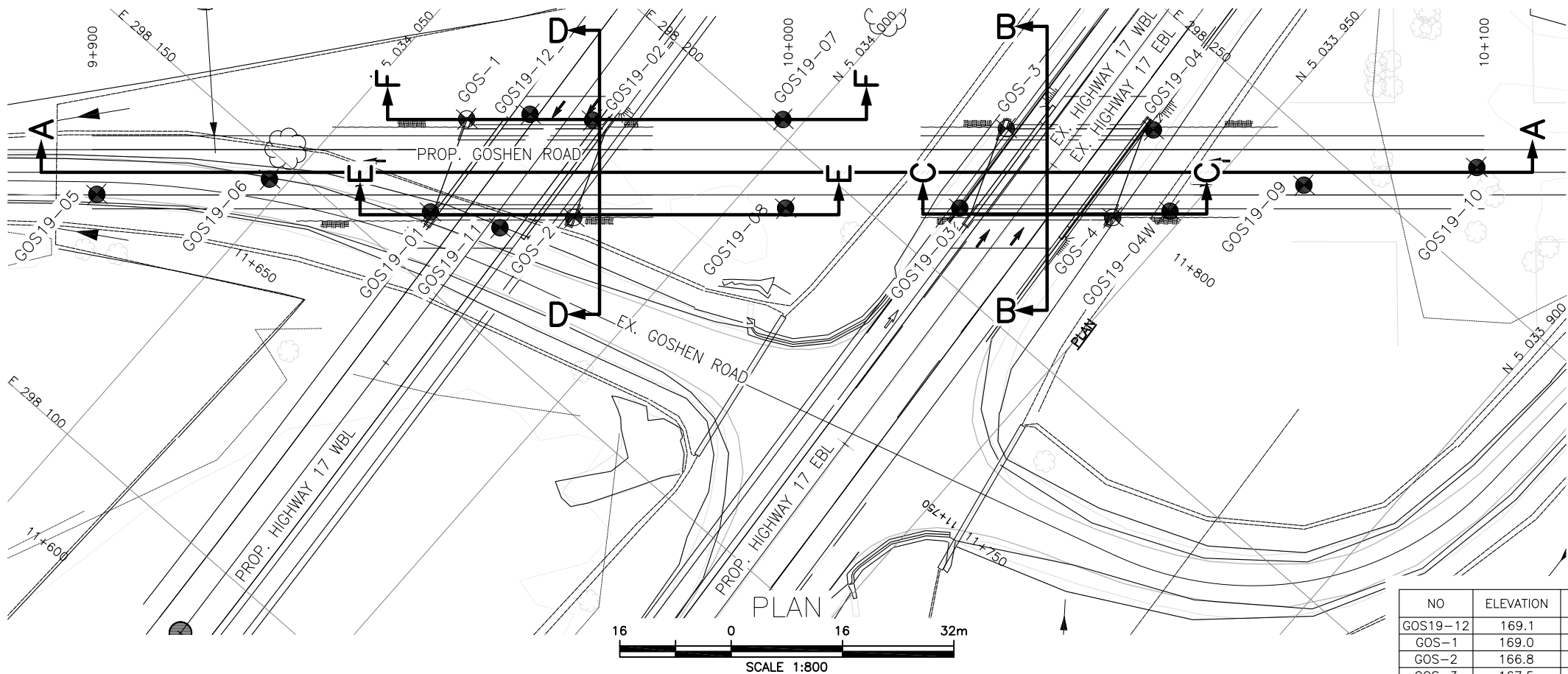


Dr. P.K. Chatterji, P.Eng.
MTO Review Principal,
Senior Geotechnical Engineer



Appendix A.

Borehole Location Plan and Stratigraphic Drawings



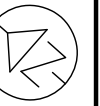
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



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GOS-1	169.0	5 034 036.7	298 171.9
GOS-2	166.8	5 034 015.8	298 171.4
GOS-3	167.5	5 033 977.5	298 222.0
GOS-4	167.2	5 033 957.6	298 222.5

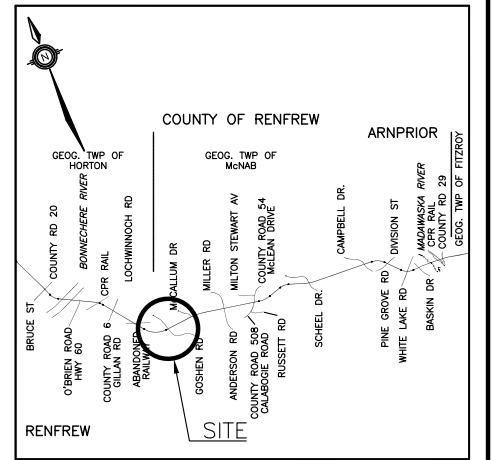
CONT No
WP No 4068-09-00

HIGHWAY 17 TWINNING
GOSHEN ROAD
OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET

Ontario



KEYPLAN

LEGEND

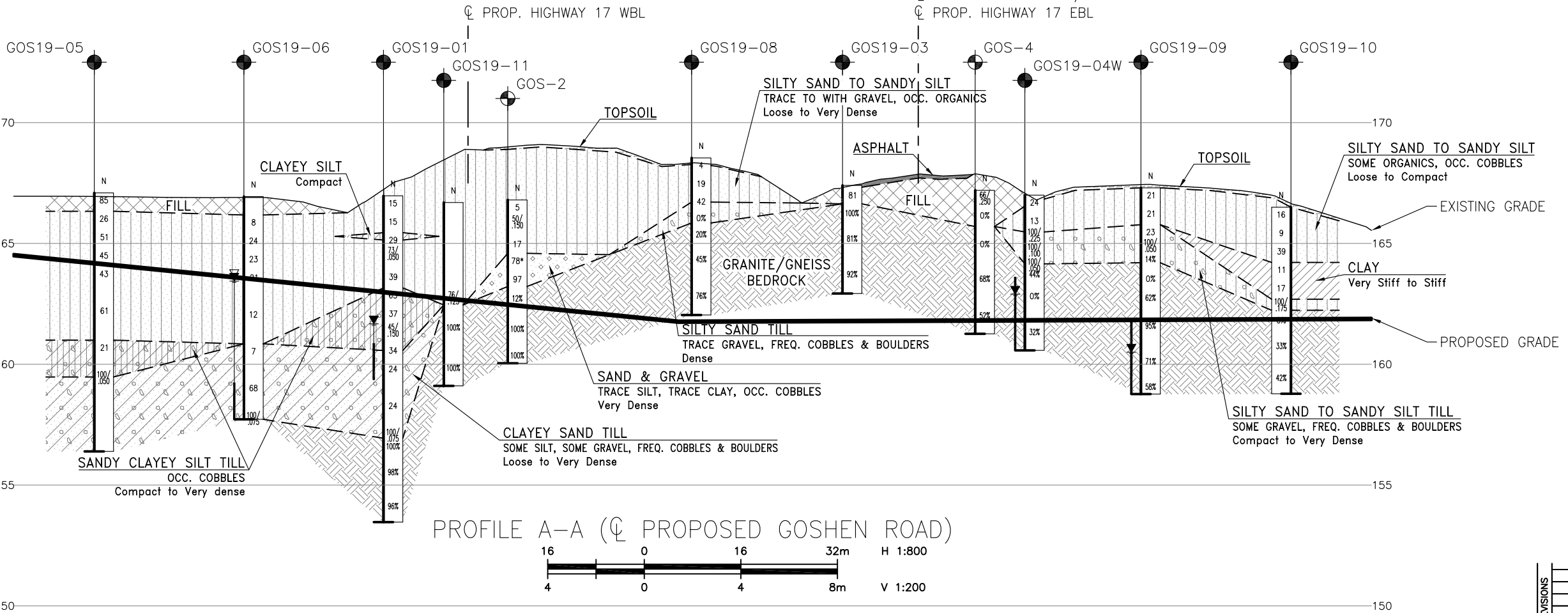
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	Borehole (2003 Investigation)
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CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

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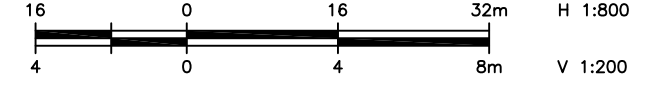
-NOTES-

- 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 9.

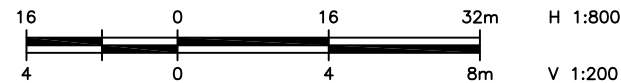
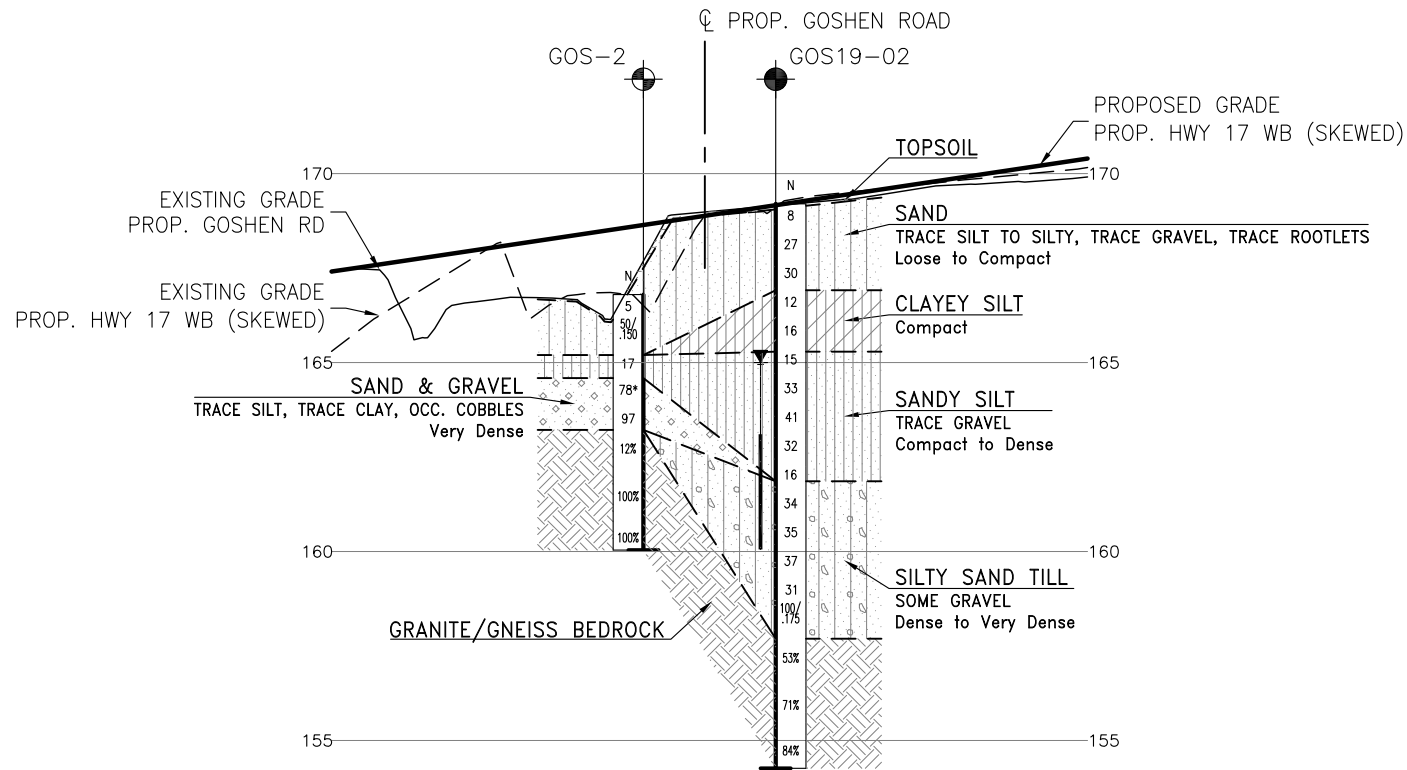
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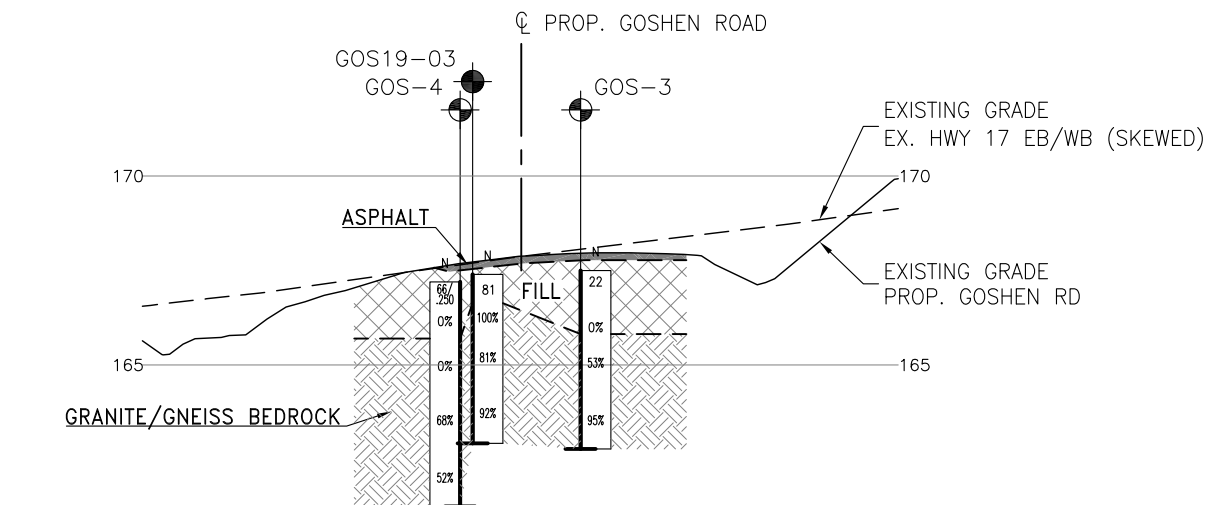
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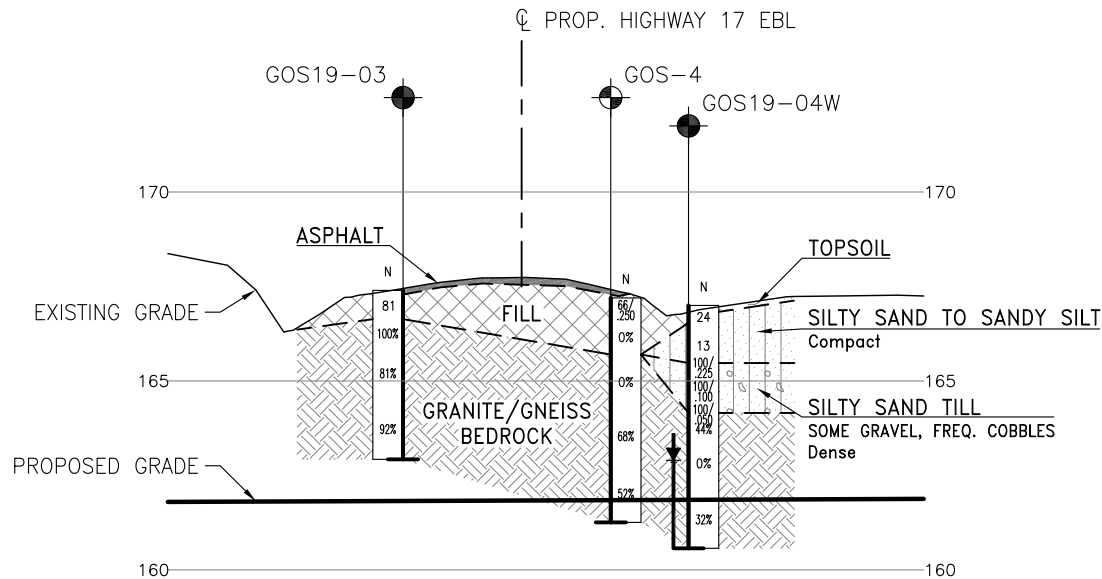
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LOAD			DATE JUL 2022
STRUCT			DWG 1



SECTION D-D

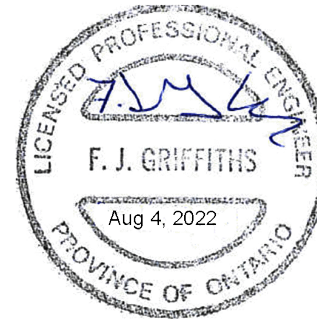


SECTION B-B



SECTION C-C

METRIC
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



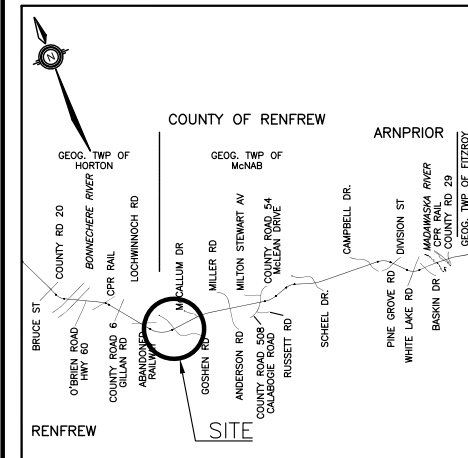
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GOS-2	166.8	5 034 015.8	298 171.4
GOS-3	167.5	5 033 977.5	298 222.0
GOS-4	167.2	5 033 957.6	298 222.5

CONT No
WP No 4068-09-00

HIGHWAY 17 TWINNING
GOSHEN ROAD
OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario



KEYPLAN

LEGEND

	Borehole (2020 Investigation)
	Borehole (2003 Investigation)
	N
	Blows /0.3m (Std Pen Test, 475J/blow)
	Blows /0.3m (60' Cone, 475J/blow)
	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
	Rock Quality Designation (RQD)
	Auger Refusal

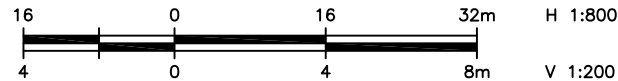
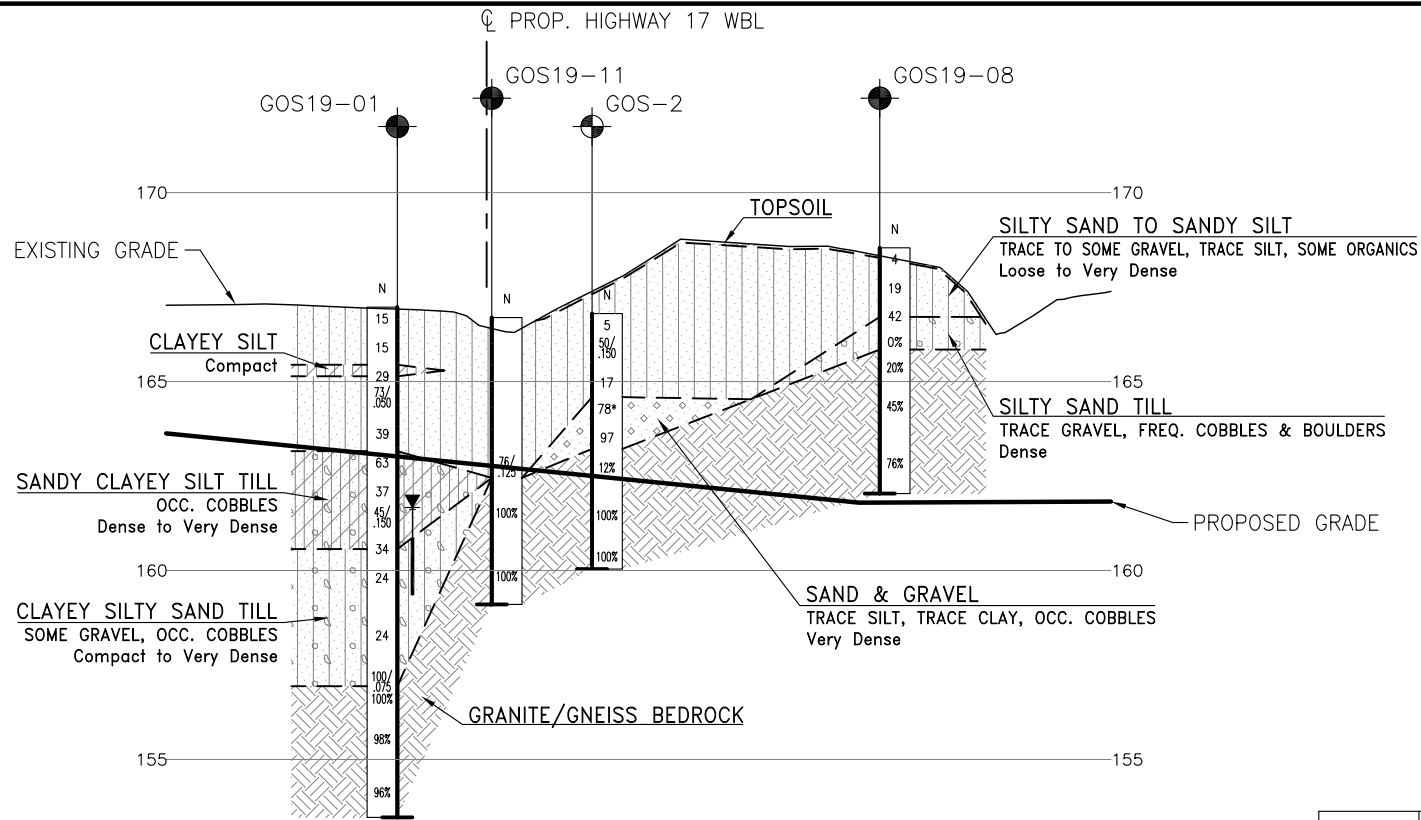
NO	ELEVATION	NORTHING	EASTING
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GOS19-02	169.2	5 034 023.0	298 183.7
GOS19-03	167.4	5 033 975.0	298 209.0
GOS19-04	168.0	5 033 961.5	298 235.8
GOS19-04W	167.0	5 033 952.0	298 228.6
GOS19-05	167.1	5 034 069.5	298 128.7
GOS19-06	167.0	5 034 052.3	298 146.7
GOS19-07	169.2	5 034 002.5	298 201.8
GOS19-08	168.5	5 033 993.8	298 192.5
GOS19-09	167.3	5 033 940.0	298 244.1
GOS19-10	166.5	5 033 923.0	298 262.4
GOS19-11	166.8	5 034 022.8	298 163.3

-NOTES-

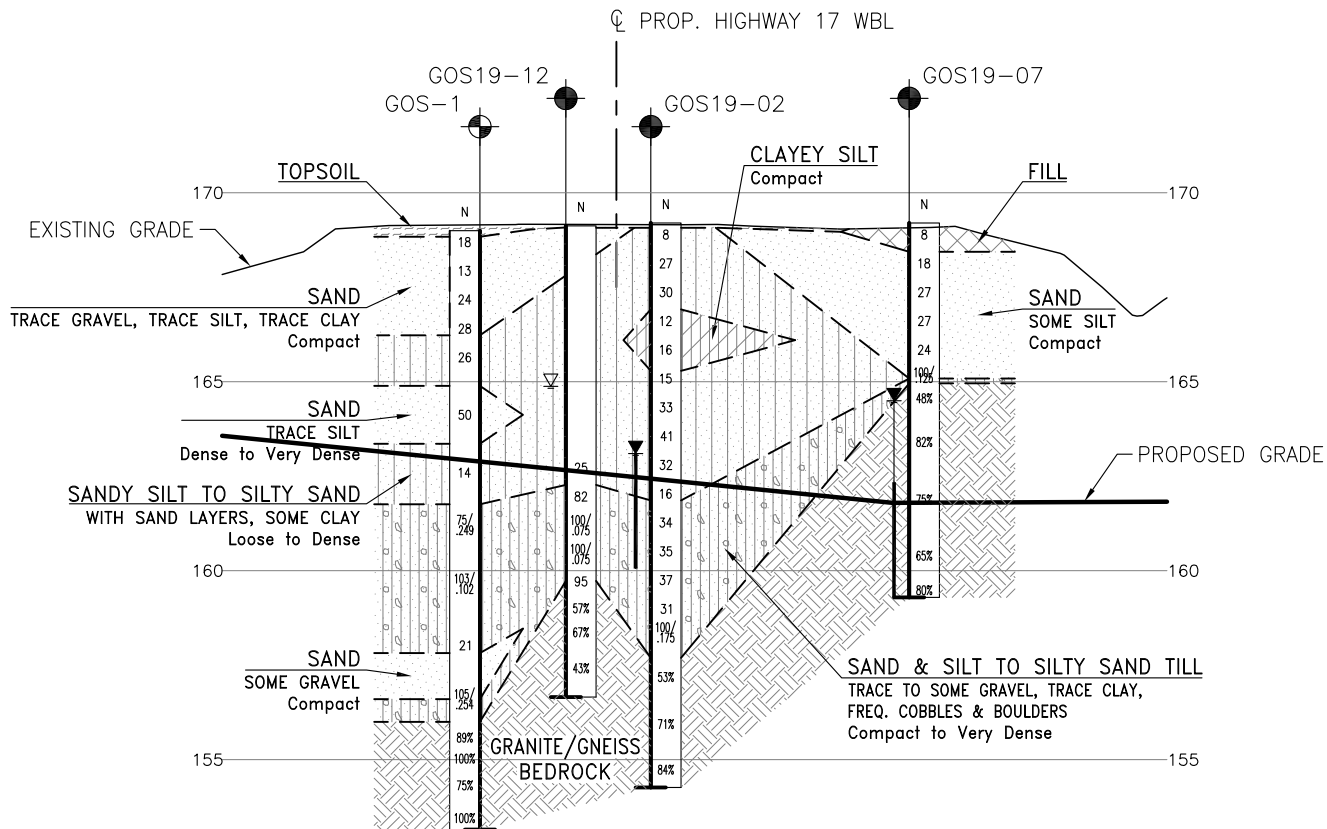
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 9.

GEOCREs No. 31F-225

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JG	CHK FG	CODE
DRAWN	MFA	CHK JG	SITE 29-410
LOAD			DATE JUL 2022
STRUCT			DWG 2

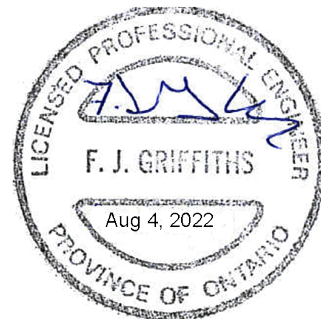


SECTION E-E



SECTION F-F

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



NO	ELEVATION	NORTHING	EASTING
GOS19-12	169.1	5 034 030.3	298 178.4
GOS-1	169.0	5 034 036.7	298 171.9
GOS-2	166.8	5 034 015.8	298 171.4
GOS-3	167.5	5 033 977.5	298 222.0
GOS-4	167.2	5 033 957.6	298 222.5

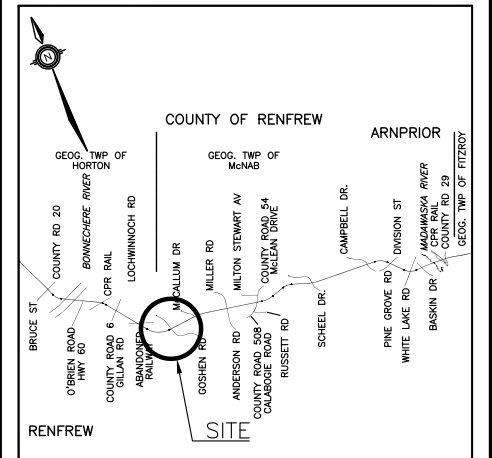
CONT No
WP No 4068-09-00

HIGHWAY 17 TWINNING
GOSHEN ROAD
OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Borehole (2020 Investigation)
- Borehole (2003 Investigation)
- 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
GOS19-01	166.9	5 034 031.8	298 158.4
GOS19-02	169.2	5 034 023.0	298 183.7
GOS19-03	167.4	5 033 975.0	298 209.0
GOS19-04	168.0	5 033 961.5	298 235.8
GOS19-04W	167.0	5 033 952.0	298 228.6
GOS19-05	167.1	5 034 069.5	298 128.7
GOS19-06	167.0	5 034 052.3	298 146.7
GOS19-07	169.2	5 034 002.5	298 201.8
GOS19-08	168.5	5 033 993.8	298 192.5
GOS19-09	167.3	5 033 940.0	298 244.1
GOS19-10	166.5	5 033 923.0	298 262.4
GOS19-11	166.8	5 034 022.8	298 163.3

-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 9.

GEOCREs No. 31F-225

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JG	CHK FG	CODE
DRAWN	MFA	CHK JG	SITE 29-410
LOAD			
STRUCT			
DWG	3		
DATE	JUL 2022		



Appendix B.

Record of Borehole 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).

