THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 7-NEW EBL AND WBL OVERPASSES
AT WOODLAWN ROAD
HIGHWAY 7-NEW, KITCHENER TO GUELPH
SITE 35-608/2
G.W.P. 408-88-00

GEOCRES No. 40P9-63

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Report

to

WSP

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of the proposed overpass structures to carry the EBL and WBL of Highway 7-New over Woodlawn Road in the City of Guelph, Ontario. The proposed Woodlawn overpass structures are part of the Highway 7-New Project.

The purpose of the 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, a stratigraphic profile, cross sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the potential foundation footprints was developed from the data obtained in the course of the investigation.

Thurber was retained by WSP to carry out the site investigation under the Ministry of Transportation Ontario (MTO) Agreement Order Number 3014-E-0013.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site during the preliminary design phase. The title of the report is:

- Preliminary, Foundation Investigation and Design Report, Proposed Highway 7 Bridge Over Woodlawn Road, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P9-46, Report to Ministry of Transportation Ontario Southwestern Region, File: 15-64-17, dated October 8, 2008. (Reference 1).

2. SITE DESCRIPTION

The proposed Woodlawn Road overpass structures are located approximately 4.5 km northwest of the city centre of the City of Guelph at the intersection of Highway 7 and Woodlawn Road. . The existing highway corridor south of Woodlawn Road is surrounded primarily by commercial and industrial properties and there is a vacant lot north of the intersection of Highway 7 and Woodlawn Road which extends northerly to Curtis Drive. The existing topography in the vicinity of the site is generally flat.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within an area referred to as the Guelph Drumlin Field, an area of drumlinized till plain, also mapped as containing eskers. The till is described as stony and the occurrence of surface boulders is noted. Chapman and Putnam give a typical gradation of the till as being 50% sand, 35% silt and 15% clay. Swampy valleys are reported to occur between the drumlins and associated gravel terraces.

3. SITE INVESTIGATION AND FIELD TESTING

The foundation investigation was completed in two phases. An initial investigation was completed at the site in June 2008, at which time four (4) boreholes (i.e. 08-236 to 08-239) were drilled at the west and east abutments of the proposed overpass structures. Subsequently, in April 2021, an additional nine (9) boreholes (i.e.WL16-01 to WL16-08 and WL16-04B) were advanced at the site near the foundation units and the approach embankments of the structures. The approximate locations of the boreholes are shown on the Borehole Location and Soil Strata Drawings included in Appendix D. The Records of Boreholes sheets from the initial and recent investigations are provided in Appendices A and B, respectively.

The ground surface elevations and coordinates of the recent as-drilled boreholes were surveyed by Thurber using a Trimble R10.

Prior to commencing the site investigation, utility clearances were obtained for all borehole locations. A field work notification was also submitted to the MTO Western Region.

During the current investigation, track-mounted B57 and truck-mounted B60 drill rigs were used in conjunction with hollow-stem augers to advance the boreholes in the overburden soils. In general, soil samples were obtained at selected intervals using a 50mm diameter split spoon sampler in conjunction with the Standard Penetration Testing (SPT). HQ coring methods were used to advance Boreholes WL16-03 to WL16-06, 0.9 to 4.3 m into bedrock. All remaining boreholes were advanced to auger refusal on probable bedrock and refusal density soils as defined by SPT ‘N’ values of greater than 100 blows per 0.3 m of penetration.

The drilling, sampling and in-situ testing operations were supervised on a full-time basis by a member of Thurber’s technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber’s Oakville laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed in selected boreholes (WL16-04B, WL16-06, WL16-07, 08-237 and 08-238). Each piezometer consisted of either a 50 mm (WL16-04B, WL16-06 and WL16-07) or 25 mm (08-237 and 08-238) Schedule 40 PVC pipe with a 1.5m to 3.0 m long slotted screen enclosed in a column of filter sand to permit groundwater level monitoring. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. Upon completion of the drilling operations, the boreholes without piezometers were abandoned in general accordance with Ontario Regulation 903 (as amended by O. Reg. 372/07). The details of standpipe piezometer installation and borehole completion are provided on the Record of Borehole Sheets in Appendix A and B. The piezometer installations were decommissioned as per O.Reg. 903.

Table 3.1 – Borehole Completion Details

Foundation Unit		Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
Hwy 7-New EBL	West abutment	WL16-01	6.1 / 334.2	None Installed	Backfilled with bentonite.
		WL16-03	8.9 / 331.2	None Installed	Backfilled with bentonite.
		08-238	5.3 / 335.7	5.0 / 336.0	Piezometer with 1.5 m slotted screen installed with sand filter from 5.0 m to 3.2 m, bentonite holeplug from 3.2 m to 0.3

Foundation Unit		Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
					m, concrete to surface.
	East abutment	WL16-07	4.4 / 335.9	4.3 / 336.0	Bentonite holeplug from 4.4 m to 4.3 m, Piezometer with 3.0 m slotted screen installed with sand filter from 4.3 m to 0.9 m, bentonite holeplug from 0.9 m to 0.3 m, concrete from 0.3 m to 0.1, then sand to surface.
		08-239	8.5 / 331.5	None Installed	Backfilled with bentonite.
Hwy 7-New WBL	West abutment	WL16-04	6.2 / 334.7	None Installed	Backfilled with bentonite.
		WL16-02	4.4 / 336.8	None Installed	Backfilled with bentonite.
		08-236	7.8 / 333.7	None Installed	Backfilled with bentonite to 0.6m, grout to surface
	East abutment	WL16-05	7.6 / 333.0	None Installed	Backfilled with bentonite to 0.3 m, sand and gravel to surface.
		WL16-06	7.0 / 333.4	4.0 / 336.4	Bentonite holeplug from 7.0 m to 4.0 m, Piezometer with 1.5 m slotted screen installed with sand filter from 4.0 m to 2.1 m, bentonite holeplug from 2.1 m to 0.5 m, concrete from