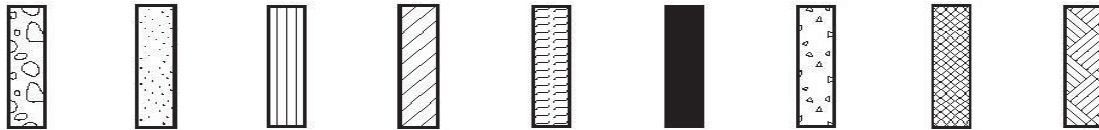
DYNAMIC CONE PENETRATION TEST (DCPT):

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 GOS19-01

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446186°, Long: -76.584904°
Goshen Road MTM Zone 9: N 5 034 031.8 E 298 158.4 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, NW Casing/NQ Coring COMPILED BY MW
DATUM Geodetic DATE 2019.09.03 - 2019.09.03 CHECKED BY JG

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						
166.9	Ground Surface							20 40 60 80 100						
0.0	SILTY SAND (SM) Compact Brown		1	SS	15		166							0 86 14 (SI+CL)
165.4			2	SS	15									
1.5	CLAYEY SILT Compact, Brown		3	SS	29		165							0 58 42 (SI+CL)
165.1			4	SS	73/ 50mm		164							
1.8	SILTY SAND (SM) Compact to Dense Brown		5	SS	39									
163.1			6	SS	63		163							
3.8	SANDY CLAYEY SILT(CL) , occasional cobbles Dense to Very Dense Grey-Brown TILL		7	SS	37		162							5 43 36 16
			8	SS	45/ 150mm		161							
160.5			9	SS	34		160							
6.4	CLAYEY SILTY SAND (SC-SM) , some gravel, occasional cobbles Compact to Very Dense Grey TILL		10	SS	24		159							
			11	SS	24		158							13 43 30 14
156.9							157							

Continued Next Page

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

RECORD OF BOREHOLE No GOS19-01

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446186°, Long: -76.584904°
Goshen Road MTM Zone 9: N 5 034 031.8 E 298 158.4 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, NW Casing/NQ Coring COMPILED BY MW
DATUM Geodetic DATE 2019.09.03 - 2019.09.03 CHECKED BY JG

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											WATER CONTENT (%)		
								20 40 60 80 100											20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
10.0	Continued From Previous Page		12	SS	100/ 75mm												GR SA SI CL				
	GRANITE/GNEISS BEDROCK Fresh jointed, grey and pink, very strong, coarse grained, some foliation		1	RUN													RUN #1 TCR=100% SCR=100% RQD=100%				
			2	RUN													RUN #2 TCR=100% SCR=90% RQD=98%				
											</										

RECORD OF BOREHOLE No GOS19-02

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446106°, Long: -76.584581°
Goshen Road MTM Zone 9: N 5 034 023.0 E 298 183.7 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.07 - 2020.07.07 CHECKED BY JG

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											
169.2	Ground Surface							20	40	60	80	100							
0.0	TOPSOIL (50 mm)							20	40	60	80	100							
0.1	SAND (SP-SM) with silt Loose to compact Brown to grey-brown		1	SS	8		169												
			2	SS	27		168												10 81 9 (SI+CL)
			3	SS	30														
166.9	CLAYEY SILT Compact Grey-brown		4	SS	12		167												
2.3			5	SS	16		166												
165.3	SANDY SILT (ML) Compact to dense Grey-brown		6	SS	15		165												0 32 56 12 non-plastic
3.9			7	SS	33		164												
			8	SS	41														
			9	SS	32		163												2 43 48 7 non-plastic
			10	SS	16		162												
161.9	SILTY SAND (SM) some gravel Dense to very dense Grey-brown to grey (TILL)		11	SS	34		161												15 69 16 (SI+CL)
7.3			12	SS	35														
			13	SS	37		160												

Continued Next Page

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

METRIC

Lat: 45.446106°, Long: -76.584581°
Goshen Road MTM Zone 9: N 5 034 023.0 E 298 183.7

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No GOS19-03

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445675°, Long: -76.584256°
Goshen Road MTM Zone 9: N 5 033 975.0 E 298 209.0 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, NW Casing/NQ Coring COMPILED BY JP
DATUM Geodetic DATE 2019.09.18 - 2019.09.18 CHECKED BY JG

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					
167.4	Pavement Surface												
0.0	ASPHALT												
0.2	SILTY SAND with gravel FILL Very Dense Brown		1	SS	81								
166.6													
0.8	GRANITE/GNEISS BEDROCK Fresh, pink and grey, strong, coarse grained		1	RUN									
			2	RUN									
			3	RUN									
162.9													
4.5	End of Borehole												

DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

RECORD OF DRILLHOLE GOS 19-03

PROJECT : Highway 17 Twinning
LOCATION : Goshen Road
STARTED : 2019 September 18
COMPLETED : 2019 September 18

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 033 975.0 E 298 209.0

Project No. 4068-09-00

SHEET 1 OF 2
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



RECORD OF DRILLHOLE GOS 19-03

PROJECT : Highway 17 Twinning
LOCATION : Goshen Road
STARTED : 2019 September 18
COMPLETED : 2019 September 18

Project No. 4068-09-00

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 033 975.0 E 298 209.0

SHEET 2 OF 2
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



RECORD OF BOREHOLE No GOS19-04

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445554°, Long: -76.583914°
Goshen Road MTM Zone 9: N 5 033 961.5 E 298 235.8 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, NW Casing/NQ Coring COMPILED BY JP
DATUM Geodetic DATE 2019.09.18 - 2019.09.18 CHECKED BY JG

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					
168.0	Shoulder							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
0.0	SILTY SAND with gravel FILL Dense Brown		1	SS	41								44 47 9 (SI+CL)
167.1			2	SS	100/								
0.9	ROCK FILL -Gravel, cobbles and boulders		3	NQ	125mm		167						
165.6							166						
2.4	GRANITE/GNEISS BEDROCK Fresh, pink and grey, strong to very strong, coarse grained - Vertical Fracture from 3 m to 3.5 m		1	RUN			165						RUN #1 TCR=100% SCR=76% RQD=100% UCS=91MPa
							164						
			2	RUN			163						RUN #2 TCR=100% SCR=96% RQD=86% UCS=90MPa
							162						
			3	RUN			161						RUN #3 TCR=100% SCR=81% RQD=58% UCS=88MPa
							160						RUN #4 TCR=100% SCR=98% RQD=98% UCS=113MPa
			4	RUN			159						RUN #5 TCR=100% SCR=100% RQD=96% UCS=123MPa
158.4			5	RUN									
9.6	End of Borehole												

DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

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

RECORD OF DRILLHOLE GOS 19-04

PROJECT : Highway 17 Twinning
LOCATION : Goshen Road
STARTED : 2019 September 18
COMPLETED : 2019 September 18

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 033 961.5 E 298 235.8

Project No. 4068-09-00

SHEET 1 OF 3
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



ROCKM2 24726 GOSHEN ROAD- ROCK.GPJ 22-7-25

RECORD OF DRILLHOLE GOS 19-04

PROJECT : Highway 17 Twinning
 LOCATION : Goshen Road
 STARTED : 2019 September 18
 COMPLETED : 2019 September 18

INCLINATION: Vertical
 AZIMUTH: Vertical
 N 5 033 961.5 E 298 235.8

Project No. 4068-09-00

SHEET 2 OF 3
 DATUM Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	RECOVERY TOTAL CORE % SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	DIP wrt Core Axis	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	Unconfined Compressive Strength (MPa)	FIELD/LABORATORY TESTING RESULTS ● Point Load Test Diametral ▲ Point Load Test Axial ■ Laboratory UCS Test
6	Rotary Drill NQ Core	GRANITE/GNEISS BEDROCK Fresh Pinkish White and Grey Phaneritic (Coarse grained) texture Massive structure Igneous formation Strong to very strong	+									J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight with non-softening clay J, SP, oxidized J, SP, tight			
												J, SP, oxidized			
												J, SP, tight			
												J, SP, tight			
7	Rotary Drill NQ Core		+		3							J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight			
												J, SP, tight, oxidized			
												J, SP			
												J, SP, tight, oxidized			
8	Rotary Drill NQ Core		+		4										

GROUNDWATER ELEVATIONS



WATER LEVEL UPON COMPLETION



WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



RECORD OF DRILLHOLE GOS 19-04

PROJECT	:	Highway 17 Twinning
LOCATION	:	Goshen Road
STARTED	:	2019 September 18
COMPLETED	:	2019 September 18

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 033 961.5 E 298 235.8

Project No. 4068-09-00

SHEET 3 OF 3
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



RECORD OF BOREHOLE No GOS19-04W

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445471°, Long: -76.584001°
Goshen Road MTM Zone 9: N 5 033 952.0 E 298 228.6 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.14 - 2020.07.14 CHECKED BY JG

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										
167.0	Ground Surface							20	40	60	80	100						
0.0	TOPSOIL (100 mm)							20	40	60	80	100						
0.1	SILTY SAND to SANDY SILT Compact Moist to wet Brown		1	SS	24													
			2	SS	13		166											
165.5																		
1.5	SILTY SAND (SM), some gravel Frequent cobbles Wet Dense Grey TILL		3	SS	100/ 225 mm		165										17 63 20 (SI+CL)	
			4	SS	100/ 100 mm													
164.2			5	NQ														
2.8	GNEISS BEDROCK Slightly weathered to fresh Grey and pink Fine grained - Sub vertical fractures from 3.5 m to 5.7 m		6	SS	100/ 50 mm		164									FI		
			1	RUN												2	RUN #1 TCR=100% SCR=44% RQD=44%	
			2	RUN			163									>10	RUN #2 TCR=100% SCR=5% RQD=0%	
																2		
			3	RUN			162									>10	RUN #3 TCR=100% SCR=35% RQD=32%	
							161									2		
160.6																3		
6.4	End of Borehole Monitoring well consists of 50 mm diameter Schedule 40 PVC pipe with a 3 m slotted screen WATER LEVEL READINGS: Date Depth (m) Elev. (m) 2020.07.22 5.7 161.3 2020.09.29 4.9 162.1 2020.12.16 4.1 162.9 2021.09.28 4.2 162.8 2021.10.02 4.5 162.5 2022.01.20 5.0 162.0																	

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

RECORD OF BOREHOLE No GOS19-05

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446525°, Long: -76.585284°
Goshen Road MTM Zone 9: N 5 034 069.5 E 298 128.7 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, HSA/NW Casing COMPILED BY MW
DATUM Geodetic DATE 2019.08.29 - 2019.08.29 CHECKED BY JG

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					
167.1	Shoulder							20 40 60 80 100					
0.0	SILTY SAND, some gravel FILL Very Dense Brown		1	SS	85		167						
166.3													
0.8	SILTY SAND (SM) Compact to Dense Brown		2	SS	26		166						
			3	SS	51		165						0 78 22 (SI+CL)
			4	SS	45		164						
			5	SS	43		163						
162.5							162						
4.6	SILTY SAND (SM) some gravel Very Dense Brown		6	SS	61		161						35 50 15 (SI+CL)
161.0							160						
6.1	SANDY CLAYEY SILT (CL) Compact Brownish Grey (TILL)		7	SS	21		159						2 47 37 14
159.5							158						
7.6	CLAYEY SAND (SC), some gravel Frequent Cobbles and Boulders Very Dense Grey (TILL)		8	SS	100/ 50mm								
			9	NQ									
			10	NQ									14 41 32 13

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

RECORD OF BOREHOLE No GOS19-05

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446525°, Long: -76.585284°
Goshen Road MTM Zone 9: N 5 034 069.5 E 298 128.7 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, HSA/NW Casing COMPILED BY MW
DATUM Geodetic DATE 2019.08.29 - 2019.08.29 CHECKED BY JG

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			
156.4	CLAYEY SAND (SC), some gravel Frequent Cobbles and Boulders Very Dense, Grey (TILL)					157											
10.7	End of Borehole																

DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

RECORD OF BOREHOLE No GOS19-06

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446371°, Long: -76.585054°
Goshen Road MTM Zone 9: N 5 034 052.3 E 298 146.7 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, HSA/NW Casing COMPILED BY MW
DATUM Geodetic DATE 2019.08.29 - 2019.08.29 CHECKED BY JG

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 (%)				
167.0	Shoulder							20 40 60 80 100		W _P W W _L				
0.0	SAND with silt and gravel FILL Compact Brown		1	GS				○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					28 62 10 (SI+CL)	
166.2								20 40 60 80 100		20 40 60				
0.8	SILTY SAND (SM) Loose to Compact Brown		2	SS	8		166							
			3	SS	24		165							
			4	SS	23		164							0 61 39 (SI+CL)
			5	SS	21		163							
			6	SS	12		162							
							161							
160.9														
6.1	CLAYEY SAND (SC), occasional cobble Loose to Very Dense Brown to Grey-Brown TILL		7	SS	7		160							
			8	NQ										
			9	SS	68		159							3 48 35 14
157.8							158							
9.2	End of Borehole		10	SS	100/75mm									
	Monitoring well consists of 46 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GOS19-06

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446371°, Long: -76.585054°
Goshen Road MTM Zone 9: N 5 034 052.3 E 298 146.7 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, HSA/NW Casing COMPILED BY MW
DATUM Geodetic DATE 2019.08.29 - 2019.08.29 CHECKED BY JG

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					
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.09.26 3.4 163.6 2020.04.21 0.6 166.4 2020.09.29 3.5 163.5 2022.10.22 3.7 163.3																

DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

RECORD OF BOREHOLE No GOS19-07

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445922°, Long: -76.584349°
Goshen Road MTM Zone 9: N 5 034 002.5 E 298 201.8 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.08 - 2020.07.08 CHECKED BY JG

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												
169.2	Ground Surface							20	40	60	80	100								
0.0	TOPSOIL (25 mm)							20	40	60	80	100								
	SILTY SAND FILL Loose Brown		1	SS	8		169													
168.4																				
0.8	SAND (SP-SM)some silt Compact Grey-brown		2	SS	18		168													
			3	SS	27		167													
			4	SS	27		166													
			5	SS	24		165													
165.1			6	SS	100/		164													
164.0	SILTY SAND trace gravel Dense, Brown (TILL)		1	RUN	125 mm		163													
4.2	GRANITE/GNEISS BEDROCK Slightly weathered to fresh , pink to grey, very strong, fine grained - Subvertical fractures (4.4 m to 4.5 m, 4.7 m to 4.8 m, 7.2 m to 7.5 m, and 9.2 m to 9.9 m)						162													
			2	RUN			161													
			3	RUN			160													
			4	RUN																
159.3			5	RUN																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]




+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No GOS19-08

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445845°, Long: -76.584467° Goshen Road MTM Zone 9: N 5 033 993.8 E 298 192.5 ORIGINATED BY AC
 HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
 DATUM Geodetic DATE 2020.07.09 - 2020.07.09 CHECKED BY JG

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	
168.5	Ground Surface						20	40	60	80	100	20	40	60				
0.0	TOPSOIL (50 mm) SILTY SAND (SM) to SANDY SILT (ML) Some organics Loose to compact Grey-brown		1	SS	4													
0.1																		
			2	SS	19													
166.7			3	SS	42													
1.8	SILTY SAND (SM) trace gravel Frequent cobbles and boulders Dense Grey-brown (TILL)		4															
165.8			1	RUN														
2.7	GRANITE/GNEISS BEDROCK Slightly weathered to fresh, pink to grey, very strong , fine to medium grained - Fractured from 4 m to 4.6 m - Subvertical fractures from 5.6 m to 5.8 m		2	RUN														
					3	RUN												
								</										

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

RECORD OF BOREHOLE No GOS19-09

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445361°, Long: -76.583801°
Goshen Road MTM Zone 9: N 5 033 940.0 E 298 244.1 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.13 - 2020.07.13 CHECKED BY JG

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								
167.3	Ground Surface															
0.0	TOPSOIL (50 mm)															
	SILTY SAND (SM)trace gravel Compact Grey brown to grey Moist to wet		1	SS	21		167									8 67 25 (SI+CL)
			2	SS	21		166									
165.8																
1.5	SILTY SAND compact to very dense brown wet (TILL)		3	SS	23		165									
	- Frequent cobbles and boulders 2.3 m to 3.1 m		4	SS	100/ 50 mm											
			1	RUN			164									
164.2	GRANITE/GNEISS BEDROCK Slightly weathered to fresh, pink and grey, very strong, fine to medium grained - Highly fractured from 3.4 m to 4.1 m		2	RUN			163									
3.1			3	RUN			162									
			4	RUN			161									
			5	RUN			160									
			6	RUN			159									
158.8																
8.5	End of Borehole Monitoring well consists of 51 mm diameter Schedule 40 PVC pipe with a 3 m slotted screen WATER LEVEL READINGS: Date Depth (m) Elev. (m) 2020.07.15 6.1 161.2 2020.07.22 7.2 160.1 2020.09.29 7.4 159.9 2020.12.16 6.8 160.5															

Continued Next Page

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

RECORD OF BOREHOLE No GOS19-09

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445361°, Long: -76.583801°
Goshen Road MTM Zone 9: N 5 033 940.0 E 298 244.1 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.13 - 2020.07.13 CHECKED BY JG

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																				
	Continued From Previous Page																											
	<p>WATER LEVEL READINGS:</p> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev. (m)</th> </tr> </thead> <tbody> <tr> <td>2021.09.28</td> <td>7.5</td> <td>159.8</td> </tr> <tr> <td>2021.10.02</td> <td>7.6</td> <td>159.7</td> </tr> <tr> <td>2021.01.20</td> <td>7.3</td> <td>160.0</td> </tr> </tbody> </table>	Date	Depth (m)	Elev. (m)	2021.09.28	7.5	159.8	2021.10.02	7.6	159.7	2021.01.20	7.3	160.0															
Date	Depth (m)	Elev. (m)																										
2021.09.28	7.5	159.8																										
2021.10.02	7.6	159.7																										
2021.01.20	7.3	160.0																										





DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

RECORD OF BOREHOLE No GOS19-10

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.445201°, Long: -76.583601°
Goshen Road MTM Zone 9: N 5 033 923.0 E 298 262.4 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.14 - 2020.07.14 CHECKED BY JG

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											
								○ UNCONFINED + FIELD VANE											
								● QUICK TRIAXIAL × LAB VANE											
							WATER CONTENT (%)												
							20 40 60 80 100					20 40 60							
166.5	Ground Surface																		
0.0	TOPSOIL (100 mm)																		
0.1	SILTY SAND, some organics, occasional cobbles Compact to loose Grey-brown to grey		1	SS	16									○					
			2	SS	9										○				
			3	SS	39														
164.2																			
2.3	CLAY (CI) Grey-brown Very stiff to stiff		4	SS	11									○					
			5	SS	17										○				
162.7																			
3.8	SANDY SILT (ML) some gravel Grey-brown, compact TILL		6	SS	100/ 175 mm									○					
162.2																			
4.3	GRANITE/GNEISS BEDROCK Pink and grey Fine to medium grained Slightly weathered to fresh Frequent voids from 4.6 m to 4.9 m - Fractured zone at 5.1 m to 5.8 m - Fractured zone at 7.2 m to 7.3 m		1	RUN															
			2	RUN															
			3	RUN															

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

RECORD OF BOREHOLE No GOS19-11

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446105°, Long: -76.584842°
Goshen Road MTM Zone 9: N 5 034 022.8 E 298 163.3 ORIGINATED BY SOB
HWY 17 BOREHOLE TYPE CME 55 Truck, NW Casing/NQ Coring COMPILED BY MW
DATUM Geodetic DATE 2019.09.03 - 2019.09.03 CHECKED BY JG

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									
166.8	Ground Surface							20	40	60	80	100					GR SA SI CL
0.0	Advanced casing directly to 3.8 m																
163.0																	
3.8	SILTY SAND (SM) , some gravel		1	SS	76/												10 76 14
162.6	Very Dense, Brown TILL				125mm												(SI+CL)
4.2	GNEISS BEDROCK Fresh jointed, pink and grey , very strong, coarse grained, foliated		1	RUN													RUN #1 TCR=100% SCR=100% RQD=100%
			2	RUN													RUN #2 TCR=100% SCR=100% RQD=100% UCS=114MPa
159.2																	
7.6	End of Borehole																

DOUBLE LINE 24726 GOSHEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 22-7-26

RECORD OF DRILLHOLE GOS 19-11

PROJECT : Highway 17 Twinning
LOCATION : Goshen Road
STARTED : 2019 September 3
COMPLETED : 2019 September 3

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 034 022.8 E 298 163.3

Project No. 4068-09-00

SHEET 1 OF 2
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



RECORD OF DRILLHOLE GOS 19-11

PROJECT : Highway 17 Twinning
LOCATION : Goshen Road
STARTED : 2019 September 3
COMPLETED : 2019 September 3

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 034 022.8 E 298 163.3

Project No. 4068-09-00

SHEET 2 OF 2
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : SOB

CHECKED :



RECORD OF BOREHOLE No GOS19-12

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446172°, Long: -76.584649°
Goshen Road MTM Zone 9: N 5 034 030.3 E 298 178.4 ORIGINATED BY AC
HWY 17 BOREHOLE TYPE CME 75 Track, HW Casing/HQ Coring COMPILED BY MW
DATUM Geodetic DATE 2020.07.06 - 2020.07.06 CHECKED BY JG

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)			GR SA SI CL								
169.1	Ground Surface								20 40 60 80 100	20 40 60	20 40 60									
0.0	Advanced casing directly to 6.1 m																			

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF DRILLHOLE GOS 19-12

PROJECT : Highway 17 Twinning
LOCATION : Goshen Road
STARTED : 2020 June 7
COMPLETED : 2020 June 7

INCLINATION: Vertical
AZIMUTH: Vertical
N 5 034 030.3 E 298 178.4

Project No. 4068-09-00

SHEET 1 OF 2
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

 WATER LEVEL UPON COMPLETION

 WATER LEVEL IN WELL/PIEZOMETER

LOGGED : AC

CHECKED :



ROCKM2 24726 GOSHEN ROAD- ROCK.GPJ 22-7-25

RECORD OF DRILLHOLE GOS 19-12

PROJECT : Highway 17 Twinning
 LOCATION : Goshen Road
 STARTED : 2020 June 7
 COMPLETED : 2020 June 7

INCLINATION: Vertical
 AZIMUTH: Vertical
 N 5 034 030.3 E 298 178.4

Project No. 4068-09-00

SHEET 2 OF 2
 DATUM Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (mm/min)	COLOUR % RETURN	FLUSH	FR-FRACTURE		RU-ROUGH UNDULATING		T-TIGHT, HARD		HOR-HORIZONTAL		Unconfined Compressive Strength (MPa)	FIELD/LABORATORY TESTING RESULTS
				DEPTH (m)					CL-CLEAVAGE		RP-ROUGH PLANAR		SA-SLIGHTLY ALTERED, CLAY FREE		D-DIPPING			
									J-JOINT		SU-SMOOTH UNDULATING		CLAY FREE		V-VERTICAL			
									B-BEDDING		SP-SMOOTH PLANAR		SC-SWELLING, SOFT CLAY					
RECOVERY		R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec												
TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION														
80 80 80 80		80 80 80 80		80 80 80 80		6 12 12 12		0 0 0 0		-6 -5 -4 -3 10 10 10 10								
13			+	156.63														
		End of Borehole		12.47														
14																		
15																		

GROUNDWATER ELEVATIONS



WATER LEVEL UPON COMPLETION



WATER LEVEL IN WELL/PIEZOMETER

LOGGED : AC

CHECKED :



METRIC

[illegible]

(%) STRAIN AT FAILURE

ONTMT4 7450GOS.GPJ 18/06/04

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W _P	W		
						SHEAR STRENGTH kPa							
						○ UNCONFINED + FIELD VANE							
						● QUICK TRIAXIAL × LAB VANE							
						20 40 60 80 100							
						20 40 60							
157.8	SAND and SILT, trace gravel, trace clay, occasional cobbles Very Dense to Compact Grey Wet (TILL) (ML-nonplastic)		10	SS	21								
11.2	SAND, coarse grained, some gravel Compact (inferred) Grey Wet												
156.6			11	SS	105/ 254								
12.4	SAND and SILT, trace gravel, occasional cobbles Very Dense Grey Wet (TILL) (ML-nonplastic)				FI								
156.0													
13.0	GNEISS (BEDROCK) Slightly weathered, red and dark grey with black and white subvertical banding, extremely strong Vertical to subvertical joints at 12.7m, 12.8m, 13.2m, 15.2m Fractured zone from 15.1m to 15.3m		1	RUN	2								
			2	RUN	0								
			3	RUN	0								
					3								
			4	RUN	0								
153.2					0								
15.9	END OF BOREHOLE AT 15.85m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 2.13m slotted screen. WATER LEVEL READINGS: DATE ELEVATION (m) 22/10/03 163.3 18/12/03 164.4 05/02/04 164.2												RUN 1# TCR=100%, SCR=100%, RQD=89%, UCS=261MPa RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=318MPa RUN 3# TCR=100%, SCR=89%, RQD=75%, UCS=245MPa RUN 4# TCR=100%, SCR=100%, RQD=100%, UCS=196MPa

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No GOS-2

1 OF 1

METRIC

G.W.P. 647-92-00 LOCATION N 5034015.8, E 298171.4 (Goshen Road WBL) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 23.09.03 - 23.09.03 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
166.8	TOPSOIL (50mm)													
166.8	SAND , trace gravel, trace silt, trace rootlets Loose Brown Moist (SP)		1	SS	5		166							
			2	SS	50/ .150									
165.2	Sandy SILT , trace gravel Compact Brown Moist		3	SS	17		165							
164.6	SAND and GRAVEL , trace silt, trace clay, occasional cobbles Very Dense Brown Wet		4	SS	78*		164							37 52 9 2
			5	SS	97 FI									
163.2	* Sampler bouncing, probable cobbles Auger refusal at 3.6m. GNEISS (BEDROCK) Fresh to slightly weathered, red with black dots, extremely strong Subvertical joint from 4.9m to 5.3m Multiple fractures zone from 3.6m to 4.3m		1	RUN	>5 >5 >5		163							RUN 1# TCR=100%, SCR=55%, RQD=12%, UCS=258MPa
3.6			2	RUN	0 2 0 0 1		162							RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=262MPa
			3	RUN	0 3		161							RUN 3# TCR=100%, SCR=100%, RQD=100%, UCS=238MPa
160.0	END OF BOREHOLE AT 6.76m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
6.8														
WATER LEVEL READINGS: DATE ELEVATION (m) 22/10/03 164.3 18/12/03 164.8 05/02/04 164.7														

+ 3, X 3: Numbers refer to
Sensitivity





20
15-5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GOS-3

1 OF 1

METRIC

G.W.P. 647-92-00 LOCATION N 5033977.5, E 298222.0 (Goshen Road EBL) ORIGINATED BY JL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 16.10.03 - 16.10.03 CHECKED BY SKP

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								
167.5								20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L			
0.0	SAND and GRAVEL Compact Dark Brown to Black Moist (FILL)		1	SS	22		167						GR SA SI CL	
166.9														
0.6	GRAVEL and ROCK FRAGMENTS probable cobbles and boulders (POSSIBLE ROCK FILL) Auger refusal at 1.32m.		1	GS	FI		166							
165.8			1	RUN	>5								RUN 1# TCR=93%, SCR=43%, RQD=0%, UCS=216MPa	
1.7	GNEISS BEDROCK Slightly weathered, pink with black and white subvertical banding, very strong to extremely strong Subvertical joints at 1.3m to 1.4m, 1.7m, 2.3m, 2.4m, 4.6m 50mm fractured zone at 3.6m.		2	RUN	4 >5 0 0 2		165						RUN 2# TCR=100%, SCR=87%, RQD=53%, UCS=135MPa	
			3	RUN	0 >5 2 1 1		164						RUN 3# TCR=100%, SCR=95%, RQD=95%, UCS=212MPa	
162.8							163							
4.7	END OF BOREHOLE AT 4.72m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE ELEVATION (m) 22/10/03 164.6 18/12/03 164.6 05/02/04 Piezometer Destroyed													

METRIC

SOIL PROFILE			SAMPLES				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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			
167.2	SAND and GRAVEL , trace organics Very Dense (inferred) Brown to Black Moist (FILL) Auger refusal at 0.4m GRAVEL and ROCK FRAGMENTS probably cobbles and boulders (POSSIBLE ROCK FILL)		1	SS	66/250		167								RUN 1# TCR=35%, SCR=13%, RQD=0%	
166.8																
0.4																
165.7	BEDROCK GNEISS BEDROCK Slightly weathered, pink with black subvertical banding, very strong Vertical to subvertical joints at 3.8m to 4.3m, 4.9m and 5.0m Multiple fractures zone from 1.7m to 2.9m.		1	RUN	FI		166								RUN 2# TCR=43%, SCR=8%, RQD=0%	
1.5																
161.3	END OF BOREHOLE AT 5.94m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE ELEVATION (m) 22/10/03 164.4 18/12/03 164.4 05/02/04 Piezometer Destroyed		4	RUN			162							RUN 4# TCR=100%, SCR=92%, RQD=52%, UCS=194MPa		
5.9																



Appendix C.

Laboratory Testing

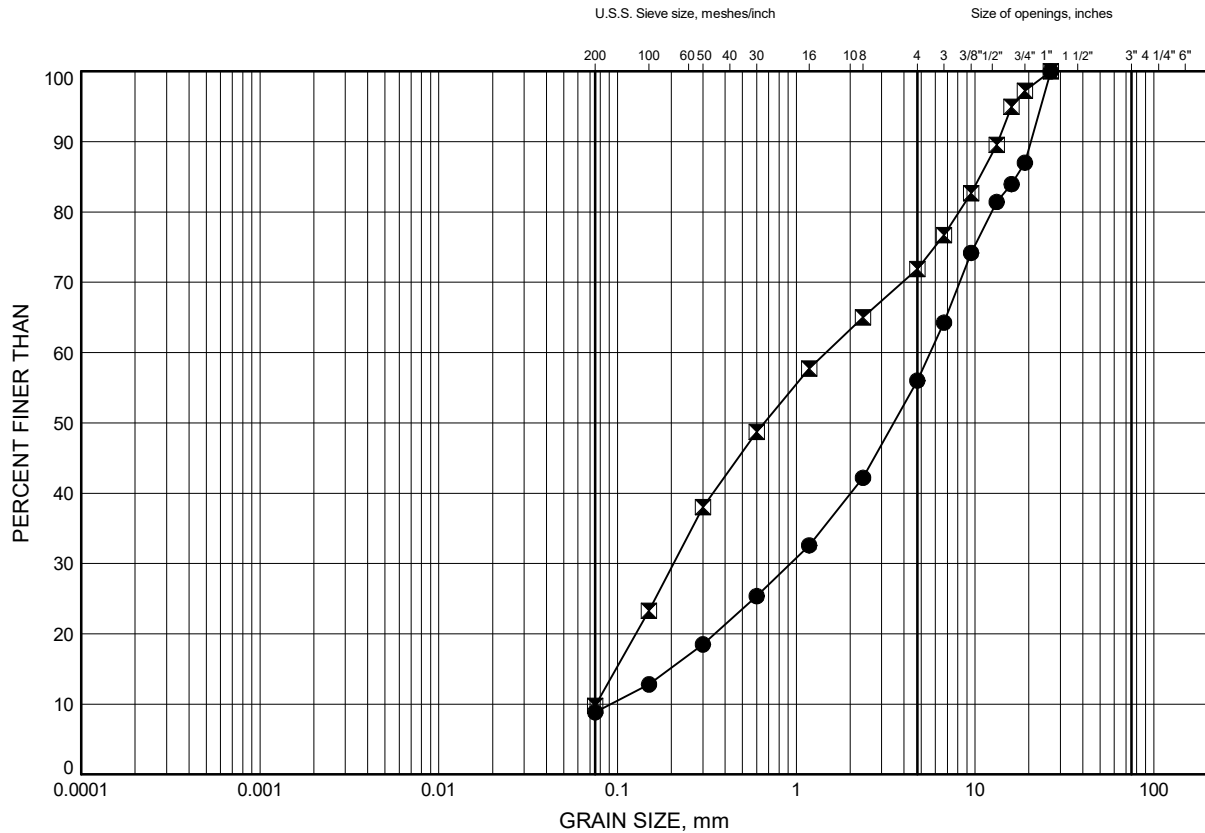


Appendix C.1
Particle Size Analysis Figures
Atterberg Limit Test Results

Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C1

Granular Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS19-04	0.3	167.7
◻	GOS19-06	0.3	166.7

Date March 2021
WP# 4068-09-00

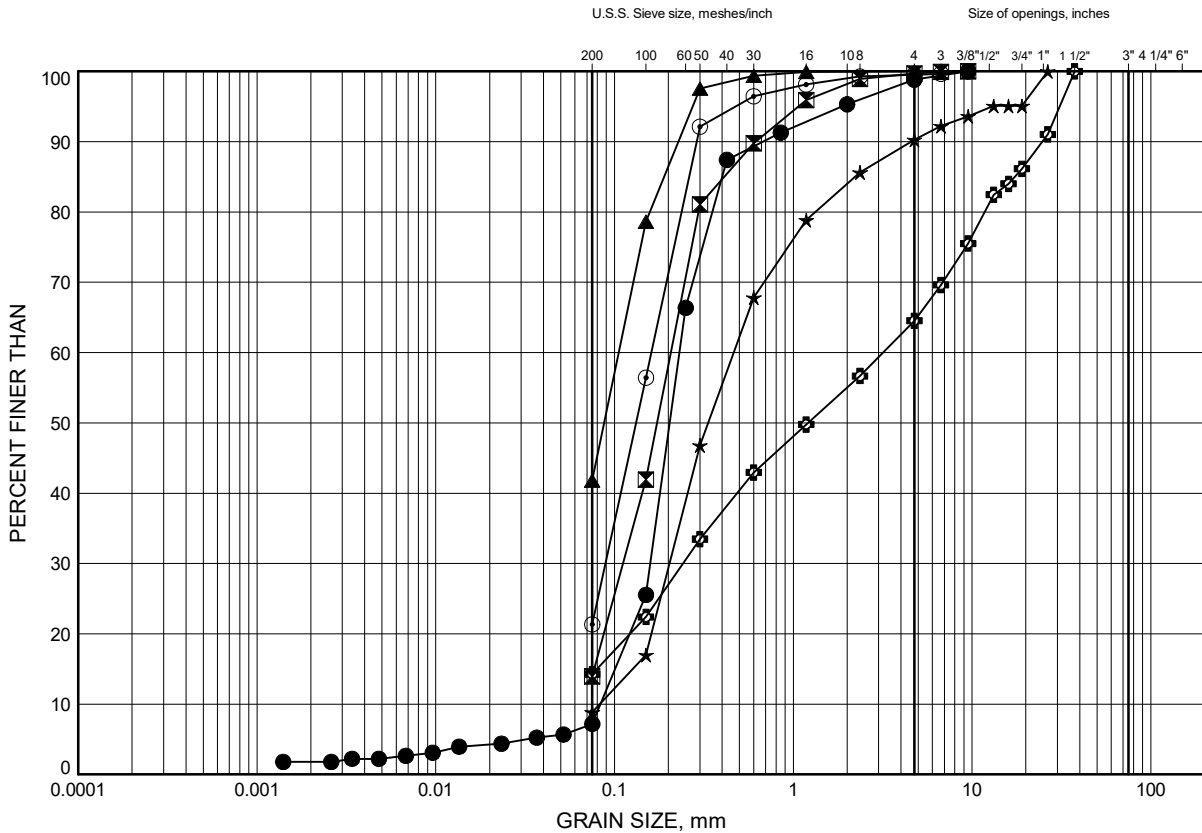


Prep'd KE
Chkd. FG

Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C2

Sand to Silty Sand (SP, SP-SM, SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS-1	1.8	167.2
⊠	GOS19-01	1.1	165.8
▲	GOS19-01	2.0	164.9
★	GOS19-02	1.1	168.1
⊙	GOS19-05	1.8	165.3
⊕	GOS19-05	4.9	162.2

Date March 2021
WP# 4068-09-00

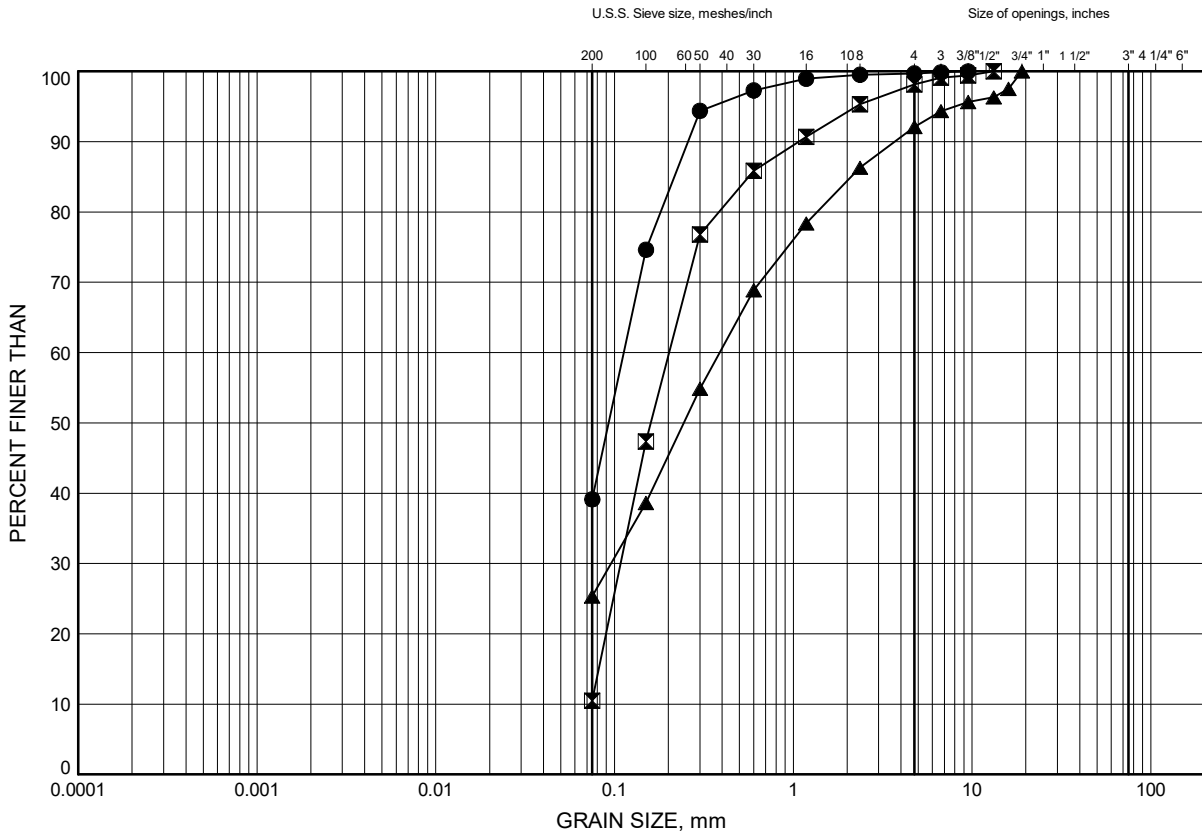


Prep'd KE
Chkd. FG

Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C3

Sand to Silty Sand (SP, SP-SM, SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS19-06	2.6	164.4
⊠	GOS19-07	1.1	168.1
▲	GOS19-09	1.0	166.3

Date March 2021
WP# 4068-09-00

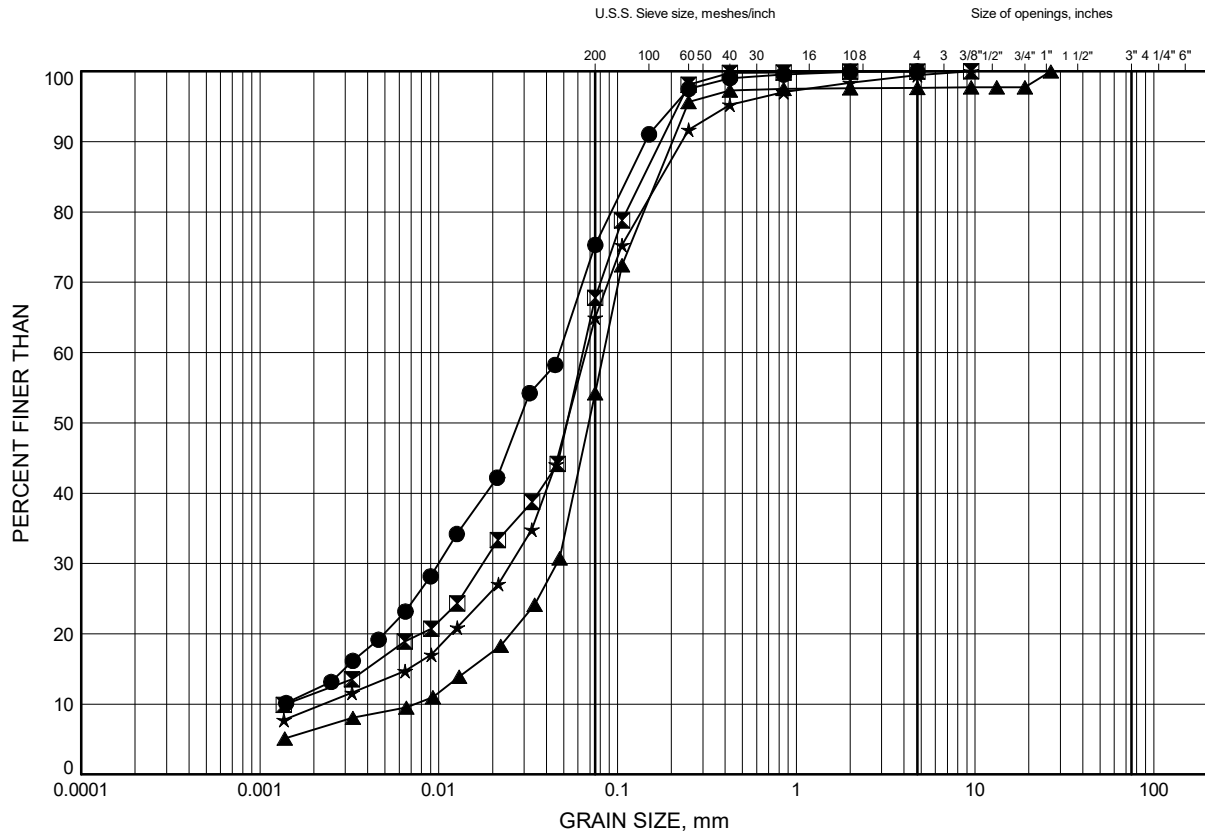


Prep'd KE
Chkd. FG

Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C4

Sandy Silt (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS-1	3.4	165.6
⊠	GOS19-02	4.2	165.0
▲	GOS19-02	6.4	162.8
★	GOS19-12	6.4	162.7

Date March 2021
WP# 4068-09-00

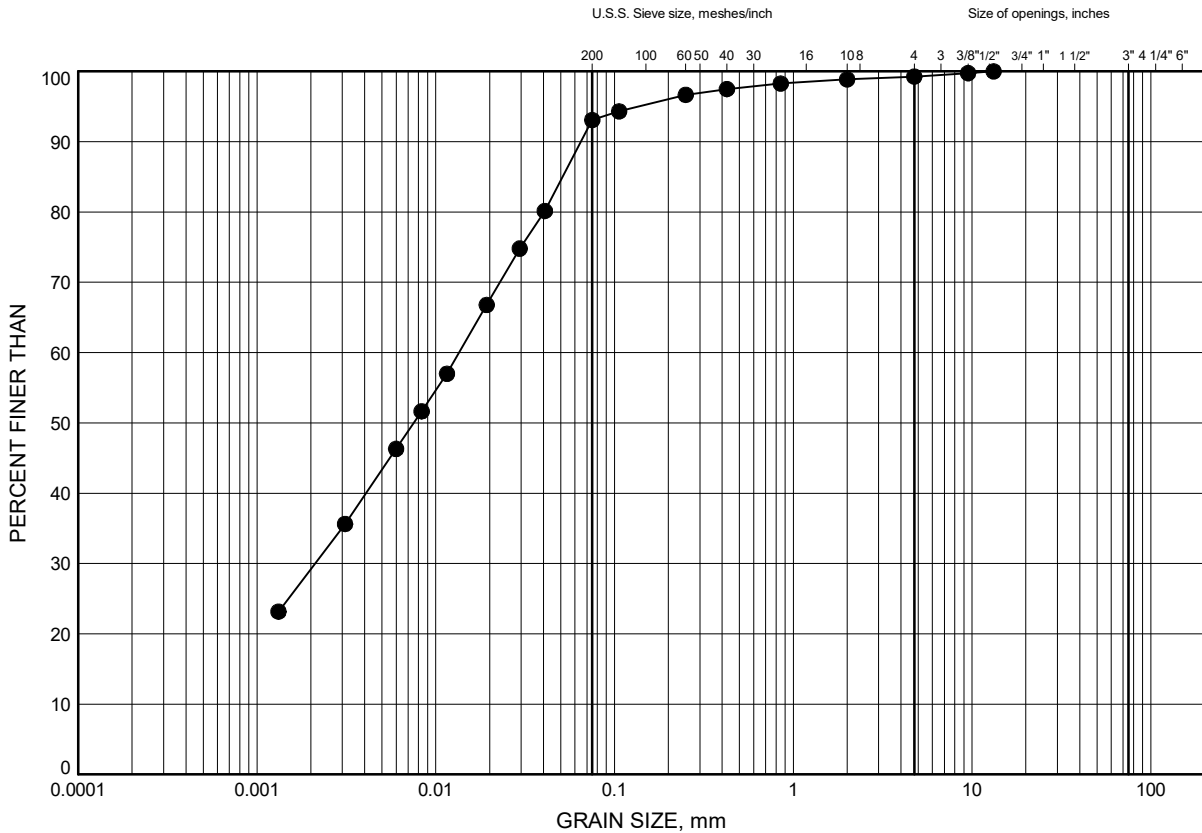


Prep'd KE
Chkd. FG

Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C5

Clay (CI)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS19-10	2.6	163.9

Date March 2021
WP# 4068-09-00



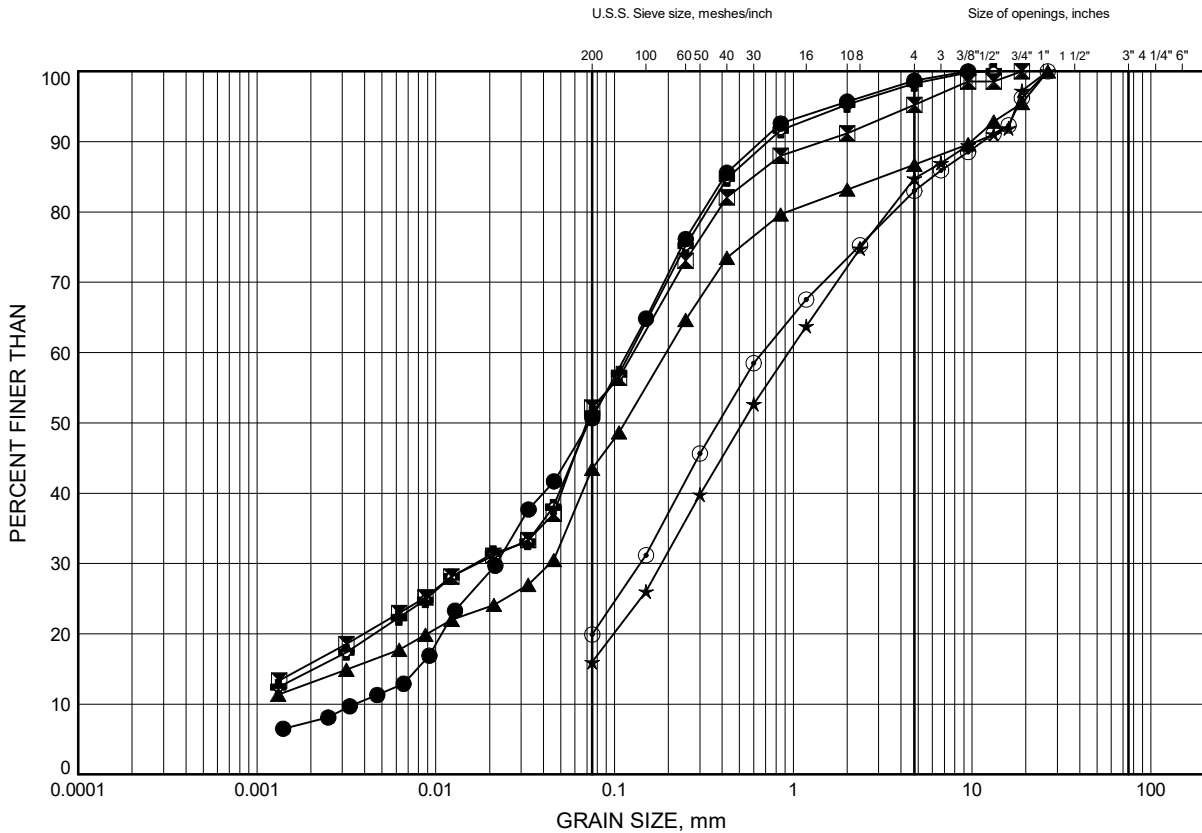
Prep'd KE
Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C6

Sandy Clayey Silt to Sandy Silt to Clayey Silty Sand to Silty Sand to Clayey Sand to Sand and Silt to Sand and Gravel (CL, ML, SC-SM, SM, SC) (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS-1	9.4	159.6
⊠	GOS19-01	4.9	162.0
▲	GOS19-01	8.7	158.2
★	GOS19-02	8.7	160.5
⊙	GOS19-04W	1.8	165.2
⊛	GOS19-05	6.4	160.7

Date March 2021
 WP# 4068-09-00



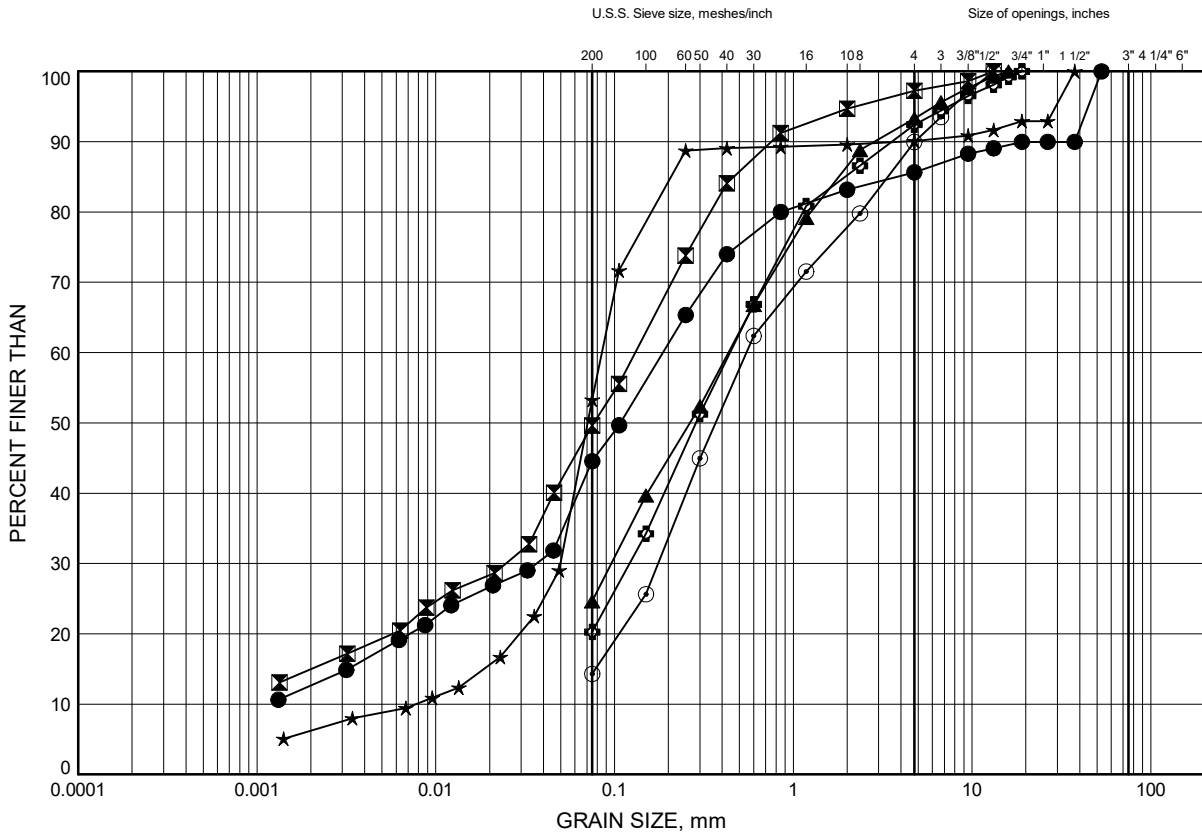
Prep'd KE
 Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C7

Sandy Clayey Silt to Sandy Silt to Clayey Silty Sand to Silty Sand to Clayey Sand to Sand and Silt to Sand and Gravel (CL, ML, SC-SM, SM, SC) (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS19-05	9.9	157.2
⊠	GOS19-06	7.9	159.1
▲	GOS19-08	2.0	166.5
★	GOS19-10	4.0	162.5
⊙	GOS19-11	4.0	162.8
⊛	GOS19-12	9.3	159.8

Date March 2021
 WP# 4068-09-00



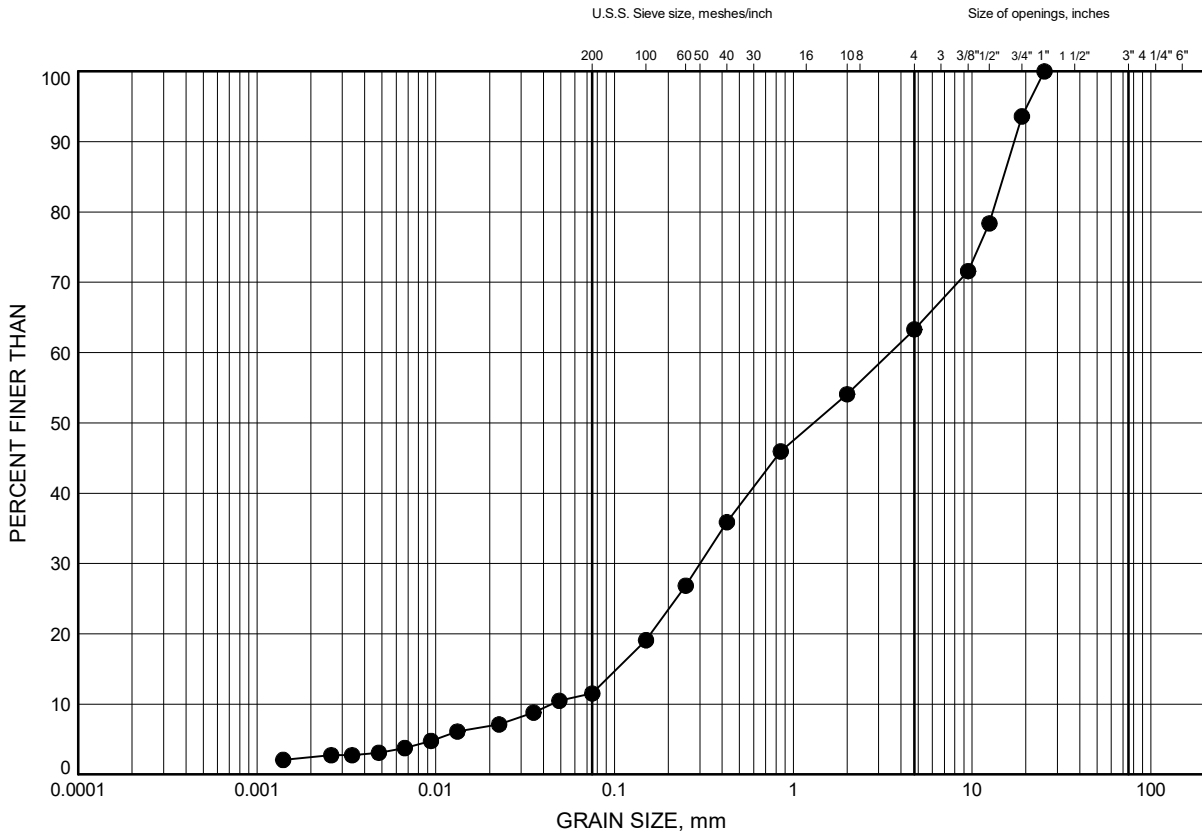
Prep'd KE
 Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C8

Sandy Clayey Silt to Sandy Silt to Clayey Silty Sand to Silty Sand to Clayey Sand to Sand and Silt to Sand and Gravel (CL, ML, SC-SM, SM, SC) (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS-2	2.5	164.3