Foundation Unit		Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
					0.5 m to 0.1, then sand to surface.
		WL16-08	4.3 / 336.1	None Installed	Backfilled with bentonite to 0.45m, concrete 0.45m to 0.15m, then asphalt to surface.
		08-237	5.3 / 335.7	5.0 / 336.0	Piezometer with 1.5 m slotted screen installed with sand filter from 3.7 m to 1.5 m, bentonite holeplug from 1.5 m to 0.5 m, concrete to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing of current and previous investigations are summarized on the Record of Borehole sheets in Appendices A and B, and are also presented on the figures included in Appendices A and B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, samples of the gravelly sand fill, native gravelly sand, sand and silt till, and silty sand were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix A.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendices A and B. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the site consist of topsoil and asphalt overlying fill above native layers of silty sand to sand, gravelly sand to sand and gravel, and sand and silt to sandy silt till. The overburden materials are underlain by dolostone bedrock. Descriptions of the individual strata are presented below.

5.1 Topsoil

Topsoil was identified at the ground surface in Boreholes WL16-02 to WL16-04, WL16-06 and WL16-07. The topsoil thickness ranged from 75 mm to 175 mm.

The topsoil thickness may vary between and beyond the borehole locations, and the limited data presented in this report should not be used for quantity estimation purposes.

5.2 Asphalt

Asphalt was encountered at the ground surface in Borehole WL16-08 which was advanced through the pavement. The asphalt thickness was measured as 125 mm.

5.3 Fill

Fill consisting of gravelly sand to sand and gravel, containing some to trace amounts of silt and clay, and clayey silt to silt, trace to with sand, trace gravel, was encountered in all boreholes at ground surface or underlying the topsoil and asphalt layers. Silty sand fill containing trace gravel and clay was also encountered below the clayey silt fill in Borehole WL16-03 at a depth of 0.7 m (Elev. 339.4 m). Cobbles and/or dolostone fragments were noted in the gravelly sand to sand and gravel fill in WL16-04, 08-236, 08-237, and 08-238, and possible boulders were noted in 08-237. Organics and rootlets were observed within the clayey silt to silt fill in all boreholes. A gas odour was noted in Boreholes 08-237 and 08-239.

The thickness of the fill ranged from 1.1 m to 3.7 m and the lower boundary was encountered between Elevation 339.3 and 335.8 .

SPT N-values in the gravelly sand to sand and gravel fill ranged from 10 blows per 0.3 m penetration to 50 blows per 0.100 m per penetration, indicating a compact to very dense relative density. It is noted that the higher N-values are likely due to the presence of cobbles within the fill and that the majority of the N-values were in the order of 10 to 30 blows. SPT N-values in the clayey silt to fill ranged from 2 to 19 blows per 0.3 m penetration, indicating a soft to very stiff consistency. An SPT N-value of 16 blows per 0.3 m penetration was recorded in the silty sand fill, indicating a compact relative density.

Moisture contents within the gravelly sand fill ranged from 3 to 16 percent. Moisture contents within the clayey silt to silt fill ranged from 6 to 27 percent with an average value of about 20 percent. A moisture content of 10 percent was recorded in the silty sand fill.

The gradation analysis completed on samples of the fill are illustrated on Figures A1 to A3 in Appendix A and Figure B1 in Appendix B. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendices A and B.

	Clayey Silt to Silt Fill	**Silty Sand Fill**	**Gravelly Sand to Sand and Gravel Fill**
Soil Particle	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Gravel	0 to 2	5	25 to 43
Sand	32 to 50	62	42 to 53
Silt	36 to 43	29	-
Clay	9 to 14	4	-
Silt + Clay	68	-	13 to 27

5.4 Silty Sand to Sand

Brown silty sand to sand, trace gravel, trace to some clay, was encountered underlying the fill in WL16-05 to WL16-08 and 08-239. Dolostone fragments were noted within this deposit in Boreholes WL16-05 and WL16-08 and a gas odour was noted in Borehole 08-239. The thickness of the silty sand to sand ranged from 0.6 m to 2.2 m and the lower boundary of the deposit was encountered at depths between 2.1 m and 4.6 m (Elev. 337.8 and 335.9).

SPT N-values in the silty sand to sand ranged from 10 to 26 blows per 0.3 m penetration indicating a compact relative density. Moisture contents measured within the silty sand to sand ranged from 9 to 19 percent.

The gradation analysis completed on samples of the silty sand to sand are illustrated on Figure A4 in Appendix A and Figure B2 in Appendix B. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendices A and B.

Soil Particle	Percentage (%)
Gravel	1
Sand	49 to 61
Silt	35 to 39
Clay	3 to 11

5.5 Gravelly Sand to Sand and Gravel

Brown gravelly sand to sand and gravel, trace silt to some silt, trace clay, was encountered underlying the fill in Boreholes WL16-01 and WL16-03, and underlying the silty sand in 08-239. Occasional cobbles were noted within this deposit in Borehole WL16-03 and numerous cobbles were noted in this deposit in Borehole 08-239. The thickness of the gravelly sand to sand and gravel ranged from 1.3 m to 1.9 m and the lower boundary of the deposit was encountered at depths between 3.0 m and 3.7 m (Elev. 337.3 and 336.3).

SPT N-values in the silty sand to sand ranged from 19 to 43 blows per 0.3 m penetration indicating a compact to dense relative density. Moisture contents measured on samples ranged from 6 to 30 percent.

The gradation analysis completed on samples of the gravelly sand to sand and gravel are illustrated on Figure A5 in Appendix A and Figure B3 in Appendix B. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendices A and B.