Date March 2021
 WP# 4068-09-00

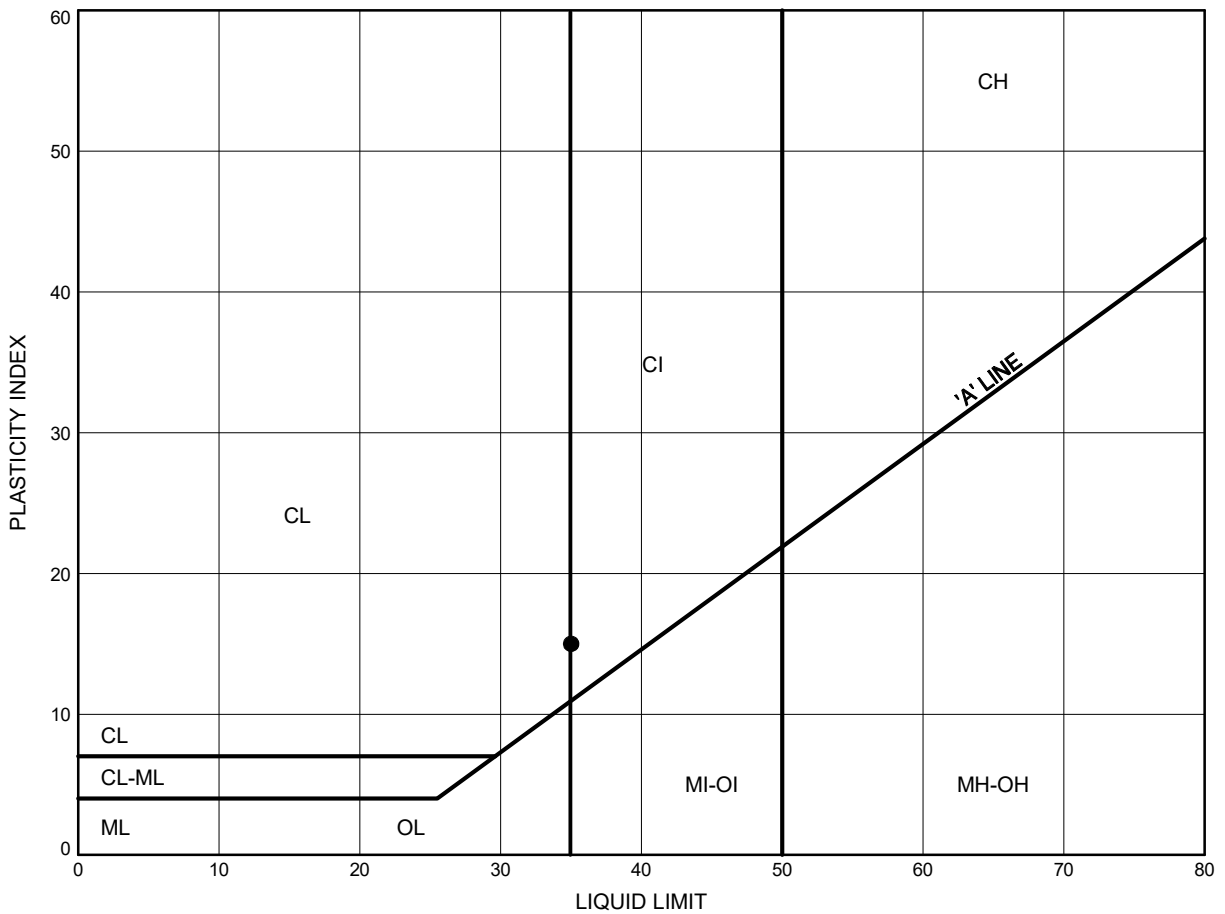


Prep'd KE
 Chkd. FG

Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C9

Clay (Cl)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS19-10	2.6	163.9

Date March 2021
 WP# 4068-09-00

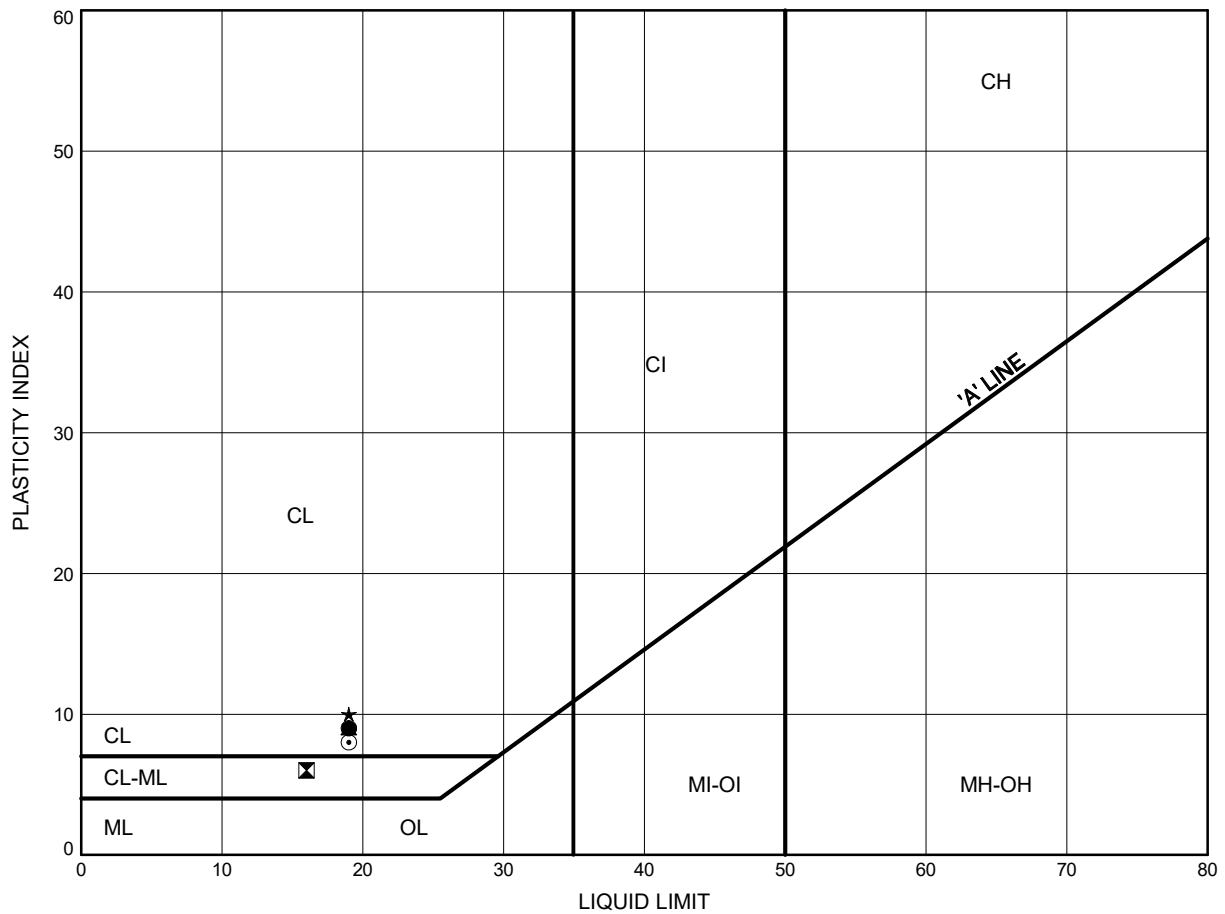


Prep'd KE
 Chkd. FG

Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C10

Sandy Clayey Silt to Clayey Silty Sand to Clayey Sand (CL, SC-SM, SC) (TILL)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GOS19-01	4.9	162.0
⊠	GOS19-01	8.7	158.2
▲	GOS19-05	6.4	160.7
★	GOS19-05	9.9	157.2
⊙	GOS19-06	7.9	159.1

Date March 2021
 WP# 4068-09-00



Prep'd KE
 Chkd. FG



Appendix C.2

Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Justin Gray

Client PO:
Project: 24726 Task 200a.202
Custody:

Report Date: 28-Jul-2020
Order Date: 22-Jul-2020

Order #: 2030239

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
2030239-01	GOS 19-2, SS3, 5'-7'
2030239-02	GOS 19-4W, SS2, 2'6"-4'-6"

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Report Date: 28-Jul-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Jul-2020

Client PO:

Project Description: 24726 Task 200a.202

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	28-Jul-20	28-Jul-20
Conductivity	MOE E3138 - probe @25 °C, water ext	27-Jul-20	27-Jul-20
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	22-Jul-20	23-Jul-20
Resistivity	EPA 120.1 - probe, water extraction	27-Jul-20	27-Jul-20
Solids, %	Gravimetric, calculation	28-Jul-20	28-Jul-20

Certificate of Analysis

Report Date: 28-Jul-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Jul-2020

Client PO:

Project Description: 24726 Task 200a.202

Client ID:	GOS 19-2, SS3, 5'-7'	GOS 19-4W, SS2, 2'6"-4'-6"	-	-
Sample Date:	07-Jul-20 09:00	14-Jul-20 09:00	-	-
Sample ID:	2030239-01	2030239-02	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	87.8	85.5	-	-
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General Inorganics

Conductivity	5 uS/cm	87	343	-	-
pH	0.05 pH Units	8.10	8.12	-	-
Resistivity	0.10 Ohm.m	114	29.1	-	-

Anions

Chloride	5 ug/g dry	22	17	-	-
Sulphate	5 ug/g dry	<5	8	-	-

Certificate of Analysis

Report Date: 28-Jul-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Jul-2020

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Report Date: 28-Jul-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Jul-2020

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	22.1	5	ug/g dry	21.8			1.4	20	
Sulphate	ND	5	ug/g dry	ND			NC	20	
General Inorganics									
Conductivity	230	5	uS/cm	227			1.3	5	
pH	11.46	0.05	pH Units	11.48			0.2	2.3	
Resistivity	43.6	0.10	Ohm.m	44.1			1.3	20	
Physical Characteristics									
% Solids	87.2	0.1	% by Wt.	87.8			0.6	25	

Certificate of Analysis

Report Date: 28-Jul-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Jul-2020

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	119	5	ug/g	21.8	96.9	82-118			
Sulphate	104	5	ug/g	ND	104	80-120			

Certificate of Analysis

Report Date: 28-Jul-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Jul-2020

Client PO:

Project Description: 24726 Task 200a.202

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104

Ottawa, ON K1B 4S5

Attn: Justin Gray

Tel: (613) 408-6795

Fax: (613) 247-2185

Paracel Report No. **2030239**Client Project(s): **24726 Task 200a.202**

Client PO:

Reference: **Standing Offer**

Order Date: 22-Jul-20

Report Date: 31-Jul-20

CoC Number:

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
2030239-01	GOS 19-2, SS3, 5'-7'	Sulphide, solid
2030239-02	GOS 19-4W, SS2, 2'6"-4'-6"	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax: 613-731-9064

31-July-2020

Date Rec. : 23 July 2020
LR Report: CA15517-JUL20
Reference: Project#: 2030239

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		31-Jul-20
2: Analysis Start Time		10:48
3: Analysis Completed Date		31-Jul-20
4: Analysis Completed Time		11:04
5: QC - Blank		< 0.04
6: QC - STD % Recovery		106%
7: QC - DUP % RPD		ND
8: RL		0.02
9: GOS 19-2, SS3, 5'-7'	07-Jul-20 09:00	< 0.04
10: GOS 19-4W, SS2, 2'6"-4'-6"	14-Jul-20 15:00	< 0.04

RL - SGS Reporting Limit
ND - Not Detected

Note: Sample GOS 19-2, SS3, 5' - 7' was already past the 14 day holding time for sulphide analysis when received. Processed as per client's instructions; result may be unreliable.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Client PO:
Project: 24726
Custody: 49169

Report Date: 20-Sep-2019
Order Date: 16-Sep-2019

Order #: 1938127

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID
1938127-01

Client ID
G05 19-01, SS4(7'6"-8'2")

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	18-Sep-19	18-Sep-19
Conductivity	MOE E3138 - probe @25 °C, water ext	19-Sep-19	20-Sep-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Sep-19	19-Sep-19
Resistivity	EPA 120.1 - probe, water extraction	19-Sep-19	20-Sep-19
Solids, %	Gravimetric, calculation	17-Sep-19	17-Sep-19

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Client ID:	G05 19-01, SS4(7'6"-8'2")	-	-	-
Sample Date:	03-Sep-19 09:00	-	-	-
Sample ID:	1938127-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	84.1	-	-	-
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General Inorganics

Conductivity	5 uS/cm	150	-	-	-
pH	0.05 pH Units	7.50	-	-	-
Resistivity	0.10 Ohm.m	66.7	-	-	-

Anions

Chloride	5 ug/g dry	22	-	-	-
Sulphate	5 ug/g dry	<5	-	-	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	21.0	5	ug/g dry	21.5			2.6	20	
Sulphate	ND	5	ug/g dry	ND			0.0	20	
General Inorganics									
Conductivity	97.4	5	uS/cm	101			3.2	5	
pH	7.39	0.05	pH Units	7.50			1.5	2.3	
Physical Characteristics									
% Solids	90.4	0.1	% by Wt.	90.3			0.1	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	114	5	ug/g	21.5	92.9	82-118			
Sulphate	108	5	ug/g	ND	108	80-120			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Qualifier Notes:

Login Qualifiers :

Received at temperature > 25C

Applies to samples: G05 19-01, SS4(7'6"-8'2")

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1938127**

Client Project(s): **24726**

Client PO:

Reference: **Standing Offer**

CoC Number: **49169**

Order Date: 16-Sep-19
Report Date: 23-Sep-19

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1938127-01	G05 19-01, SS4(7'6"-8'2")	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

23-September-2019

Date Rec. : 18 September 2019
LR Report: CA13701-SEP19
Reference: Project#: 1938127

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		20-Sep-19
2: Analysis Start Time		12:49
3: Analysis Completed Date		20-Sep-19
4: Analysis Completed Time		14:35
5: QC - Blank		< 0.02
6: QC - STD % Recovery		113%
7: QC - DUP % RPD		3%
8: RL		0.02
9: G05 19-01, SS4 (7'6"-8'2")	03-Sep-19	0.03

RL - SGS Reporting Limit

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Client PO:
Project: 24726
Custody: 49913

Report Date: 10-Oct-2019
Order Date: 4-Oct-2019

Order #: 1940637

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID
1940637-01

Client ID
GOS19-3, SS1 (6"-2'2")

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-Oct-2019
Order Date: 4-Oct-2019
Project Description: 24726

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-Oct-19	8-Oct-19
Conductivity	MOE E3138 - probe @25 °C, water ext	9-Oct-19	9-Oct-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	9-Oct-19	9-Oct-19
Resistivity	EPA 120.1 - probe, water extraction	9-Oct-19	9-Oct-19
Solids, %	Gravimetric, calculation	7-Oct-19	7-Oct-19

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

Client ID:	GOS19-3, SS1 (6"-2'2")	-	-	-
Sample Date:	18-Sep-19 09:00	-	-	-
Sample ID:	1940637-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	94.9	-	-	-
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General Inorganics

Conductivity	5 uS/cm	391	-	-	-
pH	0.05 pH Units	7.80	-	-	-
Resistivity	0.10 Ohm.m	25.6	-	-	-

Anions

Chloride	5 ug/g dry	33	-	-	-
Sulphate	5 ug/g dry	19	-	-	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-Oct-2019
Order Date: 4-Oct-2019
Project Description: 24726

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	502	5	ug/g dry	486			3.1	20	
Sulphate	123	5	ug/g dry	122			0.6	20	
General Inorganics									
pH	7.16	0.05	pH Units	7.13			0.4	2.3	
Resistivity	90.0	0.10	Ohm.m	89.9			0.2	20	
Physical Characteristics									
% Solids	94.3	0.1	% by Wt.	94.2			0.2	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	576	5	ug/g	486	90.0	82-118			
Sulphate	229	5	ug/g	122	107	80-120			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-Oct-2019
Order Date: 4-Oct-2019
Project Description: 24726

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1940637**

Client Project(s): **24726**

Client PO:

Reference: **Standing Offer**

CoC Number: **49913**

Order Date: 04-Oct-19
Report Date: 10-Oct-19

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1940637-01	GOS19-3, SS1 (6"-2'2")	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

10-October-2019

Date Rec. : 08 October 2019
LR Report: CA13305-OCT19
Reference: Project#: 1940637

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		10-Oct-19
2: Analysis Start Time		14:36
3: Analysis Completed Date		10-Oct-19
4: Analysis Completed Time		14:53
5: QC - Blank		< 0.02
6: QC - STD % Recovery		115%
7: QC - DUP % RPD		16%
8: RL		0.02
9: GOS19-3, SS1 (6"-2'2")	18-Sep-19	0.04

RL - SGS Reporting Limit

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety



Appendix C.3

UCS Test Results

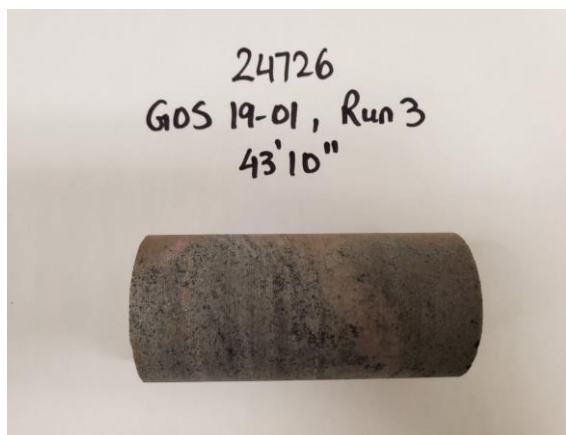
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

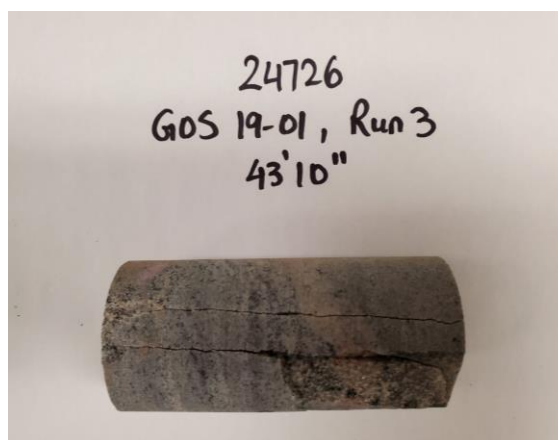
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-01	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 3		
SAMPLE DEPTH:	13.4m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.6	Weight (g):	465.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,677
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,677
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	173.72		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.6% / min
MAXIMUM COMPRESSIVE LOAD:	195.0 kN
UNCONFINED COMPRESSIVE STRENGTH:	107.8 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

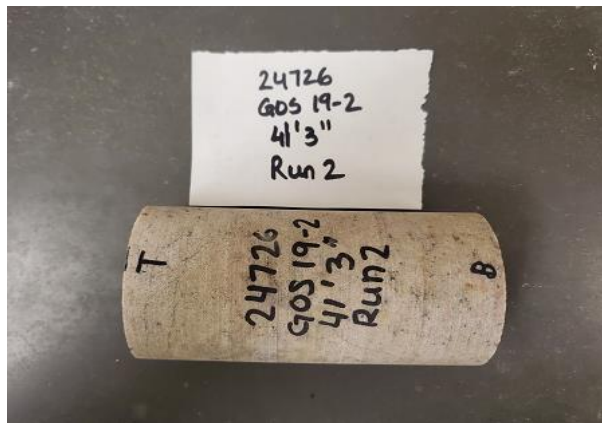
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

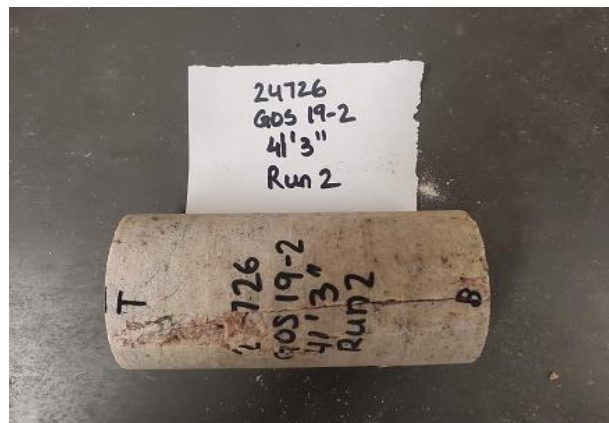
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-02	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	12.57 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.5	Weight (g):	991.5
Avg. Diameter (cm):	6.2	Wet Density (kg/m ³):	2,627
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,627
Cross Sectional Area (cm ²):	30.19	Moisture Content* (%):	0.0
Sample Volume (cm ³):	377.38		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	350.6 kN
UNCONFINED COMPRESSIVE STRENGTH:	116.1 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-02 Run 2

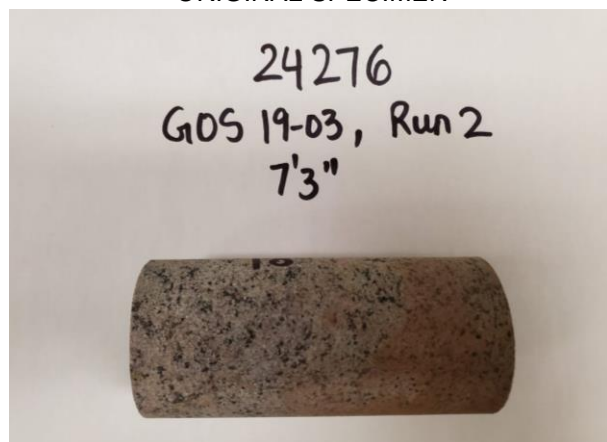
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

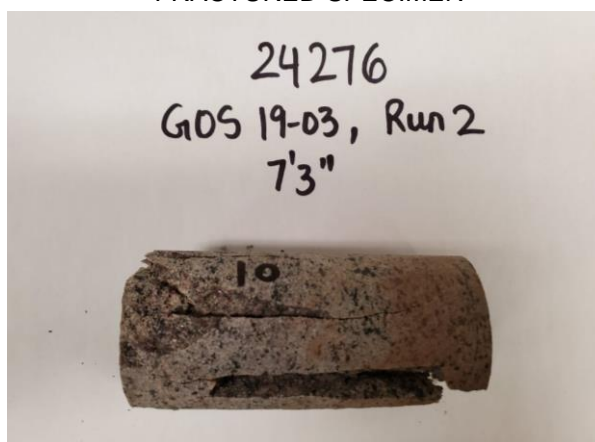
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-03	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 2		
SAMPLE DEPTH:	2.2m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.8	Weight (g):	476.9
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,689
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,689
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	177.34		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	161.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	89.5 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

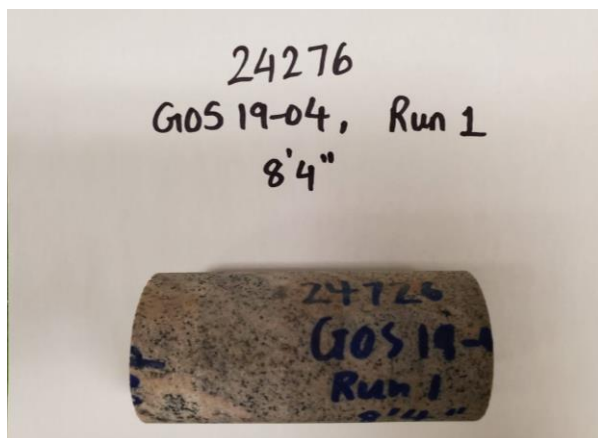
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

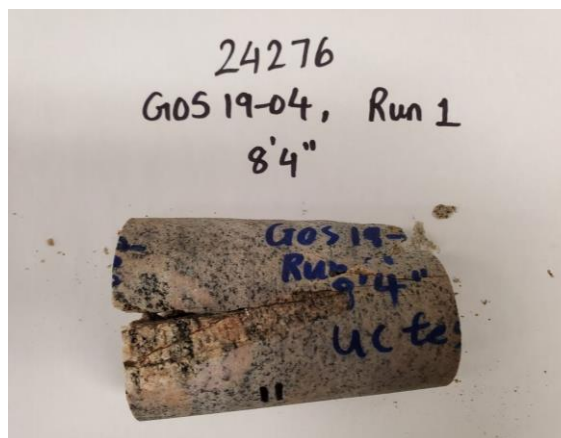
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-04	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 1		
SAMPLE DEPTH:	2.5m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.7	Weight (g):	464.4
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,646
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,646
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	175.53		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	164.2 kN
UNCONFINED COMPRESSIVE STRENGTH:	90.7 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

24726 - GOS 19-04 UCS Run 1, 8'4"

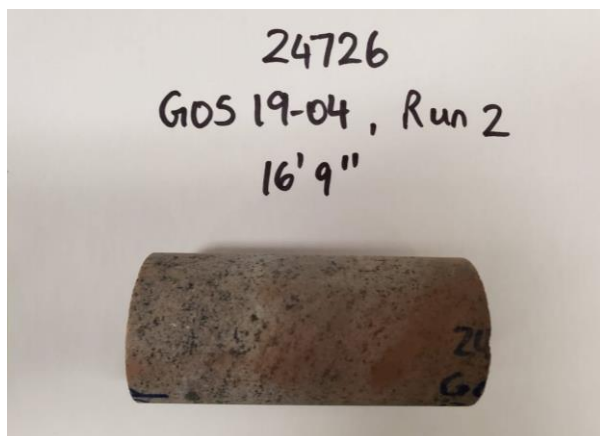
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

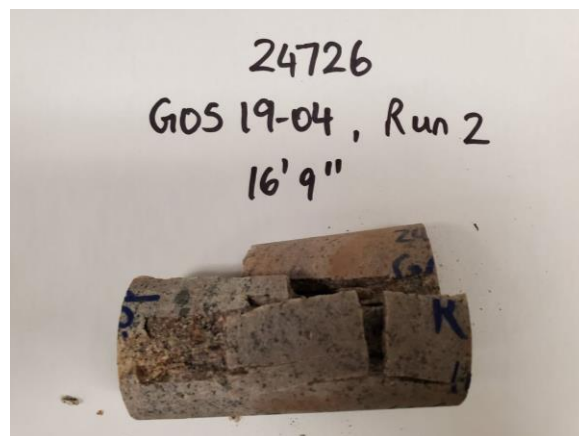
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-04	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 2		
SAMPLE DEPTH:	5.1m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.7	Weight (g):	468.6
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,670
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,670
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	175.53		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	164.0 kN
UNCONFINED COMPRESSIVE STRENGTH:	90.6 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

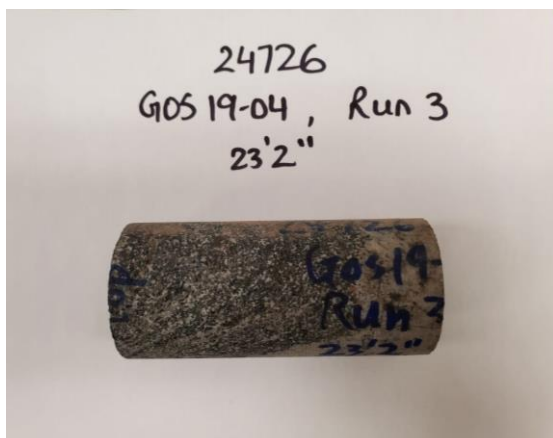
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

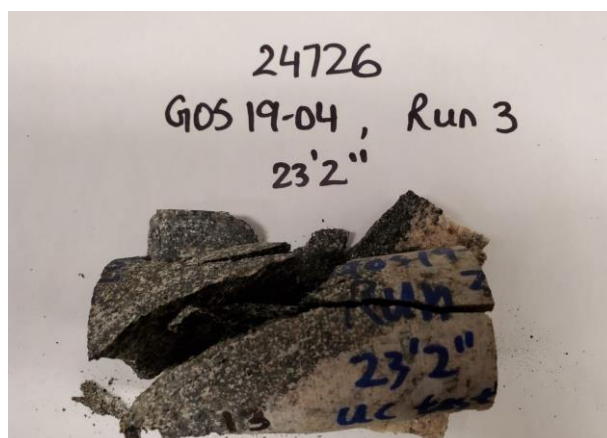
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-04	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 3		
SAMPLE DEPTH:	7.1m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.7	Weight (g):	493.8
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,813
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,813
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	175.53		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	159.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	88.0 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

24726 - GOS 19-04 UCS Run 3, 23'2"

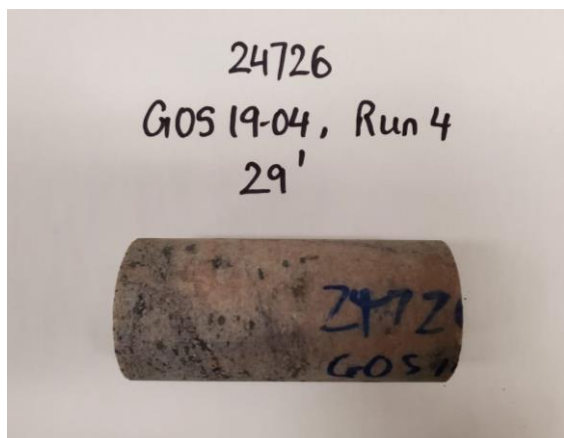
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

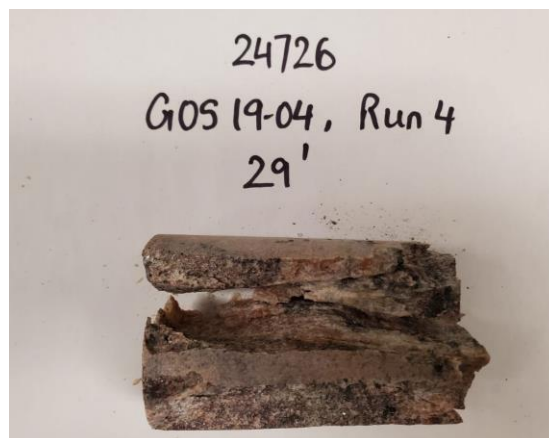
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-04	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 4		
SAMPLE DEPTH:	8.8m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.8	Weight (g):	467.9
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,638
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,638
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	177.34		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	205.1 kN
UNCONFINED COMPRESSIVE STRENGTH:	113.3 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

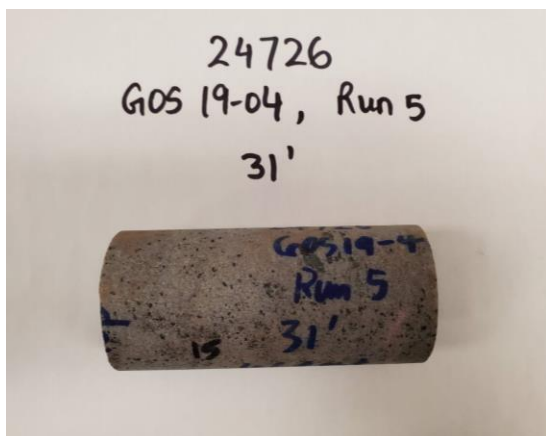
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

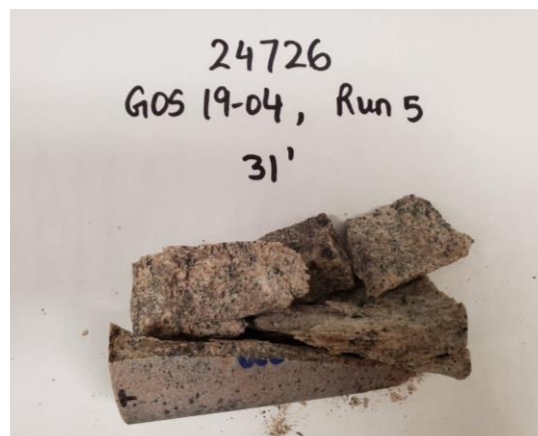
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-04	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 5		
SAMPLE DEPTH:	9.4m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.8	Weight (g):	471.2
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,657
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,657
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	177.34		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	222.7 kN
UNCONFINED COMPRESSIVE STRENGTH:	123.1 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

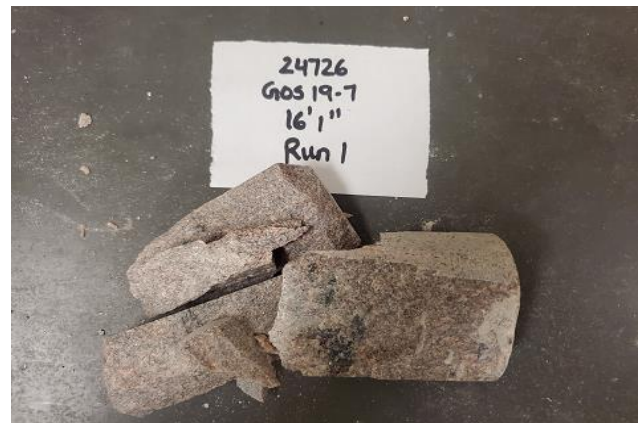
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-07	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	4.90 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	13.0	Weight (g):	1112.9
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,746
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m ³):	2,746
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	405.24		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	554.0 kN
UNCONFINED COMPRESSIVE STRENGTH:	177.7 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-07 Run 1

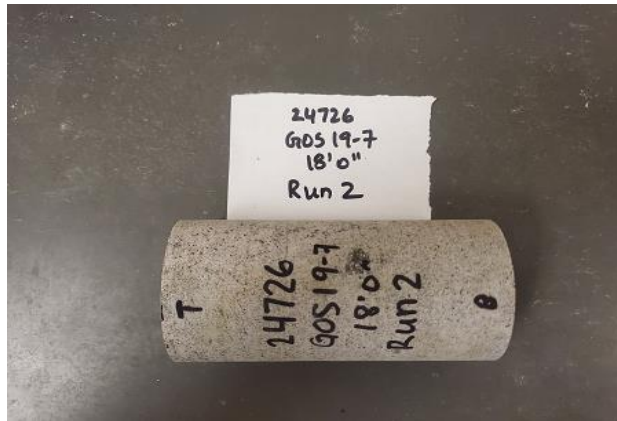
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

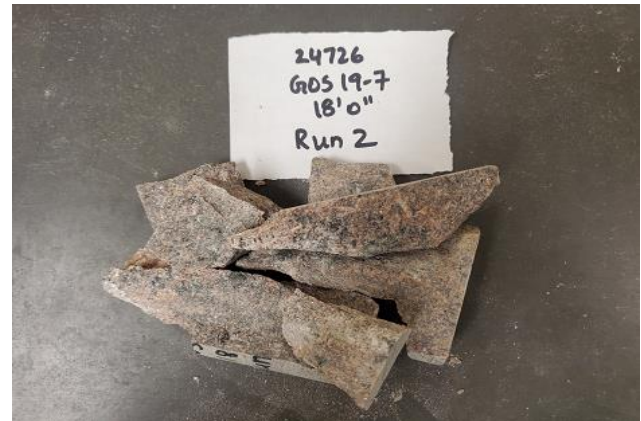
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-07	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	5.49 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.8	Weight (g):	1106.4
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,773
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,773
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	399.01		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	589.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	189.0 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-07 Run 2

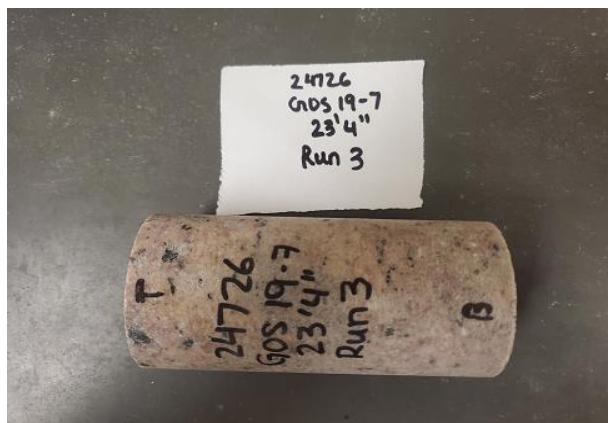
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-07	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 3		
SAMPLE DEPTH:	7.11 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.7	Weight (g):	1045.3
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,640
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,640
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	395.89		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	506.8 kN
UNCONFINED COMPRESSIVE STRENGTH:	162.6 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-07 Run 3

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

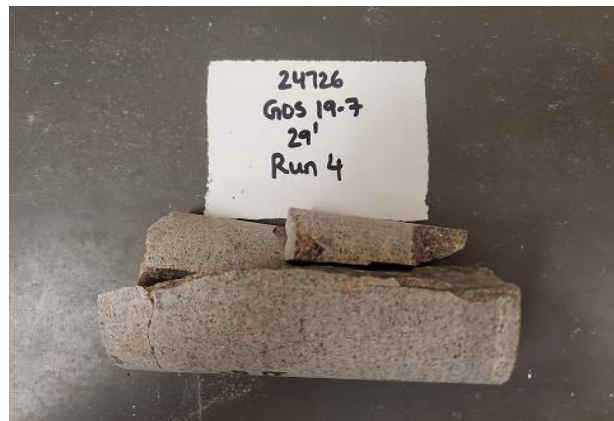
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-07	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 4		
SAMPLE DEPTH:	8.84 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.8	Weight (g):	1089.1
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,730
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,730
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	399.01		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	327.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	105.1 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-07 Run 4

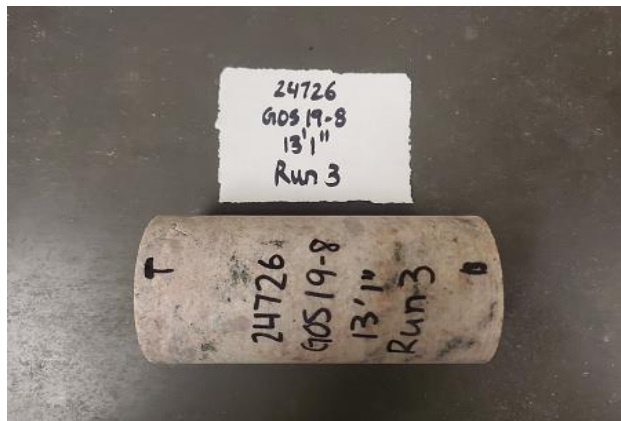
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

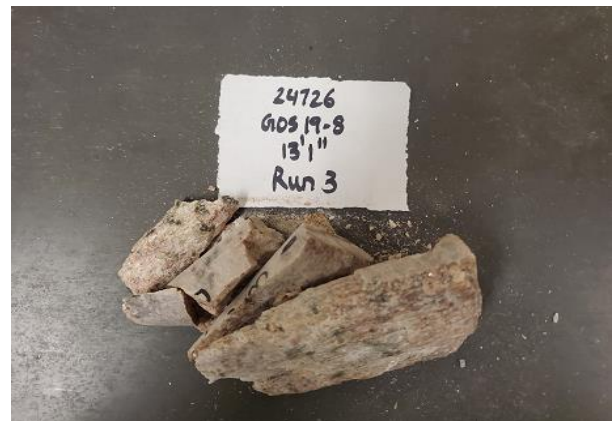
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-08	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 3		
SAMPLE DEPTH:	3.99 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.8	Weight (g):	1049.2
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,630
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,630
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	399.01		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	487.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	156.5 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-08 Run 3

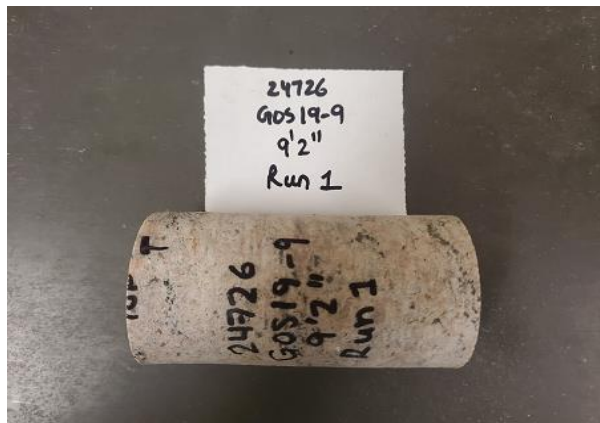
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

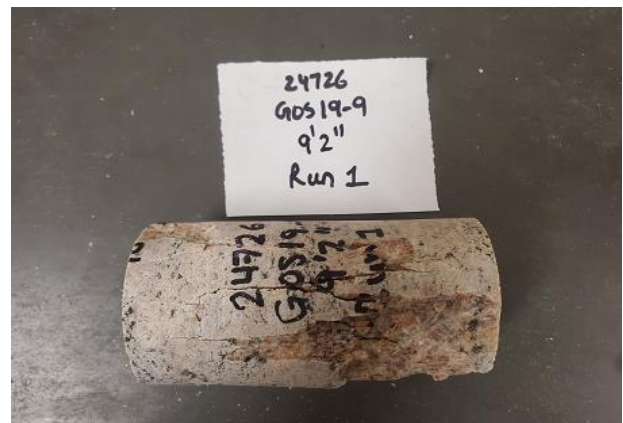
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-09	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	2.79 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	11.6	Weight (g):	930.7
Avg. Diameter (cm):	6.2	Wet Density (kg/m ³):	2,658
H. to Dia. Ratio**:	1.9:1	Dry Density (kg/m ³):	2,658
Cross Sectional Area (cm ²):	30.19	Moisture Content* (%):	0.0
Sample Volume (cm ³):	350.21		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.3% / min
MAXIMUM COMPRESSIVE LOAD:	330.2 kN
UNCONFINED COMPRESSIVE STRENGTH:	109.4 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

GOS 19-09 Run 1

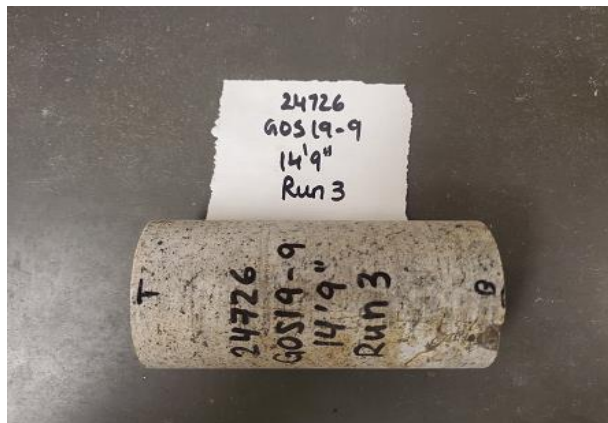
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-09	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 3		
SAMPLE DEPTH:	4.5 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.9	Weight (g):	1067.3
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,654
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,654
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	402.12		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	495.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	158.9 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

GOS 19-09 Run 3

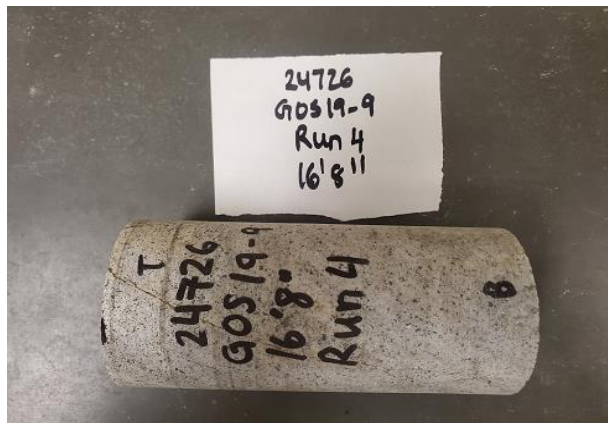
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

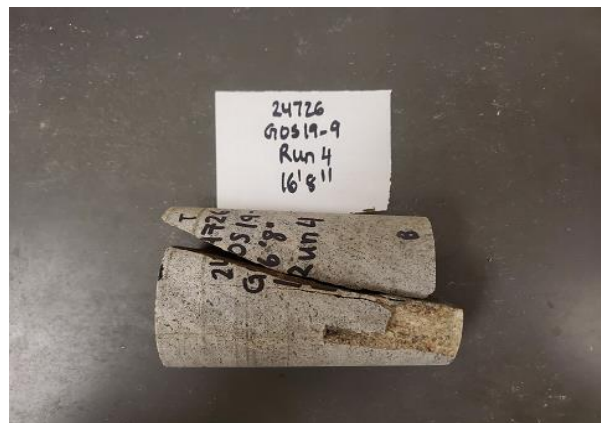
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-09	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 4		
SAMPLE DEPTH:	5.08 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	13.0	Weight (g):	1095.8
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,704
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m ³):	2,704
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	405.24		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	367.8 kN
UNCONFINED COMPRESSIVE STRENGTH:	118.0 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-09 Run 4

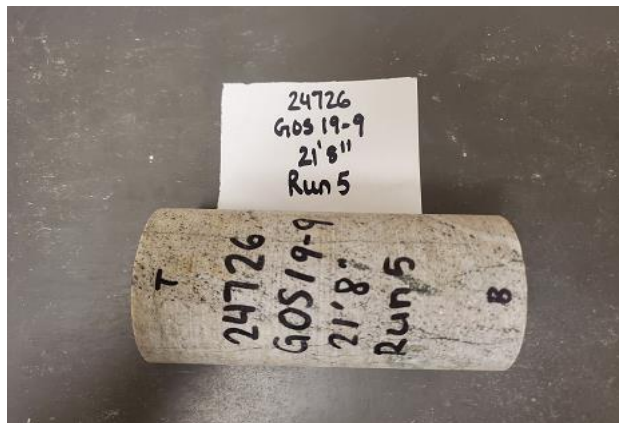
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-09	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 5		
SAMPLE DEPTH:	6.60 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.9	Weight (g):	1069.1
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,659
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,659
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	402.12		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	376.7 kN
UNCONFINED COMPRESSIVE STRENGTH:	120.8 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-09 Run 5

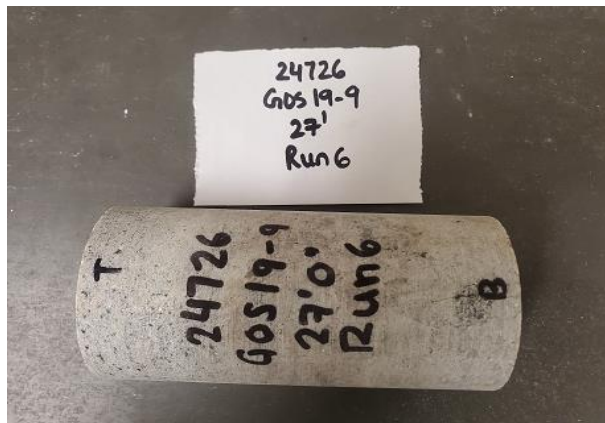
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

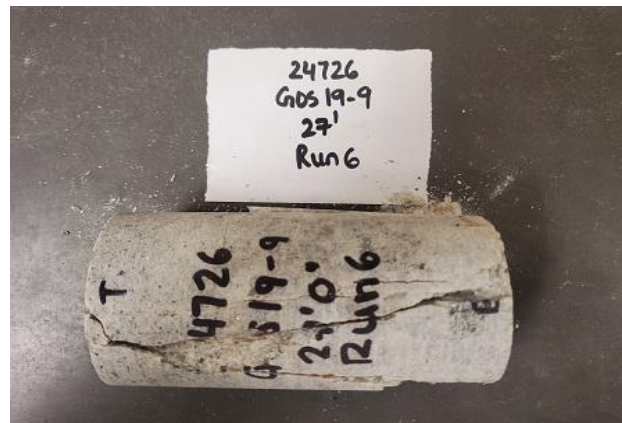
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-09	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 6		
SAMPLE DEPTH:	8.23 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.8	Weight (g):	1044.2
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,617
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,617
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	399.01		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	384.8 kN
UNCONFINED COMPRESSIVE STRENGTH:	123.4 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-09 Run 6

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-10	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	6.25 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	13.0	Weight (g):	1096.7
Avg. Diameter (cm):	6.3	Wet Density (kg/m ³):	2,706
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m ³):	2,706
Cross Sectional Area (cm ²):	31.17	Moisture Content* (%):	0.0
Sample Volume (cm ³):	405.24		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	521.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	167.3 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-10 Run 2

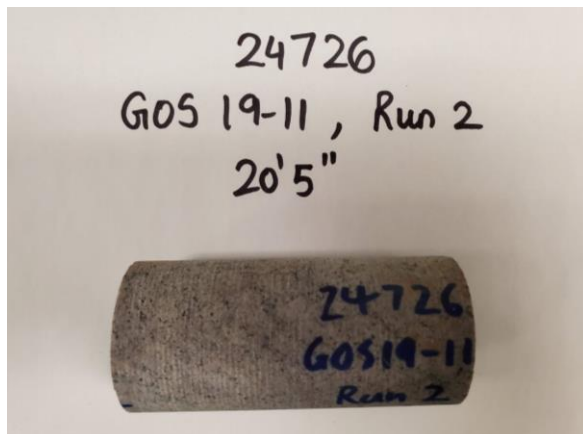
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

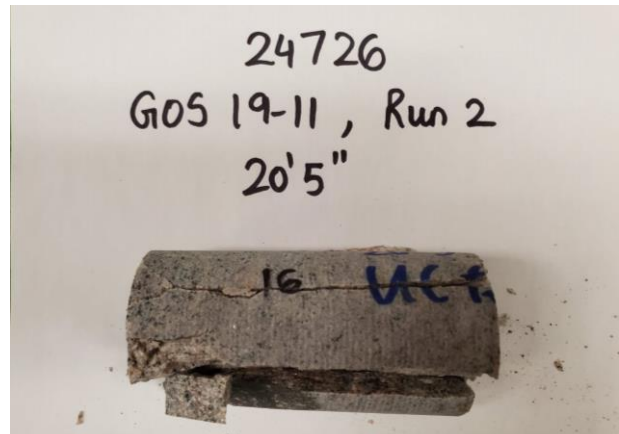
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	GOS 19-11	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 2		
SAMPLE DEPTH:	6.2m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	9.7	Weight (g):	464.7
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,647
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,647
Cross Sectional Area (cm ²):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm ³):	175.53		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	205.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	113.8 MPa

Note: * Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

24726 - GOS 19-11 UCS Run 2, 20'5

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

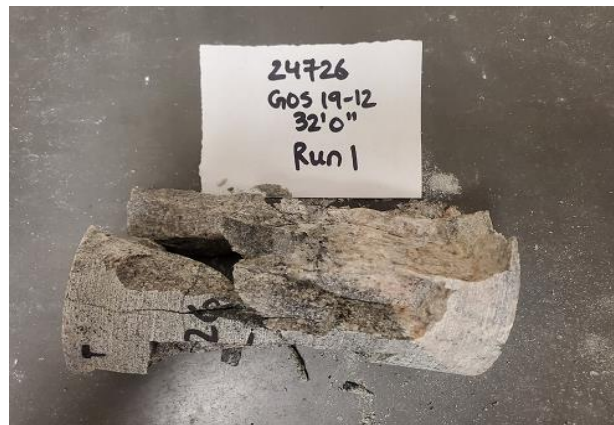
CLIENT:	Thurber Engineering Ltd. (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Hwy 17 Twinning Renfrew to Haley Sta. Part 1B	REPORT DATE:	31-Aug-20
BOREHOLE No.:	GOS 19-12	TEST DATE:	27-Aug-20
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	9.75 m		
DESCRIPTION:	Gneiss		

Avg. Height (cm):	12.8	Weight (g):	1051.4
Avg. Diameter (cm):	6.2	Wet Density (kg/m ³):	2,721
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m ³):	2,721
Cross Sectional Area (cm ²):	30.19	Moisture Content* (%):	0.0
Sample Volume (cm ³):	386.44		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	366.8 kN
UNCONFINED COMPRESSIVE STRENGTH:	121.5 MPa

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

TEST DONE BY: BS
 REVIEWED BY: WM

GOS 19-12 Run 1



Appendix C.4
Bedrock Core Photographs

Borehole GOS 19-01
Run 1 to 3 (of 3)
Elevation 156.9 m to 153.5 m



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Borehole GOS 19-02
Run 1 to 3 (of 3)
Elevation 157.7 m to 154.3 m



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Borehole GOS 19-03
Run 1 to 3 (of 3)
Elevation 166.7 m to 163 m



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Borehole GOS 19-04
Run 1 to 2 (of 5)
Elevation 165.6 m to 162 m



Borehole GOS 19-04W

Run 1 to 3 (of 3)

Elevation 164.9 m to 160.6 m

NQ5 Start
elev. 164.9 m

NQ5 End
elev. 164.0 m

Run 1 Start
elev. 164.0 m

Run 1 End
elev. 163.5 m

Run 2 Start
elev. 163.5 m

Run 2 End
elev. 162.1 m

Run 3 Start
elev. 162.1 m

Run 3 End
elev. 160.6 m



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Borehole GOS 19-05
Run 3 to 5 (of 5)
Elevation 162 m to 158.4 m

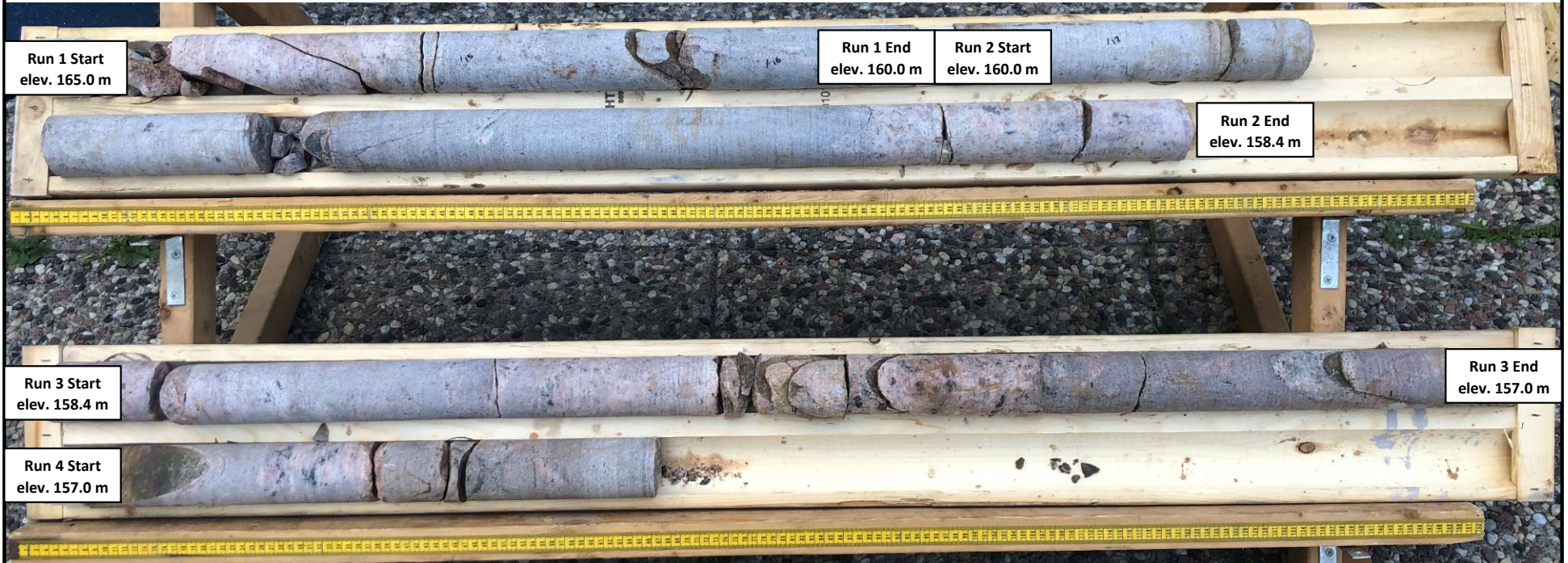


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Borehole GOS 19-7
Run 1 to 4 (of 5)
Elevation 165.0 m to 155.2 m



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Goshen Road Overpasses
Renfrew, Ontario**

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Project No.: 24726**

Borehole GOS 19-7
Run 4 to 5 (of 5)
Elevation 165.0 m to 155.2 m



Borehole GOS 19-8
Run 1 to 4 (of 4)
Elevation 166.4 m to 159.9 m

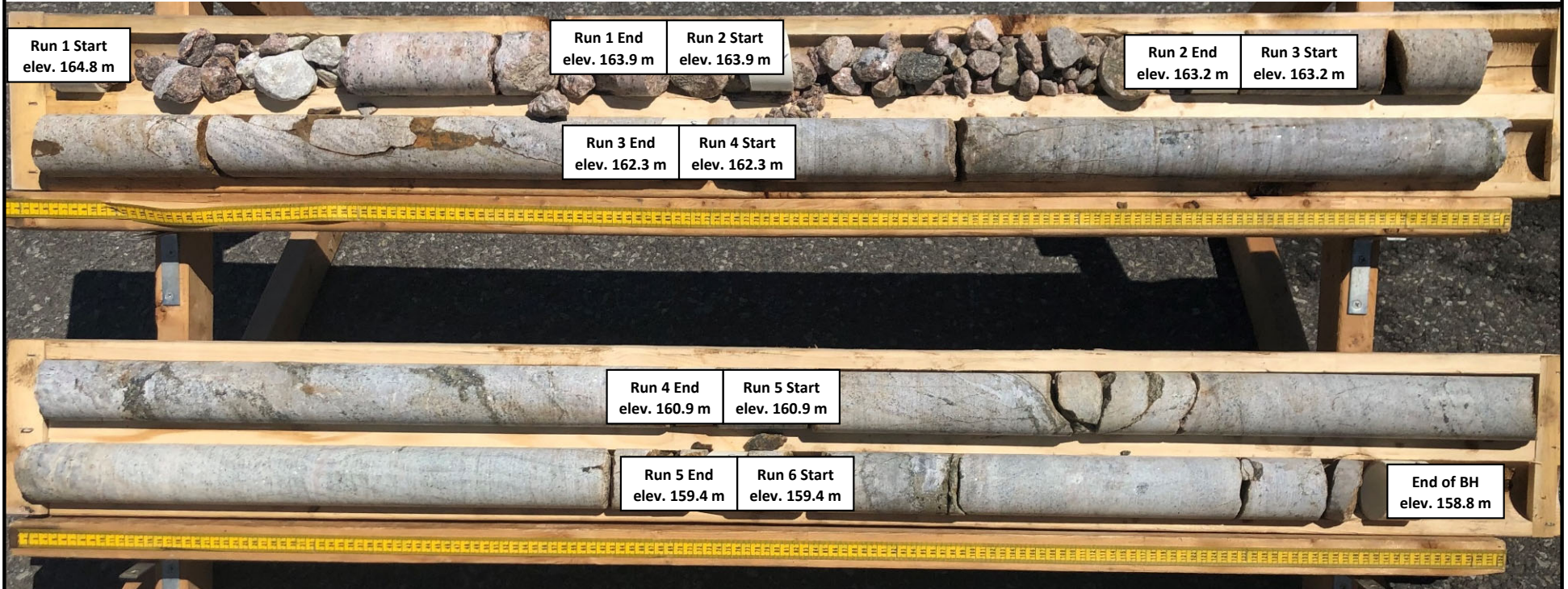


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Goshen Road Overpasses
Renfrew, Ontario**