Soil Particle	Percentage (%)
Gravel	20 to 21
Sand	58
Silt + Clay	21 to 22

5.6 Sand and Silt to Sandy Silt Till

Brown sand and silt to sandy silt till, trace gravel to gravelly, trace to some clay, was encountered underlying the gravelly sand to sand and gravel in Boreholes WL16-01 and WL16-03, and underlying fill in WL16-02, WL16-04, 08-236, 08-238, and 08-239. Cobbles were noted within the deposit. The thickness of the till ranged from 1.6 m to 2.7 m and extended to depths ranging from 4.4 m to 5.3 m (Elev. 336.8 to 334.6). Glacial tills inherently contain cobbles and boulders.

SPT N-values in the till ranged from 25 blows per 0.3 m penetration to 103 blows per 0.125 m penetration, indicating a compact to very dense relative density (typically dense to very dense). Moisture contents measured on samples ranged from 7 to 15 percent.

The gradation analysis completed on samples of the sand and silt to sandy silt till are illustrated on Figure A6 in Appendix A and Figure B4 in Appendix B. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendices A and B.

Soil Particle	Percentage (%)
Gravel	0 to 13
Sand	31 to 45
Silt	38 to 55
Clay	4 to 11

5.7 Dolostone Bedrock

The overburden soils described above are underlain by highly to moderately weathered dolostone bedrock, which was encountered at depths ranging from 4.0 m to 5.5 m (Elev. 336.8 to 334.6) in all boreholes, and proven by coring 3.0 to 4.2 m into the rock in five boreholes. The bedrock was described as light grey/white in colour. Rock core photos are presented in Appendix C.

Depths and elevations of the top of bedrock encountered in the present and previous investigations are shown in Table 5.1.

Table 5.1 – Depth and Elevation of Top of Bedrock

Foundation Unit		Borehole	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
Hwy 7-New EBL	West abutment	WL16-01	5.3	335.0
		WL16-03(1)	4.6	335.5
		08-238	5.3	335.7
	East abutment	WL16-07	4.4	335.9
		08-239	5.3	334.6
Hwy 7-New WBL	West abutment	WL16-04(1)	5.3	335.6
		WL16-04B(1)(2)	5.5	335.4
		WL16-02	4.4	336.8
		08-236(1)	4.5	336.8
	East abutment	WL16-05(1)	4.6	336.0
		WL16-06(1)	4.0	336.4
		WL16-08	4.3	336.1

(1) Proven by coring.

(2) WL16-04B was completed beside WL16-04 due to difficulties achieving 3m rock core in WL16-04

Total Core Recovery (TCR) in the bedrock ranged from 83% and 100% with Solid Core Recovery (SCR) of 83% and 100% (except Borehole WL16-04 ranging between 22% and 83%). The Rock

Quality Designation (RQD) determined from the recovered cores was 0% to 87%, indicating very poor to good rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 8.

Unconfined compressive strength (UCS) and Point Load Tests (PLT) were conducted in rock cores. Unconfined compressive strengths (UCS) interpreted from point load tests conducted on selected rock cores typically varied from 31.4 MPa to 157.3 MPa. The UCS of the rock, determined from four laboratory unconfined compression tests, ranged from 25.1 MPa to 129.0 MPa. The results indicate a medium strong to very strong rock.

Results of UCS tests and point load tests conducted on the rock core samples are included in Appendix A.

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes 08-237, 08-238, WL16-04B, WL16-06 and WL16-07 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and standpipe piezometers are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
08-236	June 18, 2008	4.0	337.4	Open Borehole
08-238	June 20, 2008 July 15, 2008	2.7 2.9	338.3 338.1	Open Borehole Piezometer
WL16-01	April 8, 2021	2.3	338.0	Inferred
WL16-02	April 7, 2021	4.3 2.5	336.9 338.7	Open Borehole Inferred
WL16-03	April 8, 2021	Dry 2.3	- 337.8	Open Borehole Inferred
WL16-04	April 9, 2021	Dry 4.1	- 336.8	Open Borehole Inferred
WL16-04B	April 14, 2021	4.4	336.5	Piezometer

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
	April 16, 2021	2.9	338.0	Piezometer
WL16-05	April 8, 2021	2.2	338.4	Open borehole
WL16-06	April 6, 2021	2.7	337.7	Open borehole
	April 16, 2021	2.7	337.7	Piezometer
08-237	June 20, 2008	2.4	337.1	Open Borehole
	July 15, 2008	2.3	337.2	Piezometer
08-239	June 19, 2008	2.1	337.8	Open Borehole
WL16-07	April 16, 2021	2.5	337.9	Piezometer
WL16-08	April 7, 2021	3.4	337.0	Open Borehole

The groundwater levels above are short-term readings, and seasonal fluctuations of the groundwater levels are to be expected. The groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

Four (4) samples selected from Boreholes WL16-03 to WL16-06 were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix A.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Test Results			
		WL16-03 SS 3B Depth 1.5 m	WL16-04 SS 6 Depth 4.6 m	WL16-05 SS 5 Depth 3.0 m	WL16-06 SS 2 Depth 0.8 m
		(Native Gravelly Sand)	(Native Sand and Silt Till)	(Native Silty Sand)	(| Sand Fill)
Sulphide	%	<0.04	<0.04	<0.04	<0.04
Chloride	µg/g	88	60	190	350
Sulphate	µg/g	4.8	8.7	7.6	11
pH	No unit	9.27	9.32	9.48	8.78
Electrical Conductivity	µS/cm	148	95	436	814
Resistivity	Ohms.cm	6760	10500	2290	1230

Parameter	Units (Soil)	Test Results			
		WL16-03 SS 3B Depth 1.5 m	WL16-04 SS 6 Depth 4.6 m	WL16-05 SS 5 Depth 3.0 m	WL16-06 SS 2 Depth 0.8 m
		(Native Gravelly Sand)	(Native Sand and Silt Till)	(Native Silty Sand)	(ǀ Sand Fill)
Redox Potential	mV	112	230	192	284

7. MISCELLANEOUS

Landshark Group of Brantford, Ontario supplied a track-mounted B57 drill rig and a truck-mounted B60 drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation.

The coordinates and elevations for the boreholes were obtained with GPS equipment by Thurber.

The drilling and sampling operations in the field for the current investigation were supervised on a full-time basis by Thurber field technicians.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc.

Details of the previous investigation, conducted in 2008, are presented in Reference 1.

Overall supervision of the field program for the present investigation was conducted by Mr. Geoff Lay, P.Eng.. Interpretation of the data and preparation of the current report was carried out by Mr. Joshua Alexander, E.I.T. and Mr. Geoff Lay, P.Eng., Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the proposed two new bridge structures that will carry the eastbound lanes (EBL) and westbound lanes (WBL) of Highway 7 over the Woodlawn Road in Guelph, Ontario.

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 the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the information provided as it may affect equipment selection, proposed construction methods and scheduling.

Based on GA drawings provided by WSP, dated June 2018, each bridge will be a single-span structure supported on integral abutments. The proposed length of each bridge will be 48.0 m. The width of the EBL and WBL structures will be approximately 14.0 m and 17.0 m, respectively. The east and west abutments of each bridge are designed to be supported on a single row of driven steel H-piles.

The discussion and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained in the course of the previous and the present investigations.

It is noted that this report does not address the design of the high fill embankments and retaining walls at Woodlawn Road interchange, which will be addressed under separate cover.

9. STRUCTURE CLASSIFICATION

In accordance with the currently applicable Canadian Highway Bridge Design Code (CHBDC) (2019) CSA S6-19, the analysis and design of structures are influenced by its importance category and consequence classification. Such designations are defined by the Regulatory Authority which, in this case, is the Ministry of Transportation of Ontario (MTO).

For the purpose of reporting, this structure has been classified as a Major-Route Bridge with Typical Consequence based on CHBDC S6-19 Sections 4.4.2 and 6.5.2, respectively.

Based on the above classification and Table 6.1 in Section 6.5.2 in the CHBDC (2019), a consequence factor, ψ, of 1.0 has been used for assessing ULS and SLS factored geotechnical resistances. Should the consequence classification change, the geotechnical assessment and recommendations will need to be reviewed and revised, as necessary.

10. STRUCTURE FOUNDATIONS

In general, the subsurface conditions encountered at the site consist of topsoil and asphalt overlying fill above native layers of silty sand to sand, gravelly sand to sand and gravel, and sand and silt to sandy silt till. The overburden materials are underlain by dolostone bedrock contacted at depths ranging from 4.0 m to 5.5 m (Elev. 336.8 to 334.6) by coring. The groundwater levels measured in the piezometers and open boreholes, and inferred from ground conditions, varied from 2.1 m to 4.4 m depth below ground surface (Elev. 338.7 to 336.5).

In the preparation of the geotechnical design recommendations, consideration was given to the following foundation types:

1. Spread footings on native soils
2. Spread footings on engineered fill
3. Drilled shafts (Caissons)
4. Steel H-piles driven to bedrock

A comparison of the technical advantages, disadvantages and relative risks and costs of the alternative foundation schemes is presented in Appendix E. Discussions on feasible foundation alternatives are presented in the following paragraphs. A preferred foundation scheme from a foundations perspective is then recommended.

Spread Footings on Native Soils

Spread footings founded on native soils are considered feasible. However, construction of spread footings would require deep excavation in the cohesionless fill and native materials and extend below groundwater table to place footing base on competent native soils. Forming and unwatering an excavation will be problematic and accordingly this option is not recommended. Furthermore, it is understood that integral abutments are being considered for support of both bridges. Therefore, recommendations for spread footings on native soils have not been developed further.

Spread Footings on Engineered Fill

Spread footings founded on an engineered fill pad are considered feasible but would require relatively deep excavations for engineered fill pad construction. This option has not been developed further.

Drilled Shafts (Caissons)

Drilled shafts (caissons) socketed into bedrock are also considered feasible. However, caisson construction will extend through cohesionless soils containing cobbles and boulders below the groundwater table and will require the use of temporary liners to support the caisson sidewalls and use of synthetic slurry to stabilize the base. The caissons will also require placement of concrete using tremie methods. For these reasons, drilled shafts (caissons) are not recommended. Therefore, recommendations for drilled caissons have not been developed further.

Driven Steel H-Piles

Steel H-piles driven to refusal on dolostone bedrock are considered suitable for supporting the bridge abutments. This foundation option would permit integral abutment design.

The sand and silt till overlying dolostone bedrock contains occasional cobbles and rock fragments.

Hard driving conditions may be encountered locally within the very dense sand and silt till. Tip protection must be provided for H-piles.

Recommended Foundations

From a geotechnical and cost effectiveness perspective, the preferred foundation alternative for the new Hwy 7 EBL and WBL bridges over Woodlawn Road are driven piles to bedrock for the east and west abutments. The subsurface conditions encountered at this site are considered suitable for use of integral abutments.

10.1 Driven Steel H-Piles

From a foundation engineering perspective, supporting the abutments on steel H-piles driven to dolostone bedrock is considered suitable.

10.1.1 Axial Resistance

Steel H-piles driven to refusal on dolostone bedrock are considered suitable for supporting the bridge abutments. For an HP 310x110 driven to dolostone bedrock, a factored geotechnical resistance at ULS of 2,200 kN per pile is recommended. For an HP 310x132 driven to dolostone bedrock, a factored geotechnical resistance at ULS of 2,600 kN per pile is recommended. The SLS condition will not govern for piles founded on the bedrock.

For piles driven to bedrock, the axial geotechnical resistances based on the bedrock strength are expected to exceed the factored structural capacity of the piles. Accordingly, the structural capacity of the piles will govern the design and should be used for design. The structural capacity for HP 310x110 and HP 310x132 piles may be taken as 2,000 kN and 2,400 kN, respectively.