**W.P. 4068-09-00
Project No.: 24726**

Borehole GOS 19-9
Run 1 to 6 (of 6)
Elevation 164.8 m to 158.8 m

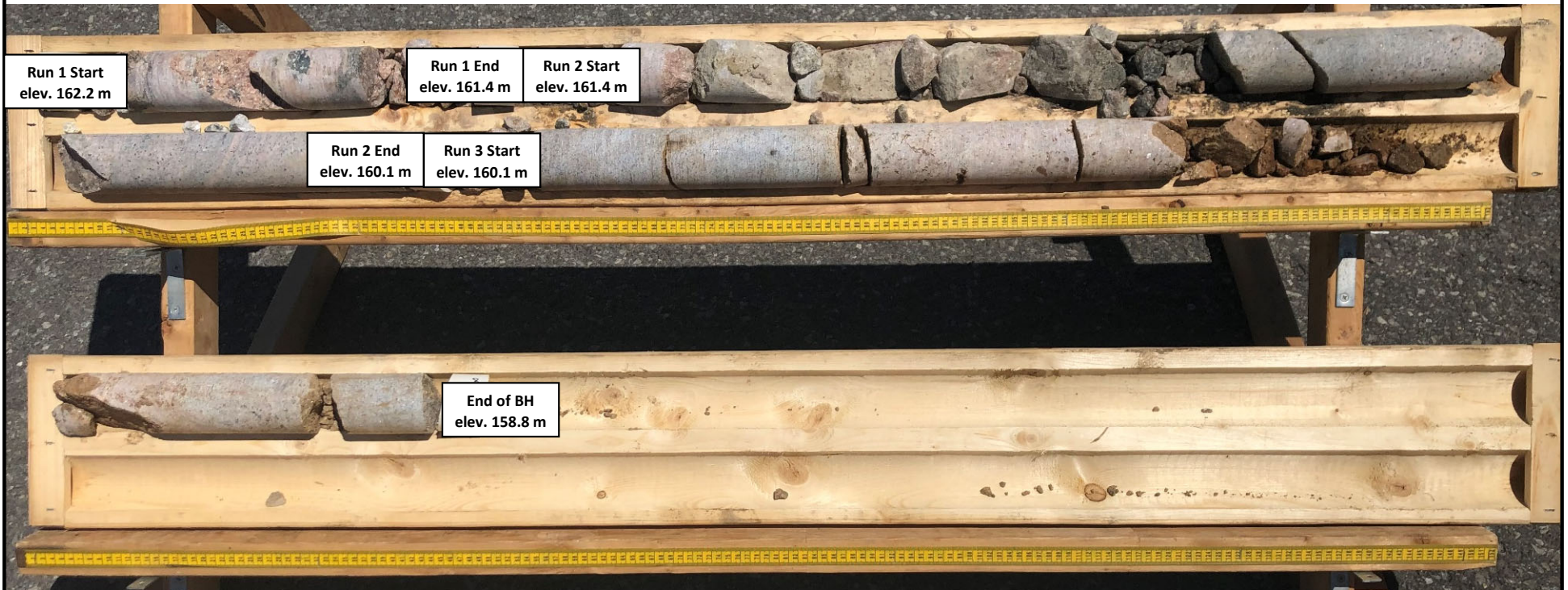


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Goshen Road Overpasses
Renfrew, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole GOS 19-10
Run 1 to 3 (of 3)
Elevation 162.2 m to 158.8 m



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Goshen Road Overpasses
Renfrew, Ontario**

**W.P. 4068-09-00
Project No.: 24726**

Borehole GOS 19-11
Run 1 to 2 (of 2)
Elevation 162.5 m to 159.2 m

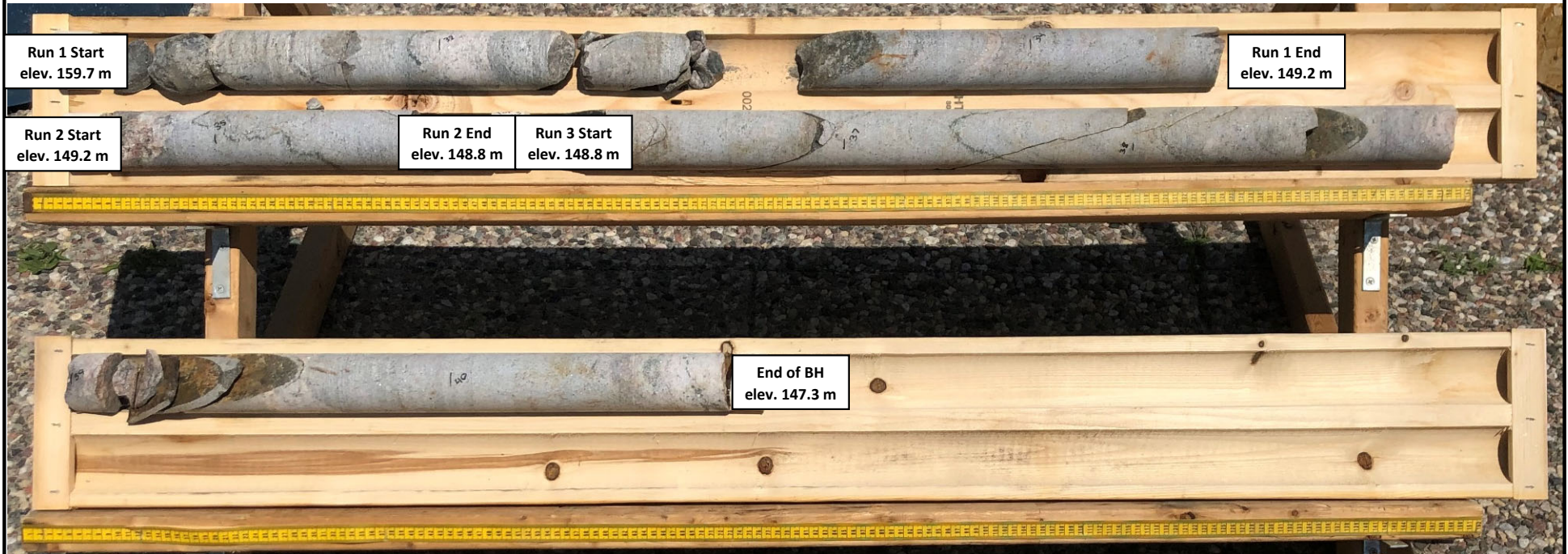


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**W.P. 4068-09-00
Project No.: 24726**

Borehole GOS 19-12
Run 1 to 3 (of 3)
Elevation 159.7 m to 147.3 m



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**Geotechnical Investigation
Goshen Road Overpasses
Renfrew, Ontario**

**W.P. 4068-09-00
Project No.: 24726**



Appendix D.
Site Photographs



Photo 1. Looking north from existing Highway 17 alignment at Goshen Rd (2020/07/08)



Photo 2. Looking south from existing Highway 17 alignment at Goshen Rd (2020/07/08)



Photo 3. Looking south towards existing Highway 17 from Goshen Road (2019/09/04)



Appendix E.

GSC Seismic Hazard Calculation

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: 45.446N 76.584W

User File Reference: Goshen Road at HWY 17

2021-03-12 15:13 UT

Requested by: Thurber Engineering Ltd.

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)	0.358	0.183	0.105	0.032
Sa (0.1)	0.424	0.228	0.138	0.045
Sa (0.2)	0.354	0.198	0.123	0.043
Sa (0.3)	0.269	0.155	0.098	0.035
Sa (0.5)	0.192	0.113	0.072	0.026
Sa (1.0)	0.098	0.059	0.038	0.013
Sa (2.0)	0.048	0.028	0.018	0.005
Sa (5.0)	0.013	0.007	0.004	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.228	0.125	0.076	0.025
PGV (m/s)	0.161	0.091	0.056	0.018

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



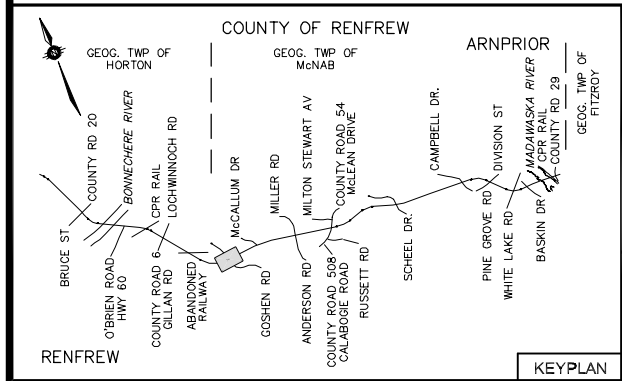
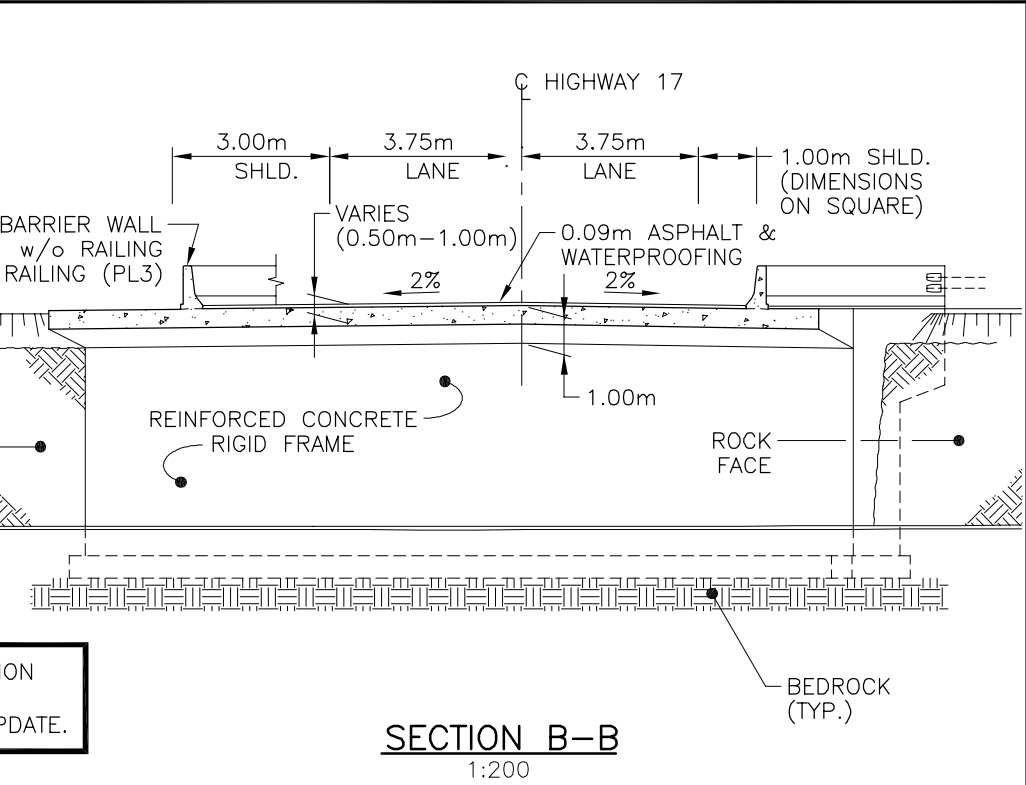
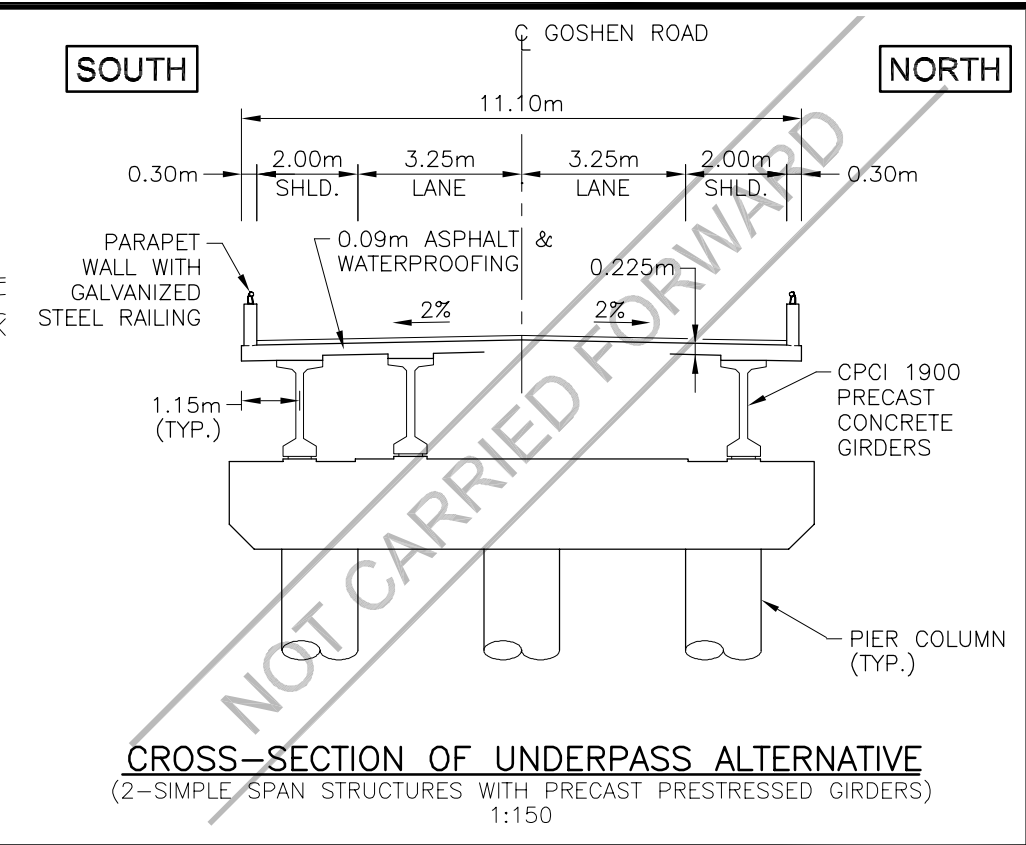
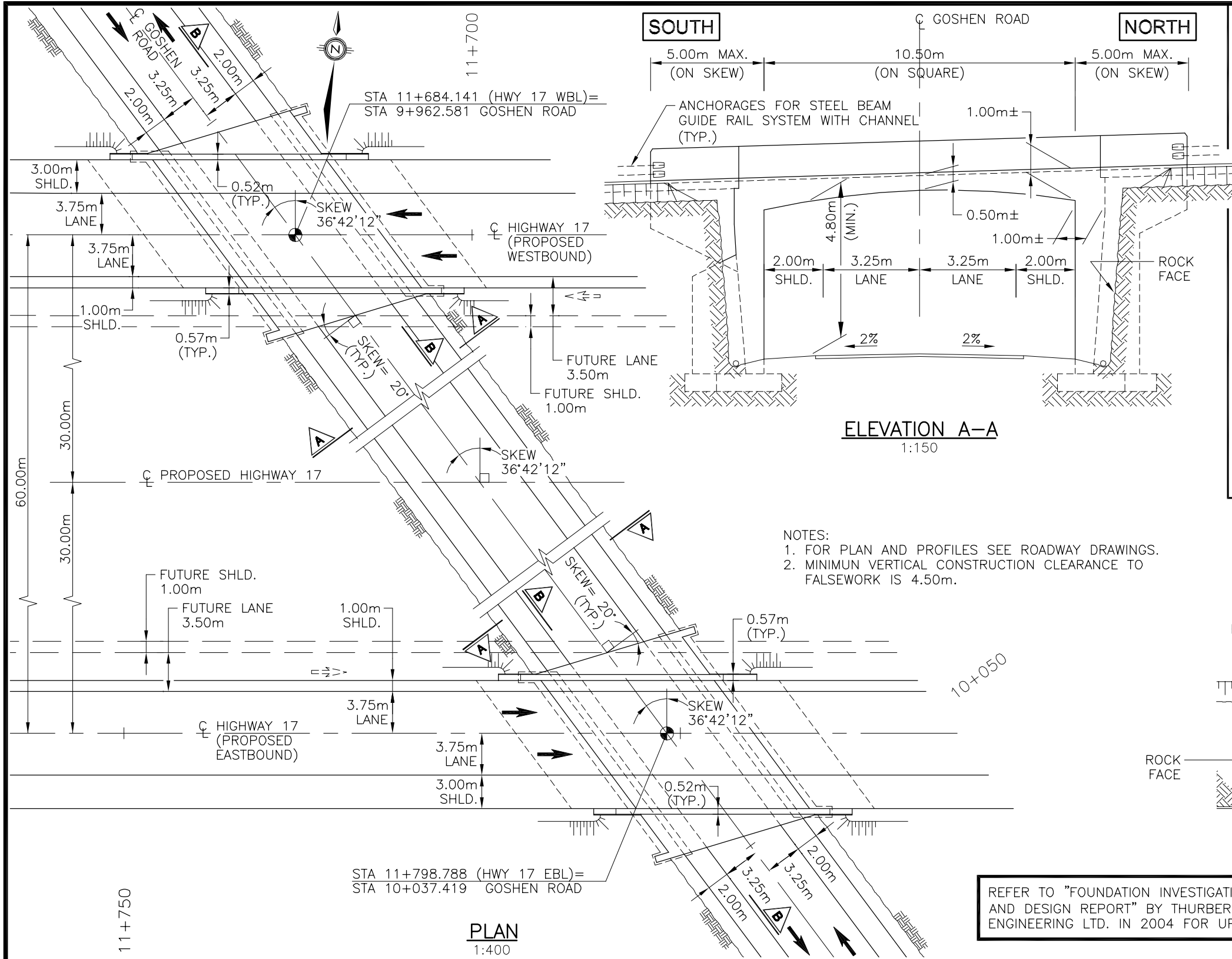
Appendix F.

Foundation Comparison Preliminary General Arrangement from Structural Planning Report



Comparison of Alternative Foundation Type

Shallow Foundation	Caisson (Drilled Shafts)
Advantages	
Bedrock at or near proposed grade of Goshen Road cut. High geotechnical resistance available on bedrock. Generally less costly construction than deep foundations Requires less specialized construction equipment	Higher geotechnical resistance than spread footings Construction can continue in winter weather conditions
Disadvantages	
Requires large excavations Less efficient for resistance to uplift or overturning Does not allow for integral abutments Mass concrete may be required to achieve founding elevation	Specialized installation measures such as equipment, liners and stabilizing slurry will be required Difficulty in cleaning and inspecting base Does not allow for integral abutments
Risk/Consequences	
Large Excavation Differential settlement unless clayey silt layer is removed Temporary Protection required to excavate to proposed founding depth	Unbalanced pressure heads and base boiling in the sands below the groundwater table requires liners and/or slurry Difficulties advancing through obstructions.
Relative Cost	
Moderate	High
Recommendation	
Recommended for support of Abutments of proposed Highway 17 EB	Recommended in combination with spread footings for support of Abutments of proposed Highway 17 WB. Additional Boreholes required to accurately define bedrock surface to determine transition location of spread footings to caissons.



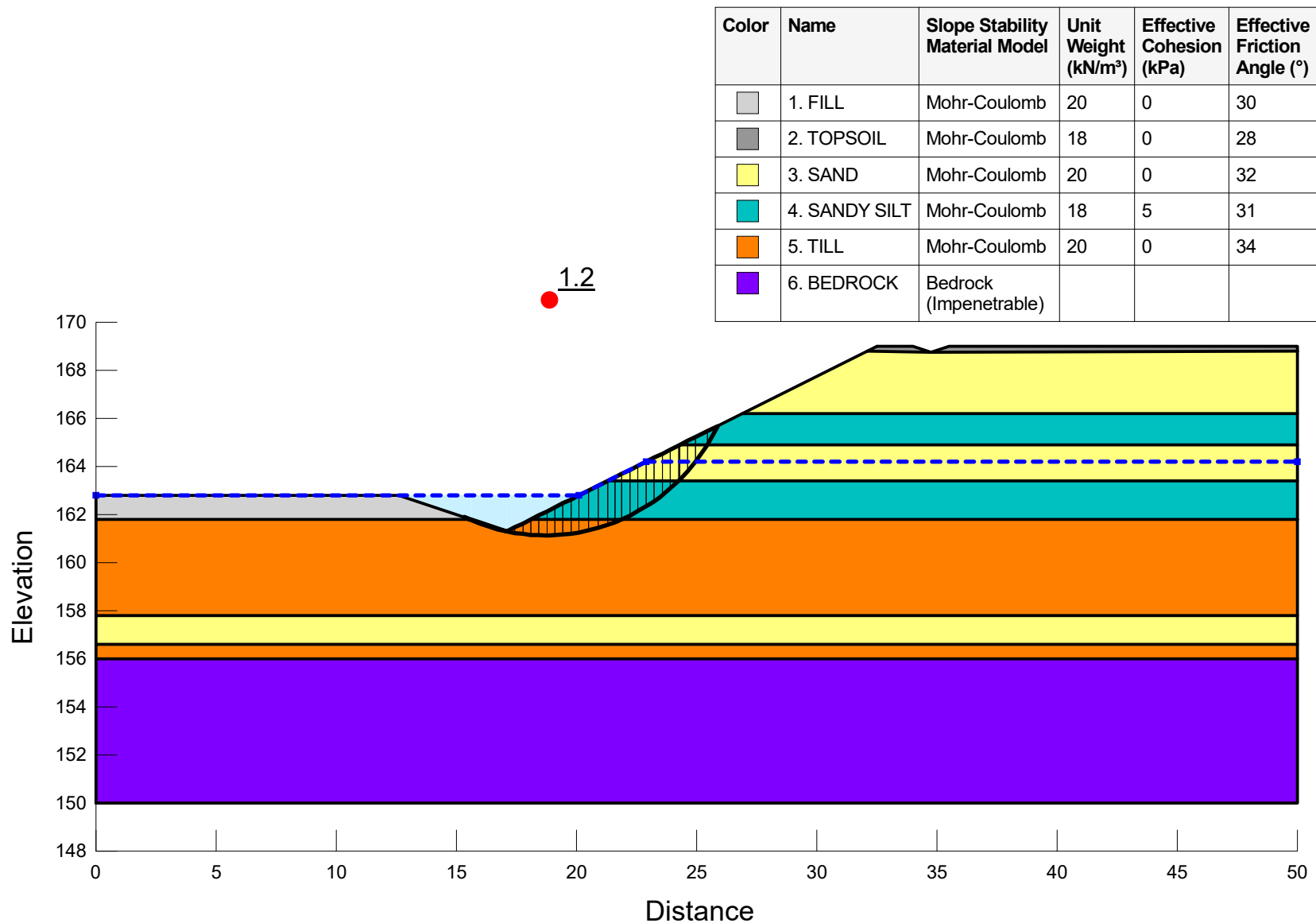
<h1>TWIN RIGID FRAME STRUCTURES ALTERNATIVE (RECOMMENDED)</h1>	
<h2>GOSHEN ROAD OVERPASS</h2>	
<p>HIGHWAY 17 TWINNING, COUNTY ROAD 29 TO 3.0 km WEST OF BRUCE STREET PRELIMINARY DESIGN/ ENVIRONMENTAL ASSESSMENT STUDY WP 647-92-00</p>	

SCALE:	AS NOTED



Appendix G.

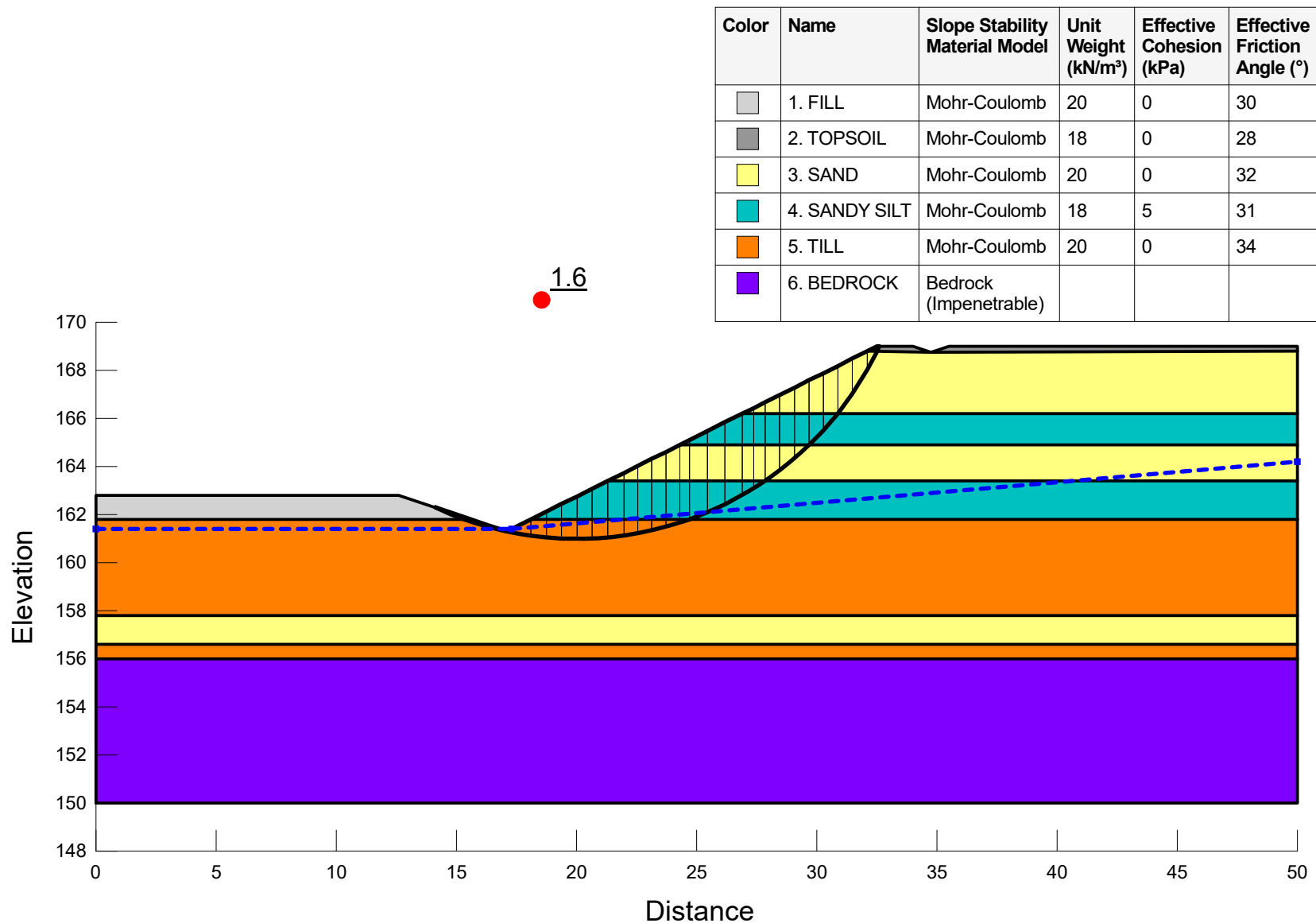
Slope Stability Analysis Figures



Project		
Goshen Rd East Abut WB, 2H:1V Earth Cut		
Analysis		
1. Static - Temporary Conditions (GW 164.2m)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/07/26, 04:02:04 PM	1:250

Additional Details	
Name: Goshen EAST abut WB, 2H:1V Earth Cut	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.52 m	
Entry: (25.8665, 165.68325) m, Exit: (15.316111, 161.89463) m	
Center: (18.702201, 169.04964) m, Radius: 7.9157904 m	