In light of hard driving conditions, consideration should be given to using HP 310x132 piles.

Table 10.1 provides a summary of the approximate bedrock elevation and estimated pile length at each abutment. The estimated pile lengths must be checked structurally with respect to the minimum pile length requirement for integral abutments.

Table 10.1 – Approximate Bedrock Elevation and Pile Lengths

Foundation Unit		Design U/S of Abutment	Reference Boreholes	Approximate Bedrock Elevation	Estimated Pile Length
Hwy 7-New WBL Overpass	West abutment	343.7 m	08-236 WL16-04/04B	336.8 – 335.4	6.9 – 8.3
	East abutment	343.4 m	WL16-05 WL16-06	336.4 – 336.0	7.0 – 7.4
Hwy 7-New EBL Overpass	West abutment	343.7 m	WL16-03	335.5	8.2
	East abutment	343.4 m	08-239	334.6	8.8

The values above will have to be reviewed and modified if necessary during detail design and following completion of additional subsurface investigation. No boreholes have been completed at the east abutment of the EBL overpass due to access issues. Additional borehole investigation should be carried out at the east abutment of the EBL overpass during detailed design, once the layout of the proposed bridge foundations elements is finalized, to confirm soil stratigraphy and bedrock elevation.

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019.

The structural resistance of the pile must be checked by the structural designer.

10.1.2 Downdrag

Downdrag on the piles is not expected to be an issue at this site.

10.1.3 Lateral Resistance

The geotechnical lateral resistance acting on a pile in cohesive soils may be calculated using the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = 67\,S_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9\,S_u \quad (\text{kPa})$$

Where S_u = undrained shear strength (kPa)

D = width or diameter of pile chosen

The geotechnical lateral resistance acting on a pile in cohesionless soils may be calculated using the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

k_s = $n_h\ z\ /\ D$ (kN/m^3)

p_{ult} = $3\ \gamma'\ z\ K_p$ (kPa)

Where z = depth of embedment of pile (m)

D = width or diameter of pile chosen

n_h = coefficient related to soil relative density (kN/m^3)

γ' = effective unit weight (kN/m^3)

K_p = passive earth pressure coefficient

The above equations and recommended parameters in the following table may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

For pile lateral resistance design below the flexible zone, soil-pile interaction analyses may be carried out using the coefficient of horizontal subgrade reaction values provided in Table 10.2 below.

Table 10.2 – Recommended Geotechnical Parameters for Lateral Resistance Design

Soil Unit	Elevation (m)		γ' (kN/m^3)	n_h (kN/m^3)	K_p	S_u (kPa)
	Top	Bottom				
WBL West Abutment (08-236, WL16-04)						
Firm Clayey Silt Fill	341.0	339.5	18	-	-	35
Compact/Dense Sand/Gravel Fill	339.5	338.0	20	5,000	3.2	-
Compact/Dense Silt/Sand Till	338.0	336.5	11*	3,000	3.2	-
Very Dense Silt/Sand Till	336.5	Bedrock Surface	12*	9,000	3.8	-
WBL East Abutment (08-237, WL16-05, WL16-06)						
Compact Sand/Gravel Fill	340.5	340	20	3,500	3.2	-
Stiff Clayey Silt Fill	340	338.5	19	-	-	70
Compact Gravelly Sand Fill	338.5	337.5	11*	3,000	3.2	-
Compact Silty Sand	337.5	Bedrock	11*	2,700	3.1	-

Soil Unit	Elevation (m)		γ' (kN/m^3)	n_h (kN/m^3)	K_p	S_u (kPa)
	Top	Bottom				
		Surface				
EBL West Abutment (08-238, WL16-03)						
Firm Clayey Silt Fill	340	339.5	18	-	-	30
Compact Silty Sand Fill	339.5	338.5	19	2,500	3.1	-
Compact/Dense Sand/Gravel	338.5	337.0	11*	6,000	3.6	-
Dense/Very Dense Silt/Sand Till	337.0	Bedrock Surface	12*	8,000	3.7	-
EBL East Abutment (08-239)						
Compact Sand/Gravel Fill	340	338.5	20	3,500	3.3	-
Compact Silty Sand	338.5	337.5	10*	2,000	3.0	-
Compact/Dense Silty Sand	337.5	336	11*	5,000	3.5	-
Very Dense Silt/Sand Till	336	Bedrock Surface	12*	8,000	3.7	-

Note: (*) Submerged unit weight

The spring constant, K_s, for analysis may be obtained by the expression, $K_s = k_s\ L\ D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}\ L\ D$. This represents the ultimate load at which the soil fails and will not support any additional load at greater pile displacement.

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Section C6.11.3.4 of CHBDC Commentary (2019).

10.1.4 Pile Installation

All piles shall be installed in accordance with OPSS.PROV 903 and SP 109F57.

The piles must be driven to bedrock. The appropriate pile driving note is “Piles to be driven to bedrock”.

To facilitate pile installation, embankment fill through which piles will be driven must not contain any material with particle sizes greater than 75 mm.

Hard driving conditions through the hard/very dense soils should be expected. Cobbles and boulders should also be anticipated within the very dense till deposit which may affect pile installation. Pile tip protection is recommended for driven H-piles to prevent pile damage when setting the piles on the bedrock, or if cobbles or boulders are encountered in the till. The tips of all driven H-piles must be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent. The Contract Documents must contain a NSSP alerting the Bidders to the presence of hard/dense zones, cobbles, and boulders. Suggested texts for the NSSP's are included in Appendix G. The NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

A preconstruction condition survey of nearby existing structures and utilities should be carried out prior to commencement of pile installation. The preconstruction condition survey should be conducted as indicated in the City of Guelph Linear Infrastructure Standards 2021, dated March 3, 2021. An assessment of the impact of vibrations produced during pile driving on adjacent structures and buildings should also be completed.