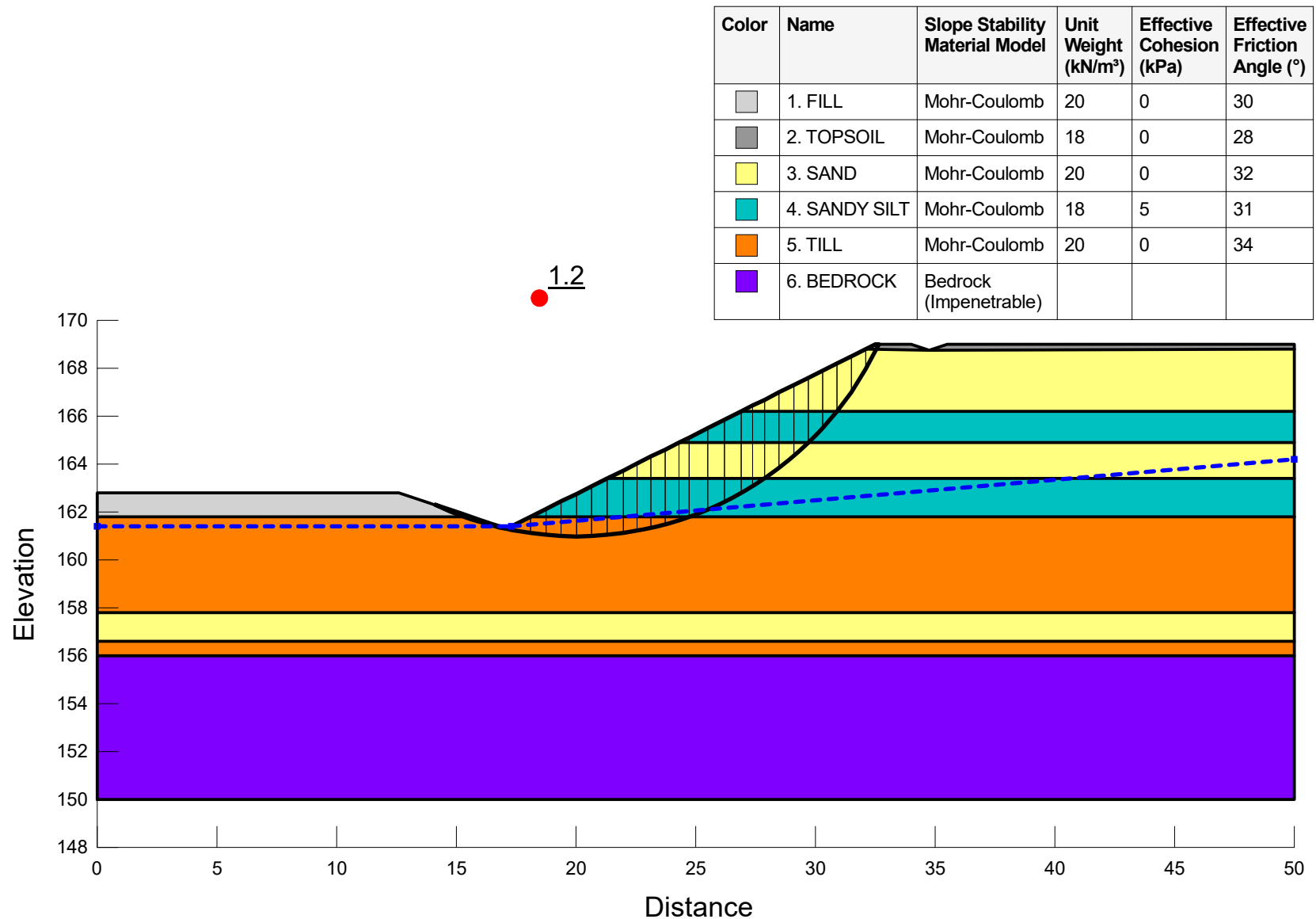
Figure G-1



Project		
Goshen Rd East Abut WB, 2H:1V Earth Cut		
Analysis		
2. Static - Permanent Conditions (GW Ditch)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/07/26, 04:02:38 PM	1:250

Additional Details
 Name: Goshen EAST abut WB, 2H:1V Earth Cut
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (32.611613, 169) m, Exit: (14.135317, 162.28823) m
 Center: (20.008204, 174.90807) m, Radius: 13.919453 m

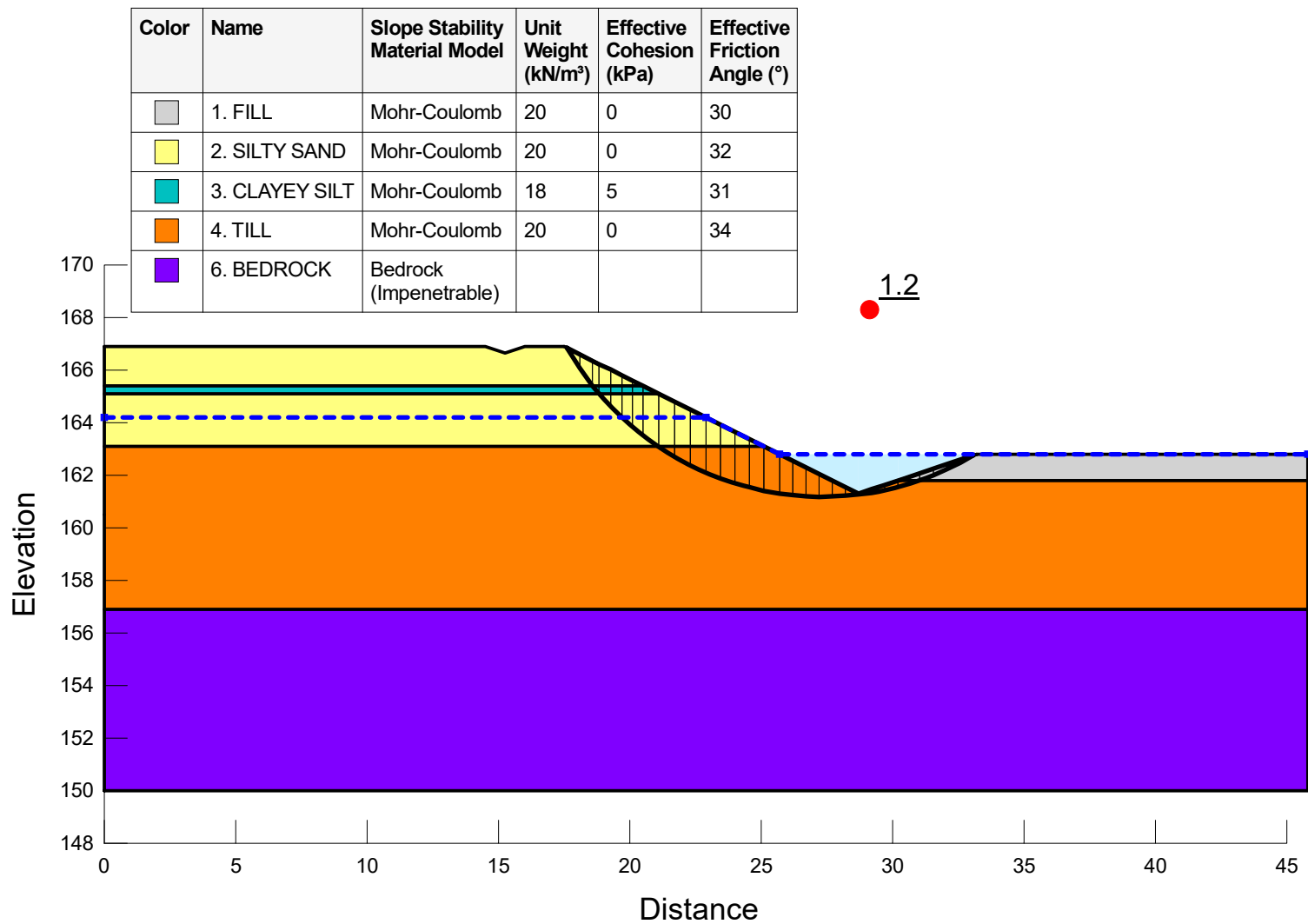
Figure G-2



Project		
Goshen Rd East Abut WB, 2H:1V Earth Cut		
Analysis		
3. Pseudo-Static Seismic - Temporary Conditions		
Seismic Coefficient	Last Run	Scale
H: 0.129g, V: 0g	2022/07/26, 04:02:21 PM	1:250

Additional Details
 Name: Goshen EAST abut WB, 2H:1V Earth Cut
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (32.637557, 169) m, Exit: (14.114146, 162.29528) m
 Center: (20.019951, 174.91914) m, Radius: 13.937007 m

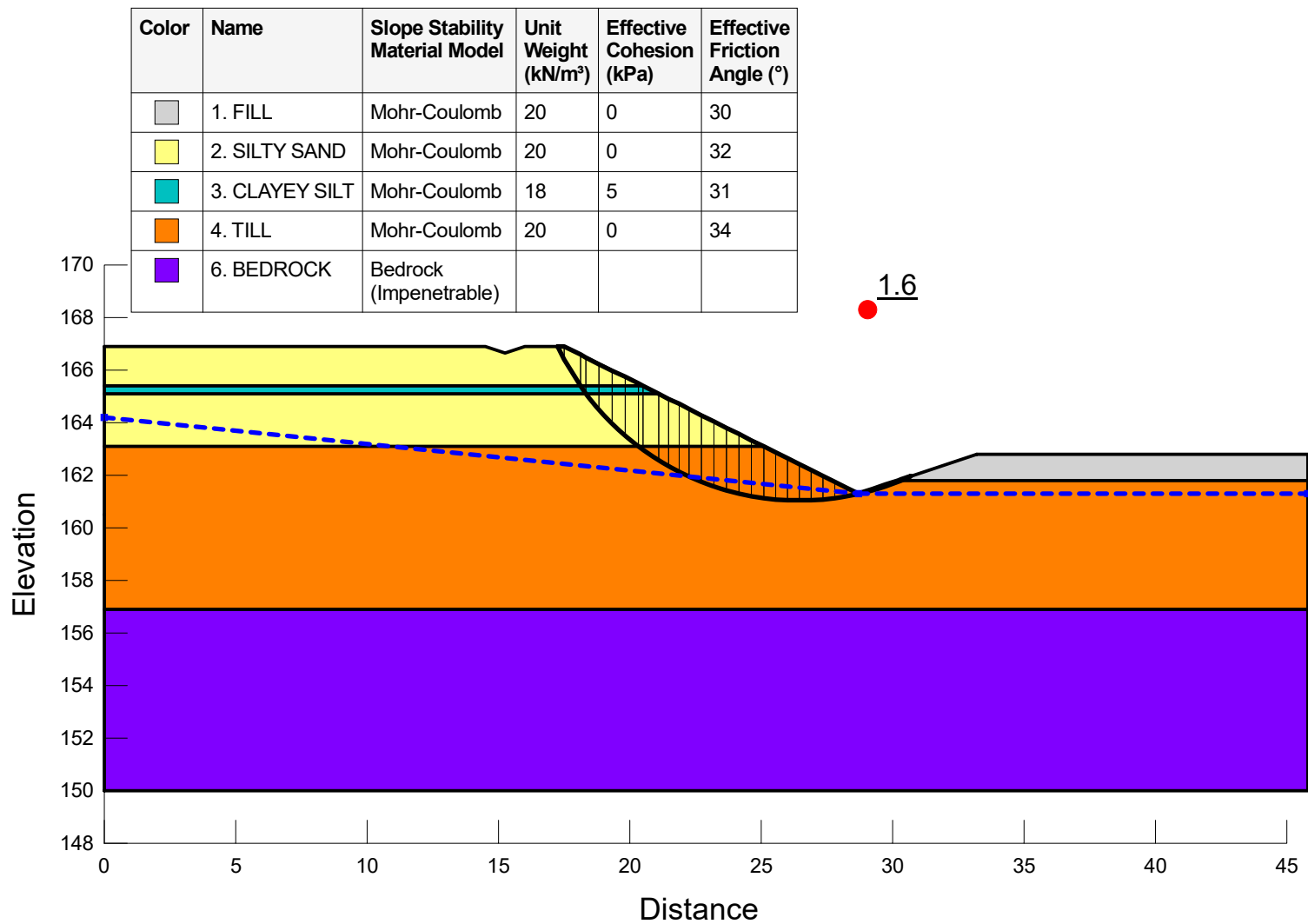
Figure G-3



Project		
Goshen Rd West Abut WB, 3H:1V Earth Cut		
Analysis		
1. Static - Temporary Conditions (GW 164.2m)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/07/26, 04:20:06 PM	1:250

Additional Details	
Name: Goshen WEST abut WB, 3H:1V Earth Cut	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.52 m	
Entry: (17.599241, 166.85038) m, Exit: (33.100006, 162.76667) m	
Center: (27.351514, 172.40721) m, Radius: 11.224312 m	

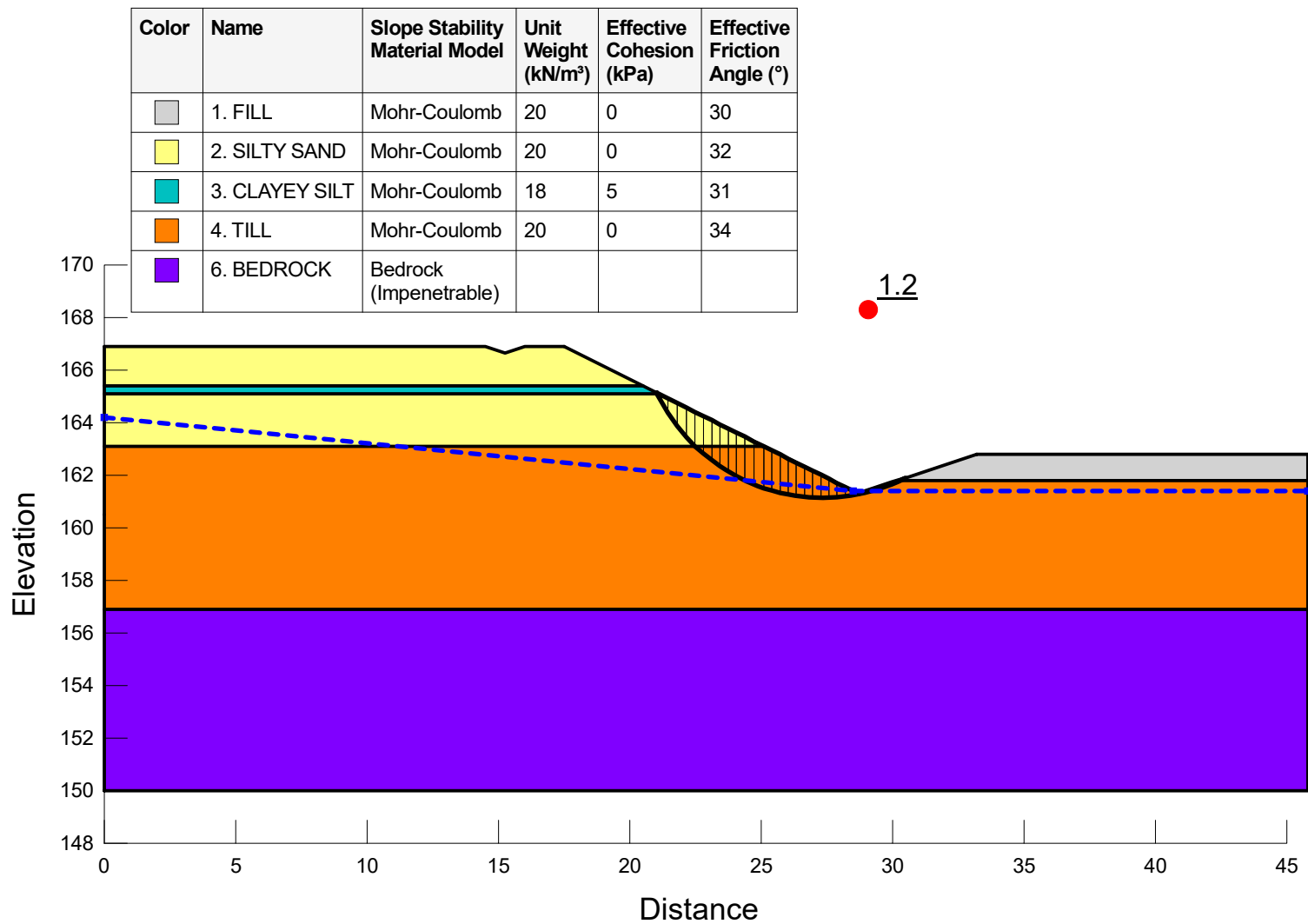
Figure G-4



Project		
Goshen Rd West Abut WB, 3H:1V Earth Cut		
Analysis		
2. Static - Permanent Conditions (GW Ditch)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/07/26, 04:20:38 PM	1:250

Additional Details
 Name: Goshen WEST abut WB, 3H:1V Earth Cut
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (17.248637, 166.9) m, Exit: (30.693176, 161.96439) m
 Center: (26.458242, 171.20767) m, Radius: 10.167244 m

Figure G-5



Project		
Goshen Rd West Abut WB, 3H:1V Earth Cut		
Analysis		
3. Pseudo-Static Seismic - Temporary Conditions		
Seismic Coefficient	Last Run	Scale
H: 0.129g, V: 0g	2022/07/26, 04:20:22 PM	1:250

Additional Details

Name: Goshen WEST abut WB, 3H:1V Earth Cut

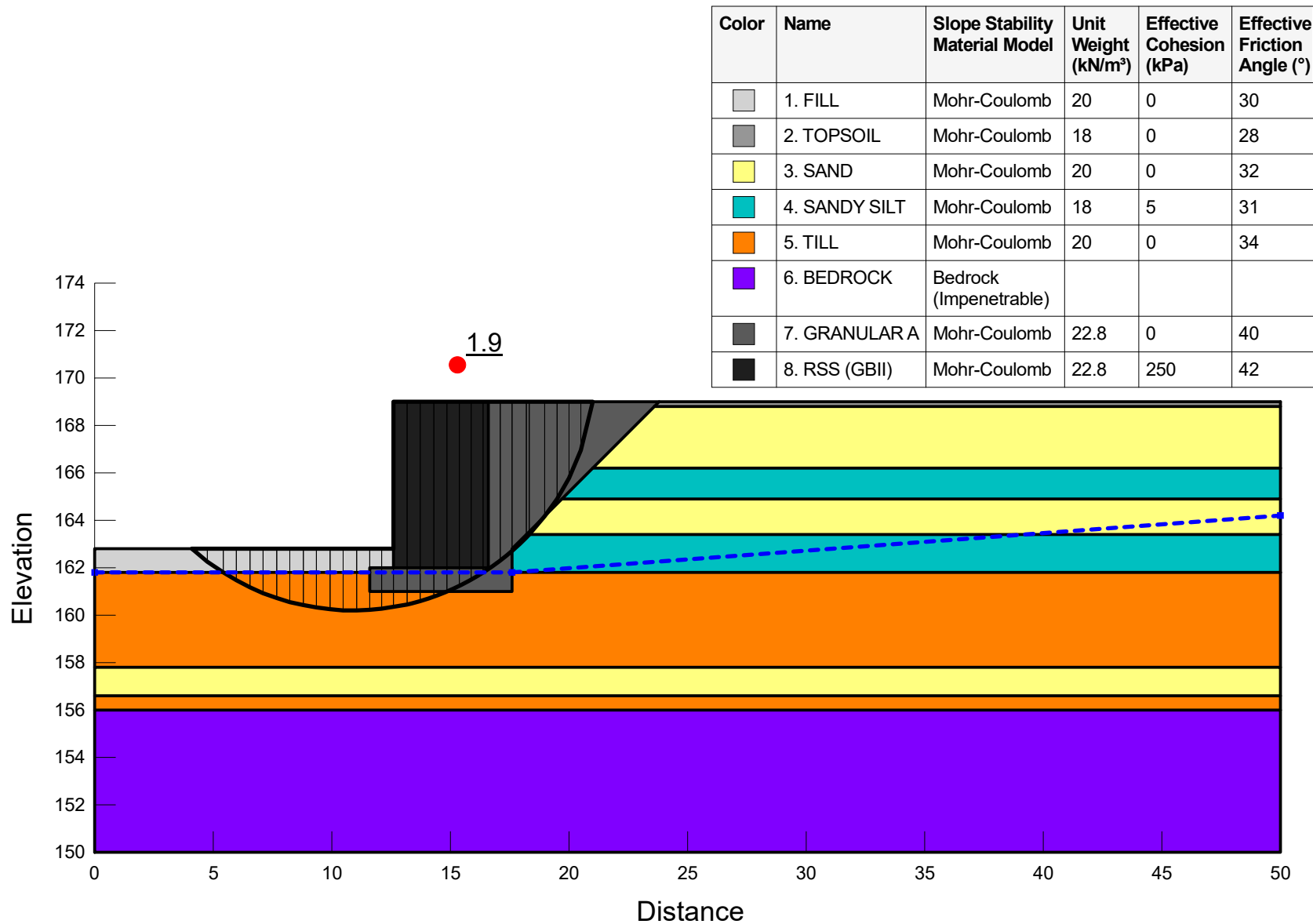
Method: Morgenstern-Price, Half-Sine

Minimum Slip Surface Depth: 1.52 m

Entry: (21.015556, 165.14222) m, Exit: (30.5, 161.9) m

Center: (27.337373, 168.14189) m, Radius: 6.9973829 m

Figure G-6

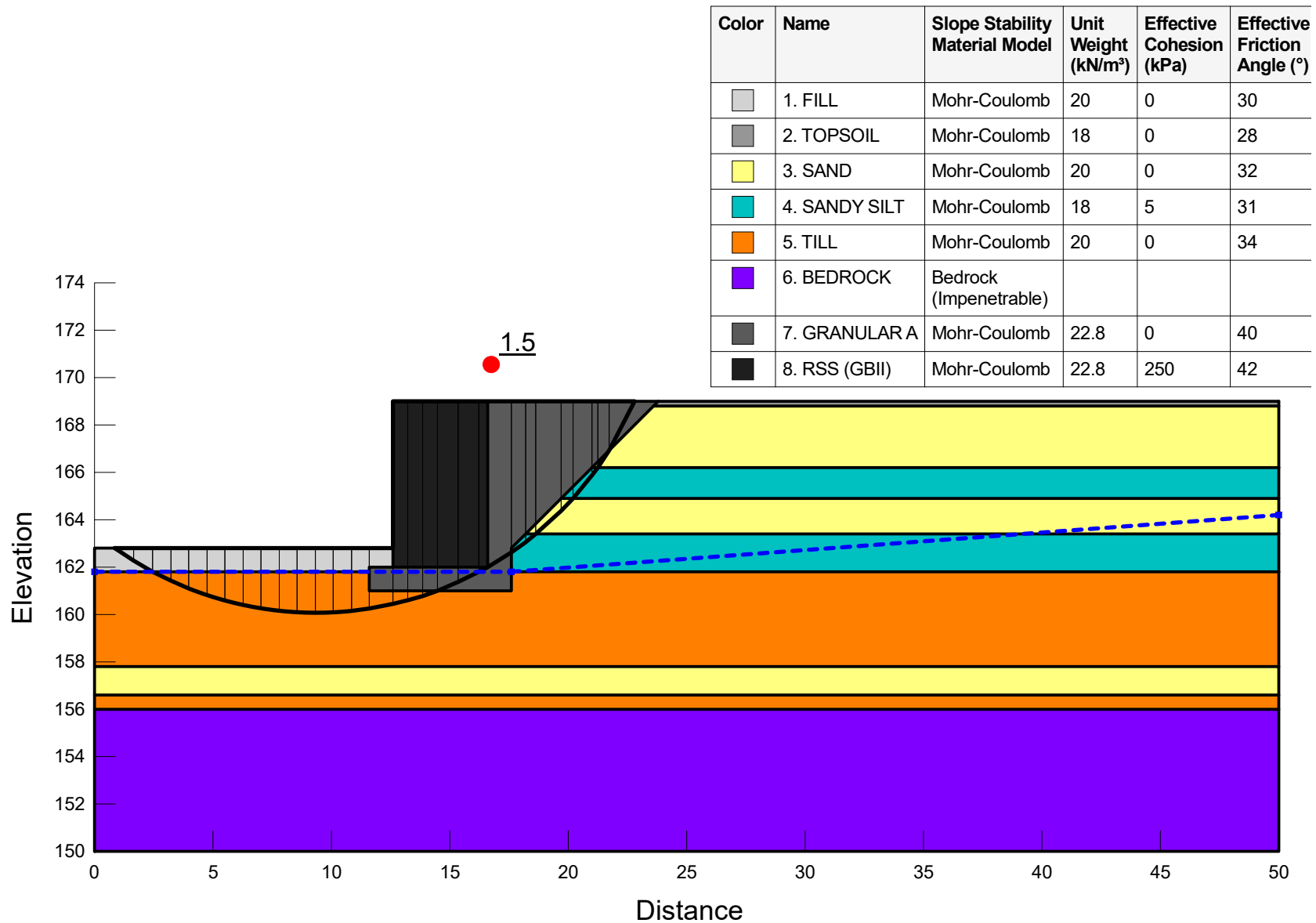


Project		
Goshen Rd RSS East		
Analysis		
1. Static Long Term Conditions		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/07/26, 04:41:27 PM	1:250

Additional Details

Name: Goshen RSS EAST
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (21, 169) m, Exit: (4.1, 162.8) m
Center: (10.89985, 170.39799) m, Radius: 10.19644 m








Figure G-7

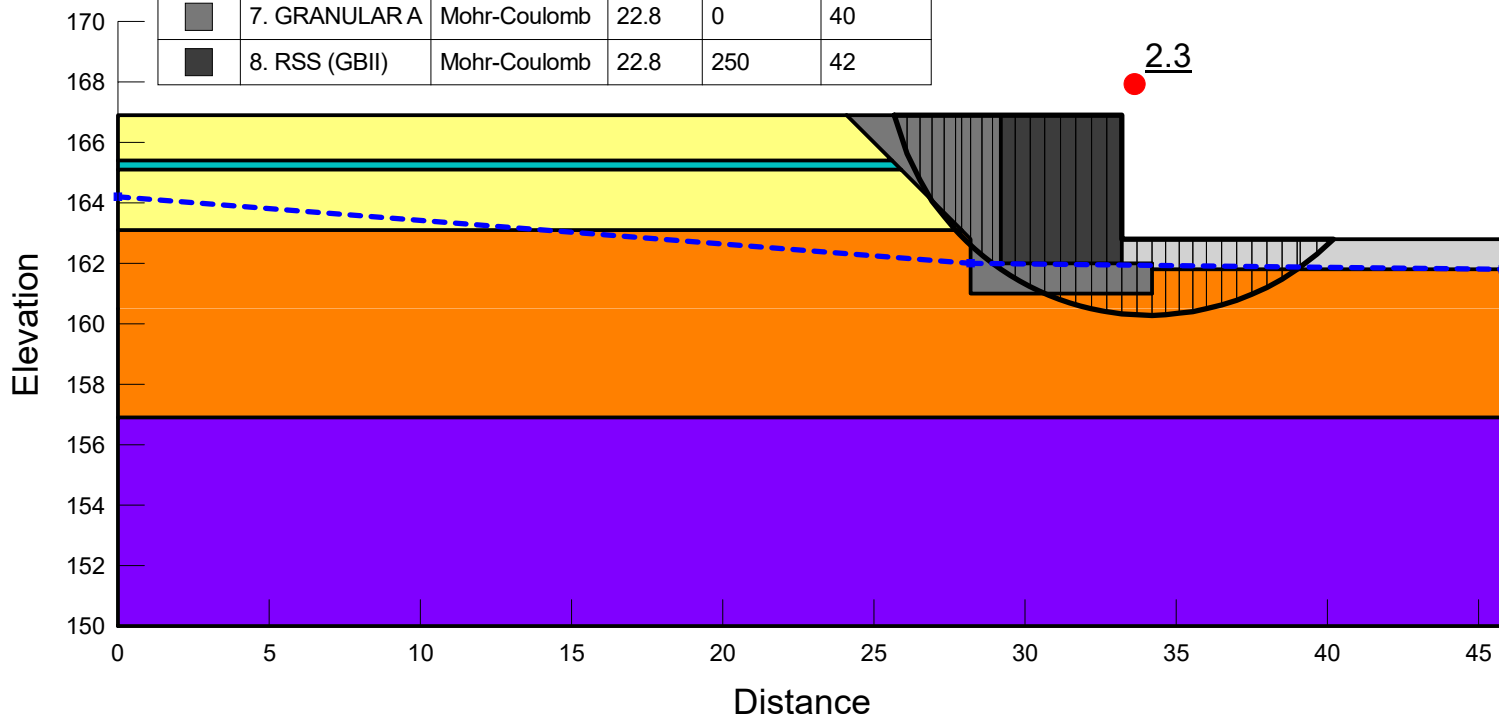


Project		
Goshen Rd RSS East		
Analysis		
2. Pseudo-Static Seismic		
Seismic Coefficient	Last Run	Scale
H: 0.129g, V: 0g	2022/07/26, 04:42:01 PM	1:250

Additional Details
 Name: Goshen RSS EAST
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (22.808, 169) m, Exit: (0.85, 162.8) m
 Center: (9.3482221, 174.68596) m, Radius: 14.611492 m

Figure G-8








Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. FILL	Mohr-Coulomb	20	0	30
	2. SILTY SAND	Mohr-Coulomb	20	0	32
	3. CLAYEY SILT	Mohr-Coulomb	18	5	31
	4. TILL	Mohr-Coulomb	20	0	34
	6. BEDROCK	Bedrock (Impenetrable)			
	7. GRANULAR A	Mohr-Coulomb	22.8	0	40
	8. RSS (GBII)	Mohr-Coulomb	22.8	250	42

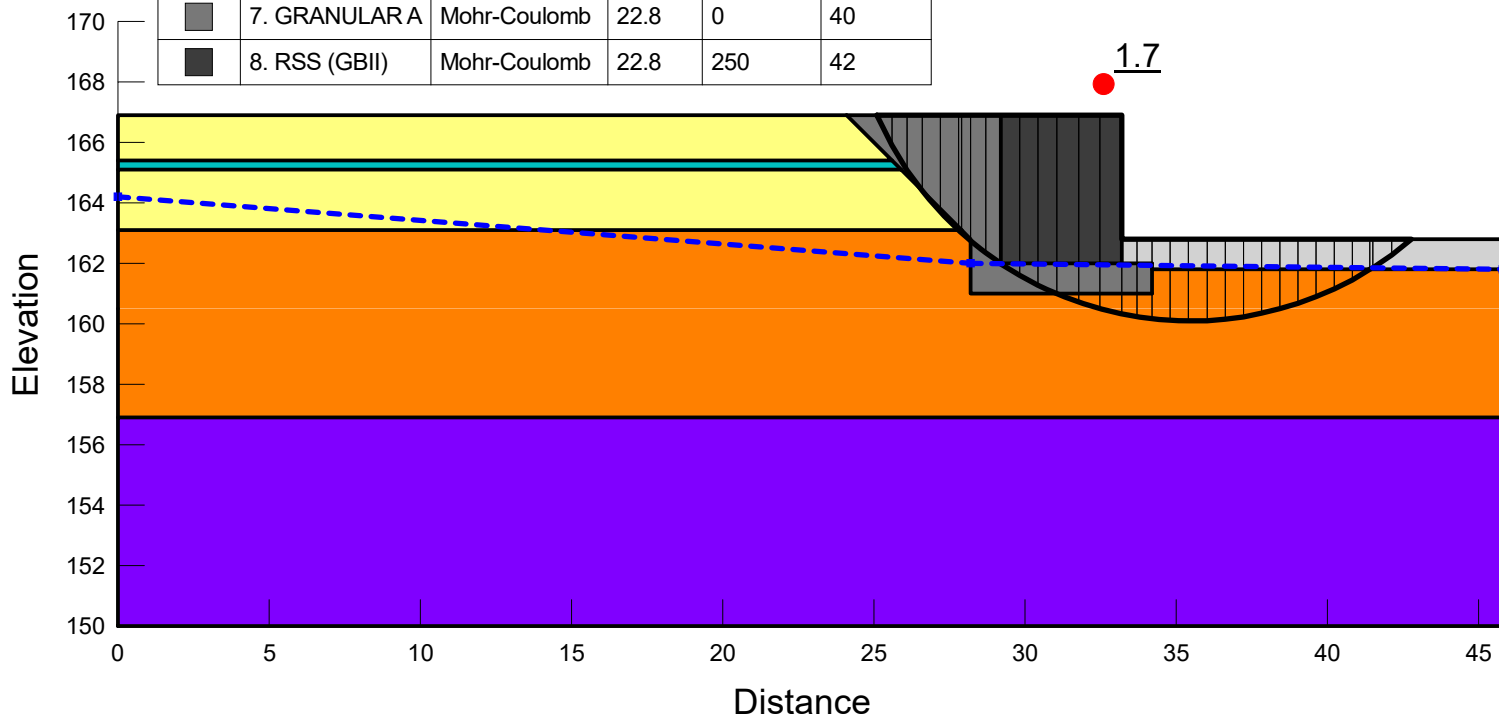


Project Goshen Rd RSS West		
Analysis 1. Static Long Term Conditions		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022/07/26, 04:46:49 PM	Scale 1:250

Additional Details
 Name: Goshen RSS WEST
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (25.668, 166.9) m, Exit: (40.2, 162.8) m
 Center: (34.095321, 168.96617) m, Radius: 8.6769127 m

Figure G-9

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. FILL	Mohr-Coulomb	20	0	30
	2. SILTY SAND	Mohr-Coulomb	20	0	32
	3. CLAYEY SILT	Mohr-Coulomb	18	5	31
	4. TILL	Mohr-Coulomb	20	0	34
	6. BEDROCK	Bedrock (Impenetrable)			
	7. GRANULAR A	Mohr-Coulomb	22.8	0	40
	8. RSS (GBII)	Mohr-Coulomb	22.8	250	42



Project Goshen Rd RSS West		
Analysis 2. Pseudo-Static Seismic		
Seismic Coefficient H: 0.129g, V: 0g	Last Run 2022/07/26, 04:47:07 PM	Scale 1:250

Additional Details
 Name: Goshen RSS WEST
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (25.108, 166.9) m, Exit: (42.778639, 162.8) m
 Center: (35.457751, 171.37707) m, Radius: 11.27659 m

Figure G-10



Appendix H.