10.2 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

For integral abutments, the flexibility of the upper portion of the pile may be provided by a single corrugated steel pipe (CSP) system. Reference should be made to MTO's integral abutment manual for details of this system.

10.3 Frost Cover

The design depth of frost penetration for this site is 1.4 m as per OPSD 3090.101. The undersides of all pile caps/abutment stems must be provided with at least 1.4 m of soil cover as protection again frost action.

11. BACKFILL TO ABUTMENTS

For backfilling immediately behind the new west and east abutment walls, it is recommended that the new fill be Granular A or Granular B Type II materials meeting the gradation and relevant requirements stipulated in OPSS.PROV 1010. Beyond this zone, clean earth fill may be used. The earth fill should not contain medium or high plastic clays or deleterious materials and organics.

The backfill should be in accordance with OPSS.PROV 206 requirements and OPSD 3101.150. Compaction equipment to be used adjacent to abutments/retaining structures must be restricted in accordance to OPSS.PROV 501.

The design of the abutment must incorporate a subdrain as shown in OPSD 3101.150.

12. LATERAL EARTH PRESSURES

Earth pressures acting on the abutment stems may be assumed to be triangularly distributed and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2019 but are generally given by the expression:

$$p_h = K(\gamma h + q)$$

where: p_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see Table 12.1)
γ = unit weight of retained soil (see Table 12.1)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa).

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 12.1.

Table 12.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32^\circ$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive (Movement Towards Soil Mass)	3.7	-	3.2	-

Note: Submerged unit weight should be used below the groundwater level.

If some movement of the wall is allowed (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. For rigid walls, at-rest horizontal earth pressures should be used.

The active and passive earth pressure coefficients in Table 12.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.27 in the Commentary to the CHBDC 2019.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls. Reference may be made to OPSD 3101.150 where appropriate.

13. APPROACH EMBANKMENTS

Based on proposed finished grade levels of Highway 7-New EBL and WBL structures and the existing ground surface near the proposed bridge abutments, the anticipated heights of the west and east approach embankments are presented in Table 13.1.

Table 13.1 – Anticipated Approach Embankment Height

Foundation Unit		Borehole	Proposed finished grade elevation of Highway 7-New (1)	Existing ground surface (2)	Approximate Approach Embankment Height (m)
Hwy 7-New EBL	West abutment	WL16-01 WL16-03 08-238	348.4 to 348.5	340.1 to 341.0	7.4 to 8.4
	East abutment	WL16-07 08-239	348.4 to 348.5	339.9 to 340.3	8.1 to 8.6
Hwy 7-New WBL	West abutment	WL16-04 WL16-02 08-236	348.4 to 348.5	340.9 to 341.4	7.0 to 7.6
	East abutment	WL16-05 WL16-06 WL16-08	348.4 to 348.5	340.3 to 340.6	7.8 to 8.2

(1) Finished grade level of Highway 7-New at the abutments, obtained from the GA drawings

(2) Ground surface elevations at the proposed abutments, obtained from boreholes drilled at this site

The forward and side embankment slopes are proposed to be at inclination of 2H:1V.

Where the approach embankments are higher than 8 m, mid-height benches should be incorporated in the embankment design. The mid-height benches should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2 percent positive grade to shed run-off water

Prior to fill placement, the subgrade must be adequately prepared to receive the new fill. All vegetation, topsoil, organics, soft/loosened or wet soils should be sub-excavated. All subgrade should be inspected and approved prior to placing fill.

The approach embankments should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements. Materials used to construct the approach embankments should comprise granular materials or Select Subgrade Material (SSM) in compliance with OPSS.PROV 1010. Use of clay fill is not recommended due to relatively large post-construction fill compression, difficulties in achieving the specified compaction and potential embankment stability issues.

It is recommended that all exposed slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures must be provided for the slopes.

13.1 Slope Stability

Global stability analyses were carried for an approach embankment height of 8.5 m. The global stability analysis was conducted for the following two scenarios: embankment with a mid-height berm and without mid-height berm. The analyses were carried out utilizing the commercially available slope stability analysis program Slope/W (Version 2021) of the GeoStudio software package developed by Geo-Slope International with the option for Morgenstern-Price method of slices for the limit equilibrium analyses. Analyses were completed for both static and seismic loading conditions.

The soil parameters used in the analyses were estimated from empirical correlations using the results of the in situ Standard Penetration Tests (SPTs) and geotechnical laboratory testing. The groundwater level in our analysis was based on readings obtained to date from standpipe piezometers. The stability of the embankment was also checked under seismic loading assuming a horizontal seismic coefficient of 0.04 g.

Results of the stability analyses are presented on Figures F1 to F2 in Appendix F. The results are also summarized in Table 13.2 below.

Table 13.2 - Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix F)
Static Drained	1.7	F1
Seismic (PGA 0.0395g)	1.5	F2

As per Table 6.2 of CHBDC 2019, a Factor of Safety (F.S.) of 1.5 is acceptable for long term (drained) conditions. Under the assumed seismic loading, the minimum acceptable F.S. is 1.0. The F.S. values for global stability in the table above are acceptable for the proposed approach embankments under both static and seismic conditions.

13.2 Settlement

In accordance with MTO's Embankment Settlement Criteria for Design (July 2, 2010), one of the criteria adopted for embankment design is to limit the post-construction settlements. For bridge approach areas, the following post-construction settlement criteria (within 20 years following paving) have been adopted for the design:

- No more than 25 mm within 20 m behind the bridge abutment;
- 25 mm to 50 mm from 20 m to 50 m from the bridge abutment;
- 50 mm to 75 mm from 50 m to 75 m from the bridge abutment; and
- 75 mm to 100 mm greater than 75 m from the bridge abutment.

Placement of new fill for the proposed approaches and abutments will induce settlements within the existing fills and native soils. Based on the soil conditions at this site, foundation settlements under the proposed 7.0 to 8.6 m high approach embankments are estimated to be in the order of 50 to 60 mm and are expected to be essentially complete at the end of fill placement.

Self compression of the compacted granular fill is estimated to be approximately 0.5% of the fill height (i.e. 35 mm to 43 mm). Post-construction settlement due to fill compression has been estimated at 0.25% of the embankment height (i.e. 17 mm to 22 mm) which is less than 25 mm settlement criteria stipulated by MTO.

Therefore, no waiting period is required prior to road paving in order to meet MTO's Embankment

Settlement Criteria.

14. TEMPORARY EXCAVATION

It is anticipated that for the pile foundation option, minimal excavation will be required at this site. Where required, excavations will extend primarily through cohesionless fill materials.

All excavations at this site must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The excavation and backfilling for foundations must be carried out in accordance with OPSS.PROV 902.

For the purposes of the OHSA, the existing fills may be classed as Type 3 and the native sand/sand and silt till as Type 2 above the groundwater level. The existing fills and native cohesionless deposits may be classed as Type 4 below the water table.

Excavations should be regularly inspected for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions.

15. GROUNDWATER AND SURFACE WATER CONTROL

The groundwater levels measured in the piezometers and open boreholes, and inferred from ground conditions, varied from 2.1 m to 4.4 m depth below ground surface (Elev. 338.7 to 336.5).Based on available information in the GA drawing, it is anticipated that any excavation at this site will be above the groundwater level, however, seepage or perched water from the cohesionless soils into the excavations should be expected. Groundwater control measures such as pumping from filtered sumps is expected to be sufficient to remove any accumulation of water from shallow excavations. Surface runoff and precipitation must be diverted away from the excavations.

Dewatering of all excavations should be carried out in accordance with OPSS. PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), NSP FOUN0003 and OPSS. PROV 902 and SP 109S12.

If required, design of the dewatering system is the responsibility of the Contractor, and the

Contract Documents must alert him to this responsibility.

16. ROADWAY PROTECTION

If roadway protection is required during construction of the proposed bridges, an item titled "Protection System" as per OPSS 539 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and lagging wall. A temporary soldier pile and lagging wall may be designed using the parameters given below:

γ = 20 kN/m^3 (existing fill above water level)
= 21 kN/m^3 (silty sand/sand and silt till above water level)
γ_w = 10 kN/m^3 (existing fill below water level)
= 11 kN/m^3 (silty sand/sand and silt till below water level)
K_a = 0.33 (existing fill)
= 0.32 (silty sand)
= 0.27 (dense to very dense sand and silt till)
K_p = 3.0 (existing fill)
= 3.2 (silty sand)
= 3.7 (dense to very dense sand and silt till)

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. All shoring systems should be designed by a Professional Engineer experienced in such designs.

17. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. In general, the subsurface conditions at the site consist of surficial topsoil and/or fill (compact to dense silty sand, gravelly sand and sand and gravel, and soft to very stiff clayey silt with sand) overlying native dense to very dense silt and sand till, sandy silt till and compact silty sand/ sand. The site is underlain by dolostone bedrock. This would correspond to a Seismic Site Class C in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.079 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 6.14.7 of the CHBDC 2019, retaining structures should be designed using active (KAE) and passive (KPE) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 17.1 may be used:

Table 17.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	**Earth Pressure Coefficient (K)**	
	OPSS Granular A or Granular B Type II ϕ = 35°, γ = 22.8 kN/m3	**OPSS Granular B Type I ϕ = 32°, γ = 21.2 kN/m3**
Active (K_{AE})*	0.30	0.34
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.53	0.57

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

Based on the subsurface conditions, liquefaction is not considered to be a concern at this site.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soils during the current investigation indicates the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding fill and native soils is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested.

- The potential for soil corrosion on metal is considered to be very mild to moderate based on 2 samples from the native soils and one sample from the gravelly sand fill. However, in a gravelly sand fill sample taken from Borehole WL16-06 at 0.8 m depth, the potential for soil corrosion on metal is considered to be severe in the fill given the low resistivity value measured on the tested sample.

- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used. The effects of road de-icing salts should be also considered.

19. ADJACENT BURIED UTILITIES

Potential presence of underground utilities at the site should be confirmed prior to construction. It is recommended that the exact locations and elevations of any utilities be established by the designer, and compared with the extent of the potential work zones related to the foundations of the proposed structures and associated works. Protection and/or relocation of utilities may be required. Underground utilities should not be undermined or damaged during new foundation construction and embankment fill placement.

20. CONSTRUCTION CONCERNS

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

- No boreholes have been completed at the east abutment of the EBL overpass due to access issues. Additional borehole investigation should be carried out at the east abutment of the EBL overpass during detailed design, once the layout of the proposed bridge foundations elements is finalized, to confirm soil stratigraphy and bedrock elevation.

- Hard driving conditions should be expected through the dense to very dense till

- Glacial deposits inherently contain cobbles and boulders, which may affect installation of piles. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles to bedrock. Pile tips should be reinforced with Titus steel (Standard H-point) to protect the driven piles from damage.

- A preconstruction condition survey of nearby existing structures and utilities should be carried out prior to commencement of pile installation. An assessment of the impact of vibrations produced during pile driving on adjacent structures and buildings should also be completed.

21. CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Geoff Lay, P.Eng., and Ms. R. Palomeque Reyna, P.Eng.

The report was reviewed by Mr. Jason Lee, P.Eng, and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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THURBER

Appendix A

Record of Borehole Sheets (Present investigation)
Geotechnical and Analytical Test Results (Present investigation)

- Grain size analysis and Atterberg Limit Tests
- UCS Test Results
- Point Load Test Results
- Analytical Tests Results

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) ‘N’ VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT “N” VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
ABBREVIATIONS	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
FOR	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
SAMPLE TYPE	WH Sampler Advanced by Self Static Weight		RC Rock Core SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT ‘N’ Value Standard Penetration Test ‘N’ Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to “A” size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	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	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
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 structure are preserved.