P-Y Curves for Caissons

SOIL P-Y CURVES
Highway 17 Twinning - Goshen Road
East Abutment - 915mm Caisson

Figure H1

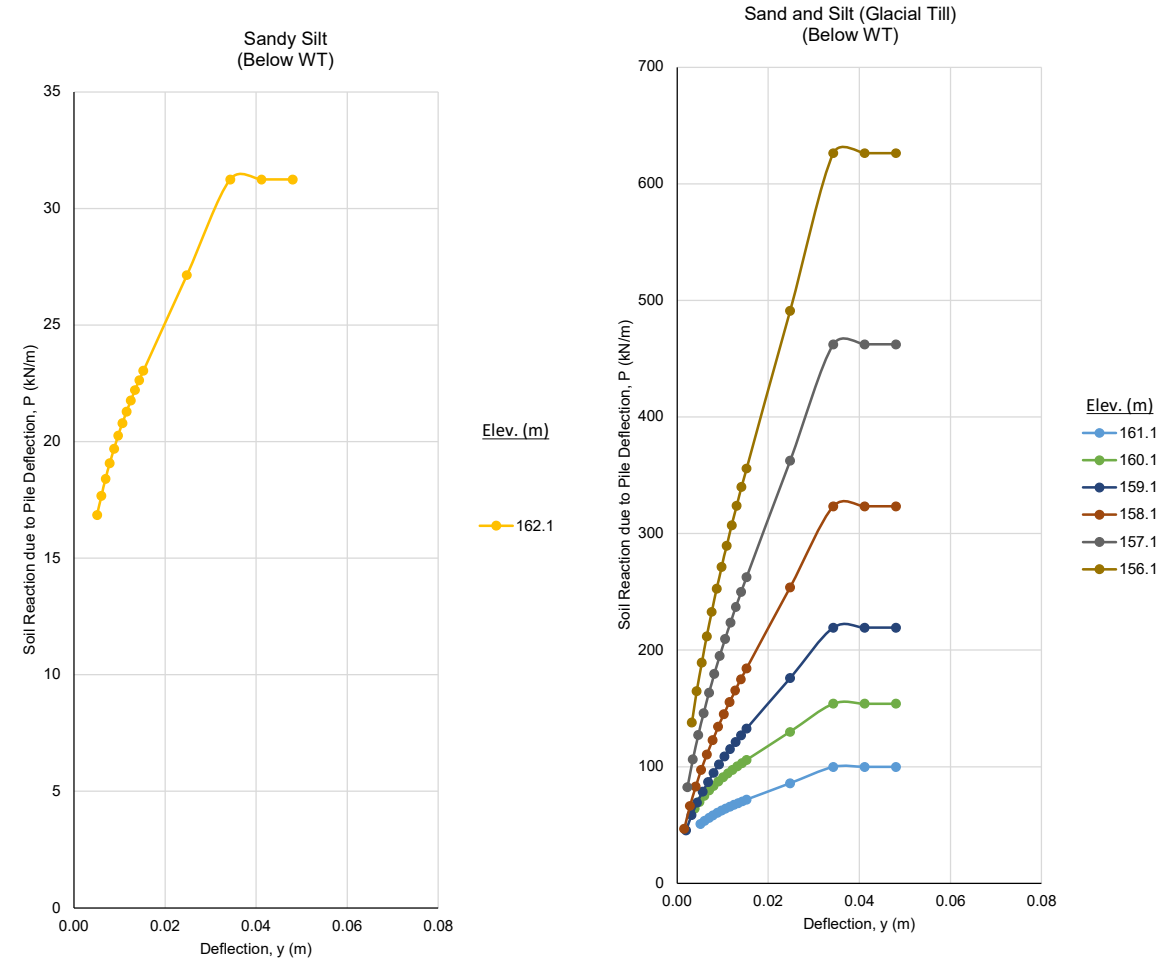
Soil Type	Sandy Silt		Sand and Silt (Glacial Till)											
Depth* (m)	0.5		1.5		2.5		3.5		4.5		5.5		6.5	
Elev* (m)	162.1		161.1		160.1		159.1		158.1		157.1		156.1	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00509	16.8514	0.00514	50.9887	0.00388	64.1684	0.00197	45.5287	0.00157	46.6728	0.00226	82.3158	0.00321	137.877
	0.00602	17.6712	0.00606	53.6873	0.00491	69.9496	0.00317	58.4653	0.00281	66.4113	0.00344	106.267	0.0043	164.848
	0.00694	18.4053	0.00698	56.1175	0.00595	75.0011	0.00438	69.1882	0.00406	82.8507	0.00462	127.136	0.0054	189.224
	0.00786	19.0726	0.0079	58.3366	0.00698	79.5214	0.00559	78.5679	0.0053	97.3737	0.0058	145.991	0.00649	211.721
	0.00879	19.686	0.00881	60.3847	0.00801	83.6342	0.0068	87.0188	0.00654	110.593	0.00698	163.389	0.00759	232.77
	0.00971	20.2548	0.00973	62.2908	0.00905	87.4224	0.008	94.7775	0.00779	122.846	0.00817	179.666	0.00868	252.657
	0.01063	20.7862	0.01065	64.077	0.01008	90.9448	0.00921	101.994	0.00903	134.343	0.00935	195.041	0.00978	271.581
	0.01156	21.2856	0.01157	65.7602	0.01112	94.2448	0.01042	108.771	0.01027	145.228	0.01053	209.672	0.01087	289.691
	0.01248	21.7572	0.01249	67.354	0.01215	97.3551	0.01163	115.182	0.01152	155.601	0.01171	223.672	0.01197	307.097
	0.0134	22.2045	0.01341	68.8691	0.01318	100.302	0.01283	121.282	0.01276	165.539	0.01289	237.128	0.01306	323.89
	0.01433	22.6303	0.01433	70.3144	0.01422	103.105	0.01404	127.113	0.01401	175.1	0.01407	250.108	0.01416	340.138
	0.01525	23.0369	0.01525	71.6974	0.01525	105.782	0.01525	132.709	0.01525	184.329	0.01525	262.668	0.01525	355.901
	0.02478	27.1418	0.02478	85.7345	0.02478	129.921	0.02478	176.021	0.02478	253.881	0.02478	362.482	0.02478	491.144
	0.03431	31.2467	0.03431	99.7716	0.03431	154.061	0.03431	219.334	0.03431	323.433	0.03431	462.296	0.03431	626.386
	0.04118	31.2467	0.04118	99.7716	0.04118	154.061	0.04118	219.334	0.04118	323.433	0.04118	462.296	0.04118	626.386
	0.04804	31.2467	0.04804	99.7716	0.04804	154.061	0.04804	219.334	0.04804	323.433	0.04804	462.296	0.04804	626.386

* Depth is measured below the proposed ground surface of Goshen Road (elevation 162.6 m)
** The values P(kN/m) represent soil reaction per metre of pile length; The values y(m) represent soil/pile deflection
The following

- The analysis was completed for a vertical pile (i.e. no inclination) and flat ground
- The effects of construction disturbance or dredging is not considered. not included, the static p-y curves may be used under seismic loading.
- Not applicable for bedrock.

NOTES:

- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.11.3(r), C.6.11.3(s) and C6.11.3(t) of the CHBDC (S6-19)



SOIL P-Y CURVES
Highway 17 Twinning - Goshen Road
East Abutment - 1,220 mm Caisson

Figure H2

Soil Type	Sandy Silt		Sand and Silt (Glacial Till)											
Depth* (m)	0.5		1.5		2.5		3.5		4.5		5.5		6.5	
Elev* (m)	162.1		161.1		160.1		159.1		158.1		157.1		156.1	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00661	21.8825	0.00714	70.8684	0.00635	104.98	0.00485	112.224	0.00301	89.5408	0.00211	76.9667	0.00236	101.528
	0.00786	22.9622	0.00834	74.2625	0.00762	111.481	0.00625	123.623	0.00458	110.372	0.00377	107.828	0.00399	139.792
	0.00911	23.9246	0.00954	77.3307	0.00889	117.289	0.00766	133.52	0.00616	127.813	0.00543	133.322	0.00563	172.199
	0.01036	24.796	0.01074	80.14	0.01016	122.563	0.00907	142.342	0.00773	143.119	0.00708	155.715	0.00726	201.062
	0.0116	25.5948	0.01194	82.7378	0.01143	127.411	0.01048	150.35	0.00931	156.921	0.00874	176.004	0.0089	227.465
	0.01285	26.3338	0.01314	85.159	0.0127	131.909	0.01189	157.714	0.01088	169.589	0.0104	194.74	0.01053	252.022
	0.0141	27.0227	0.01434	87.4304	0.01398	136.115	0.01329	164.555	0.01246	181.363	0.01205	212.266	0.01216	275.122
	0.01534	27.669	0.01554	89.5726	0.01525	140.07	0.0147	170.96	0.01403	192.409	0.01371	228.812	0.0138	297.034
	0.01659	28.2785	0.01674	91.6021	0.01652	143.811	0.01611	176.994	0.01561	202.846	0.01536	244.542	0.01543	317.949
	0.01784	28.8557	0.01793	93.5324	0.01779	147.362	0.01752	182.709	0.01718	212.765	0.01702	259.58	0.01707	338.011
	0.01909	29.4045	0.01913	95.3745	0.01906	150.748	0.01893	188.145	0.01876	222.235	0.01868	274.018	0.0187	357.334
	0.02033	29.928	0.02033	97.1376	0.02033	153.984	0.02033	193.336	0.02033	231.314	0.02033	287.931	0.02033	376.005
	0.03304	35.1428	0.03304	115.428	0.03304	185.645	0.03304	239.164	0.03304	303.102	0.03304	392.833	0.03304	518.886
	0.04575	40.3576	0.04575	133.719	0.04575	217.306	0.04575	284.992	0.04575	374.89	0.04575	497.736	0.04575	661.768
	0.0549	40.3576	0.0549	133.719	0.0549	217.306	0.0549	284.992	0.0549	374.89	0.0549	497.736	0.0549	661.768
	0.06405	40.3576	0.06405	133.719	0.06405	217.306	0.06405	284.992	0.06405	374.89	0.06405	497.736	0.06405	661.768

* Depth is measured below the proposed ground surface of Goshen Road (elevation 162.6 m)

** The values P(kN/m) represent soil reaction per metre of pile length; The values y(m) represent soil/pile deflection

The following

1. The analysis was completed for a vertical pile (i.e. no inclination) and flat ground

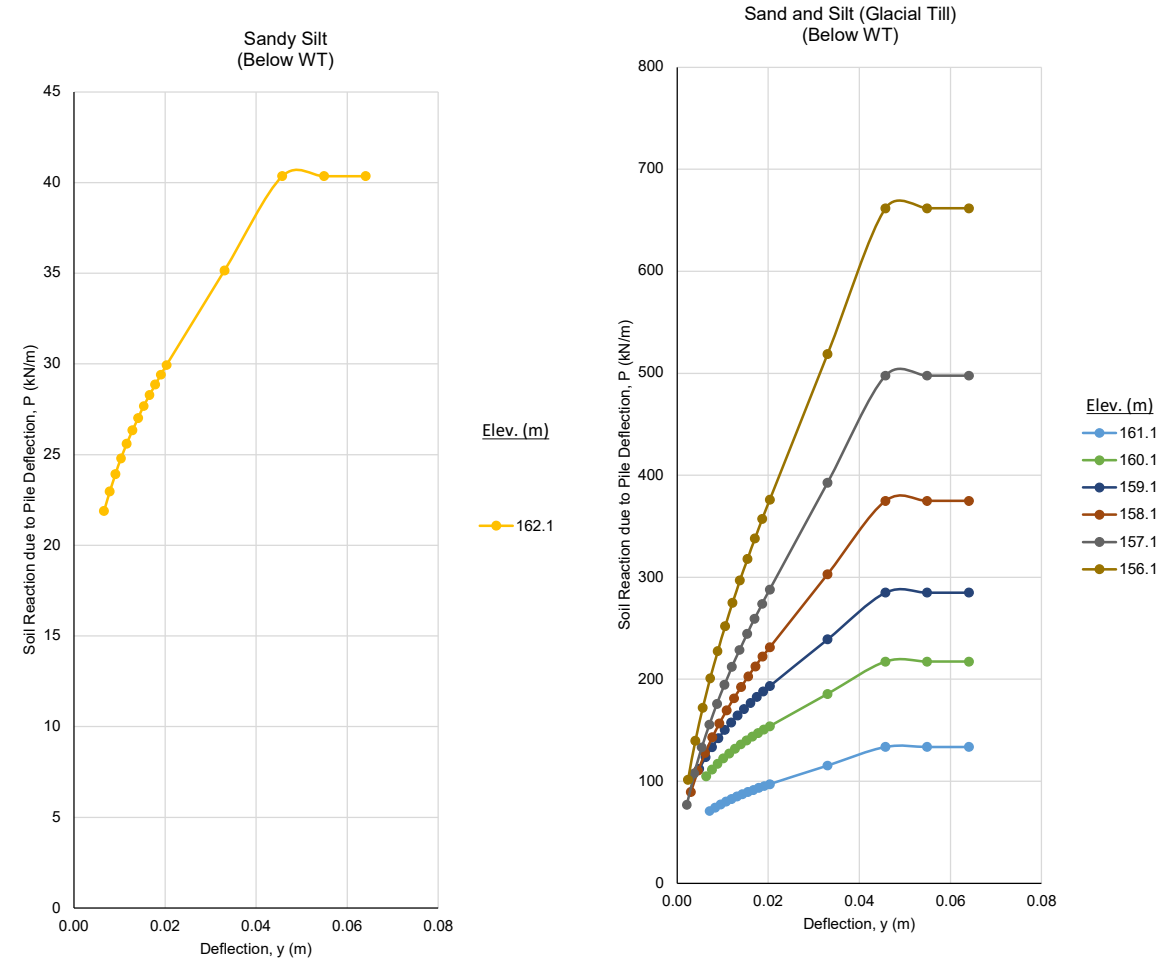
2. The effects of construction disturbance or dredging is not considered. not included, the static p-y curves may be used under seismic loading.

3. Not applicable for bedrock.

NOTES:

1. The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)

2. If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.11.3(r), C.6.11.3(s) and C6.11.3(t) of the CHBDC (S6-19)



<div>SOIL P-Y CURVES</div> <div>Highway 17 Twinning - Goshen Road</div> <div>West Abutment - 915mm Caisson</div>	Figure H3
--	-----------

Soil Type	Sandy Clayey Silt to Clayey Silty Sand (Glacial Till)											
Depth* (m)	0.5		1.5		2.5		3.5		4.5		5.5	
Elev* (m)	162.1		161.1		160.1		159.1		158.1		157.1	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00509	16.8514	0.00514	50.9887	0.00388	64.1684	0.00197	45.5287	0.00157	46.6728	0.00226	82.315821
	0.00602	17.6712	0.00606	53.6873	0.00491	69.9496	0.00317	58.4653	0.00281	66.4113	0.00344	106.26727
	0.00694	18.4053	0.00698	56.1175	0.00595	75.0011	0.00438	69.1882	0.00406	82.8507	0.00462	127.13577
	0.00786	19.0726	0.0079	58.3366	0.00698	79.5214	0.00559	78.5679	0.0053	97.3737	0.0058	145.9909
	0.00879	19.686	0.00881	60.3847	0.00801	83.6342	0.0068	87.0188	0.00654	110.593	0.00698	163.38911
	0.00971	20.2548	0.00973	62.2908	0.00905	87.4224	0.008	94.7775	0.00779	122.846	0.00817	179.66554
	0.01063	20.7862	0.01065	64.077	0.01008	90.9448	0.00921	101.994	0.00903	134.343	0.00935	195.04136
	0.01156	21.2856	0.01157	65.7602	0.01112	94.2448	0.01042	108.771	0.01027	145.228	0.01053	209.67194
	0.01248	21.7572	0.01249	67.354	0.01215	97.3551	0.01163	115.182	0.01152	155.601	0.01171	223.67163
	0.0134	22.2045	0.01341	68.8691	0.01318	100.302	0.01283	121.282	0.01276	165.539	0.01289	237.12757
	0.01433	22.6303	0.01433	70.3144	0.01422	103.105	0.01404	127.113	0.01401	175.1	0.01407	250.10807
	0.01525	23.0369	0.01525	71.6974	0.01525	105.782	0.01525	132.709	0.01525	184.329	0.01525	262.66791
	0.02478	27.1418	0.02478	85.7345	0.02478	129.921	0.02478	176.021	0.02478	253.881	0.02478	362.48171
	0.03431	31.2467	0.03431	99.7716	0.03431	154.061	0.03431	219.334	0.03431	323.433	0.03431	462.29551
	0.04118	31.2467	0.04118	99.7716	0.04118	154.061	0.04118	219.334	0.04118	323.433	0.04118	462.29551
	0.04804	31.2467	0.04804	99.7716	0.04804	154.061	0.04804	219.334	0.04804	323.433	0.04804	462.29551

* Depth is measured below the proposed ground surface of Goshen Road (elevation 162.6 m)

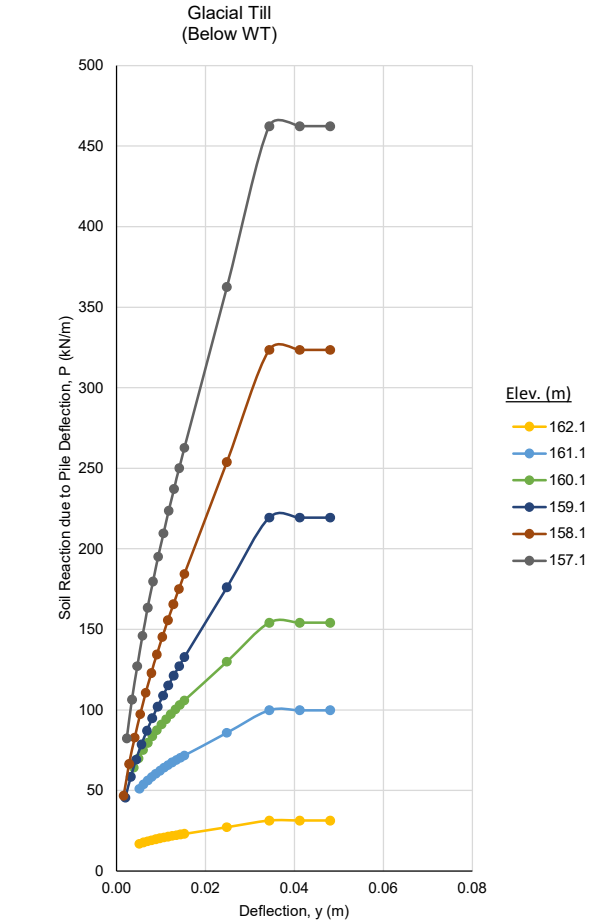
** The values P(kN/m) represent soil reaction per metre of pile length; The values y(m) represent soil/pile deflection

The following assumptions were made in the analysis:

1. The analysis was completed for a vertical pile (i.e. no inclination) and flat ground
2. The effects of construction disturbance or dredging is not considered. not included, the static p-y curves may be used under seismic loading.
3. Not applicable for bedrock.

NOTES:

1. The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (Øgu and Øgs) provided in Table 6.2 of the CHBDC (S6-19)
2. If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.11.3(r), C.6.11.3(s) and C6.11.3(t) of the CHBDC (S6-19)



Date: 2021-04-23
Project No.: 24726

Prepared By: KE
Checked By: KS

SOIL P-Y CURVES
Highway 17 Twinning - Goshen Road
West Abutment - 1,220 mm Caisson

Figure H4

Soil Type	Sandy Clayey Silt to Clayey Silty Sand (Glacial Till)											
Depth* (m)	0.5		1.5		2.5		3.5		4.5		5.5	
Elev* (m)	162.1		161.1		160.1		159.1		158.1		157.1	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00661	21.8825	0.00714	70.8684	0.00635	104.98	0.00485	112.224	0.00301	89.5408	0.00211	76.9667
	0.00786	22.9622	0.00834	74.2625	0.00762	111.481	0.00625	123.623	0.00458	110.372	0.00377	107.828
	0.00911	23.9246	0.00954	77.3307	0.00889	117.289	0.00766	133.52	0.00616	127.813	0.00543	133.322
	0.01036	24.796	0.01074	80.14	0.01016	122.563	0.00907	142.342	0.00773	143.119	0.00708	155.715
	0.0116	25.5948	0.01194	82.7378	0.01143	127.411	0.01048	150.35	0.00931	156.921	0.00874	176.004
	0.01285	26.3338	0.01314	85.159	0.0127	131.909	0.01189	157.714	0.01088	169.589	0.0104	194.74
	0.0141	27.0227	0.01434	87.4304	0.01398	136.115	0.01329	164.555	0.01246	181.363	0.01205	212.266
	0.01534	27.669	0.01554	89.5726	0.01525	140.07	0.0147	170.96	0.01403	192.409	0.01371	228.812
	0.01659	28.2785	0.01674	91.6021	0.01652	143.811	0.01611	176.994	0.01561	202.846	0.01536	244.542
	0.01784	28.8557	0.01793	93.5324	0.01779	147.362	0.01752	182.709	0.01718	212.765	0.01702	259.58
	0.01909	29.4045	0.01913	95.3745	0.01906	150.748	0.01893	188.145	0.01876	222.235	0.01868	274.018
	0.02033	29.928	0.02033	97.1376	0.02033	153.984	0.02033	193.336	0.02033	231.314	0.02033	287.931
	0.03304	35.1428	0.03304	115.428	0.03304	185.645	0.03304	239.164	0.03304	303.102	0.03304	392.833
	0.04575	40.3576	0.04575	133.719	0.04575	217.306	0.04575	284.992	0.04575	374.89	0.04575	497.736
	0.0549	40.3576	0.0549	133.719	0.0549	217.306	0.0549	284.992	0.0549	374.89	0.0549	497.736
	0.06405	40.3576	0.06405	133.719	0.06405	217.306	0.06405	284.992	0.06405	374.89	0.06405	497.736

* Depth is measured below the proposed ground surface of Goshen Road (elevation 162.6 m)

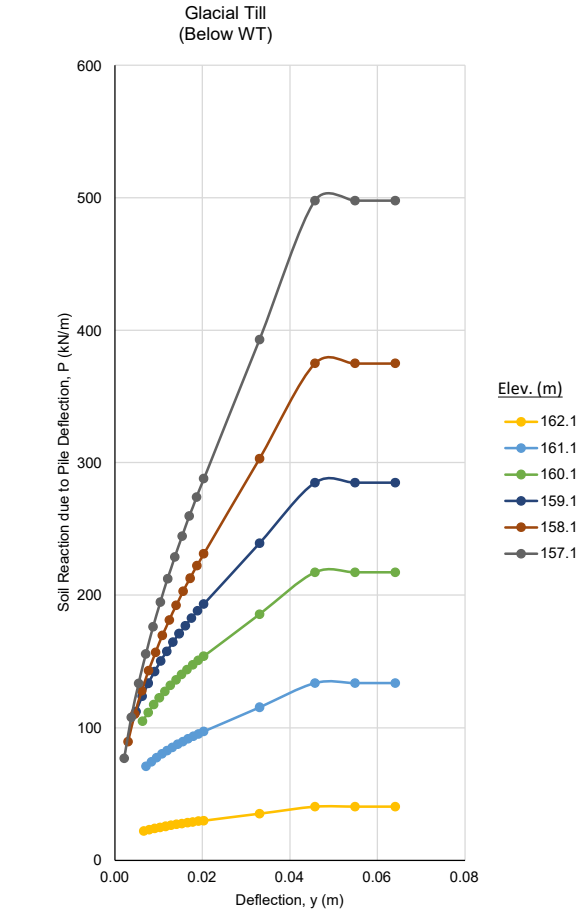
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NOTES:

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Appendix I.

List of Referenced Specifications Non-Standard Special Provisions

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

OPSD 200.010	Earth/Shale Grading Undivided Rural
OPSD 201.010	Rock Grading Undivided Rural
OPSD 201.020	Rock Grading Divided Rural
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 3101.150	Walls Abutment, Backfill Minimum Granular Requirement
OPSD 3101.200	Walls, Abutment, Backfill, Rock
OPSS.PROV 120	Construction Specification for The Use of Explosives
OPSS.PROV 202	Construction Specification for Rock Removal by Manual Scaling, Machine Scaling, Trim Blasting, or Controlled Blasting
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 942	Construction Specification for Prestressed Soil and Rock Anchors
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1860	Material Specification for Geotextiles
SP 110S06	Amendment to OPSS 1010 - Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material

Suggested wording for NSSPs

“Notice to Contractor: Obstructions”

The Contractor is hereby notified that the native discontinuous tills at the site and as inferred from available information should be expected to contain cobbles and boulders. Considerations of these obstructions must be made in the selection of appropriate equipment and procedures for excavations, installations of deep foundations and temporary protection systems.