SYMBOLS

▨	CLAYSTONE
▤	SILTSTONE
░	SANDSTONE
■	COAL
▩	Bedrock (general)

DISCONTINUITY SPACING

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

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 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength**		**Field Estimation of Hardness***
	(MPa)	**(psi)**	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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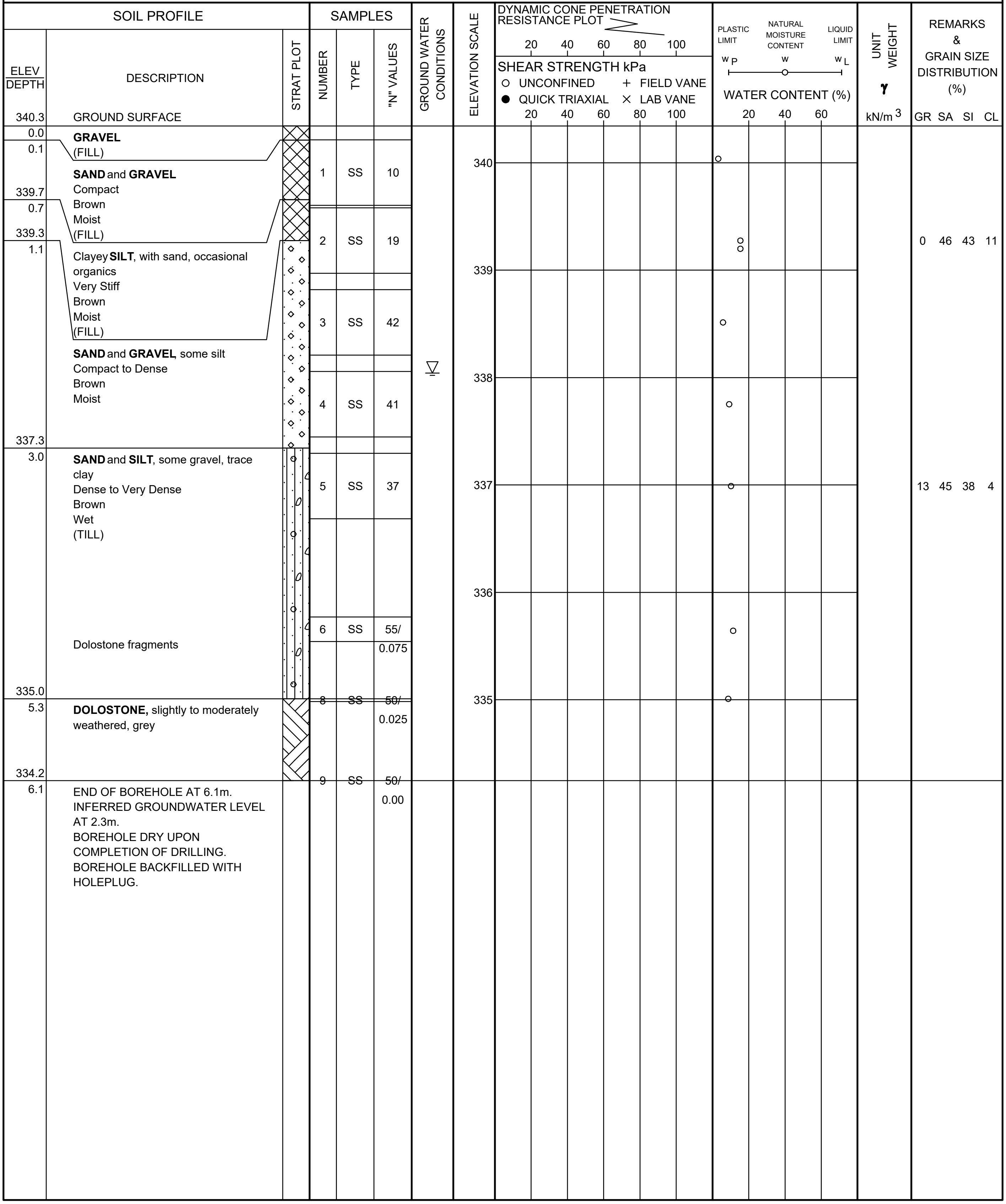
Ontario

THURBER

RECORD OF BOREHOLE No WL16-01

1 OF 1 **METRIC**

GWP# 408-88-00
LOCATION EBL North Approach, MTM NAD 83 Zone 10: N 4 823 669.7 E 240 284.5
ORIGINATED BY MC
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.08 - 2021.04.08 LATITUDE 43.550167 LONGITUDE -80.298442
CHECKED BY JA



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
340.3	GROUND SURFACE							
0.0	**GRAVEL** (FILL)							
0.1	**SAND** and **GRAVEL** Compact Brown Moist (FILL)	1	SS	10				
339.7 0.7	Clayey **SILT**, with sand, occasional organics Very Stiff Brown Moist (FILL)	2	SS	19	0	46	43	11
339.3 1.1	**SAND** and **GRAVEL**, some silt Compact to Dense Brown Moist	3 4	SS SS	42 41				
337.3 3.0	**SAND** and **SILT**, some gravel, trace clay Dense to Very Dense Brown Wet (TILL) Dolostone fragments	5 6	SS SS	37 55/ 0.075	13	45	38	4
335.0 5.3	**DOLOSTONE,** slightly to moderately weathered, grey	8	SS	50/ 0.025				
334.2 6.1	END OF BOREHOLE AT 6.1m. INFERRED GROUNDWATER LEVEL AT 2.3m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG.	9	SS	50/ 0.00				

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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Ontario

THURBER

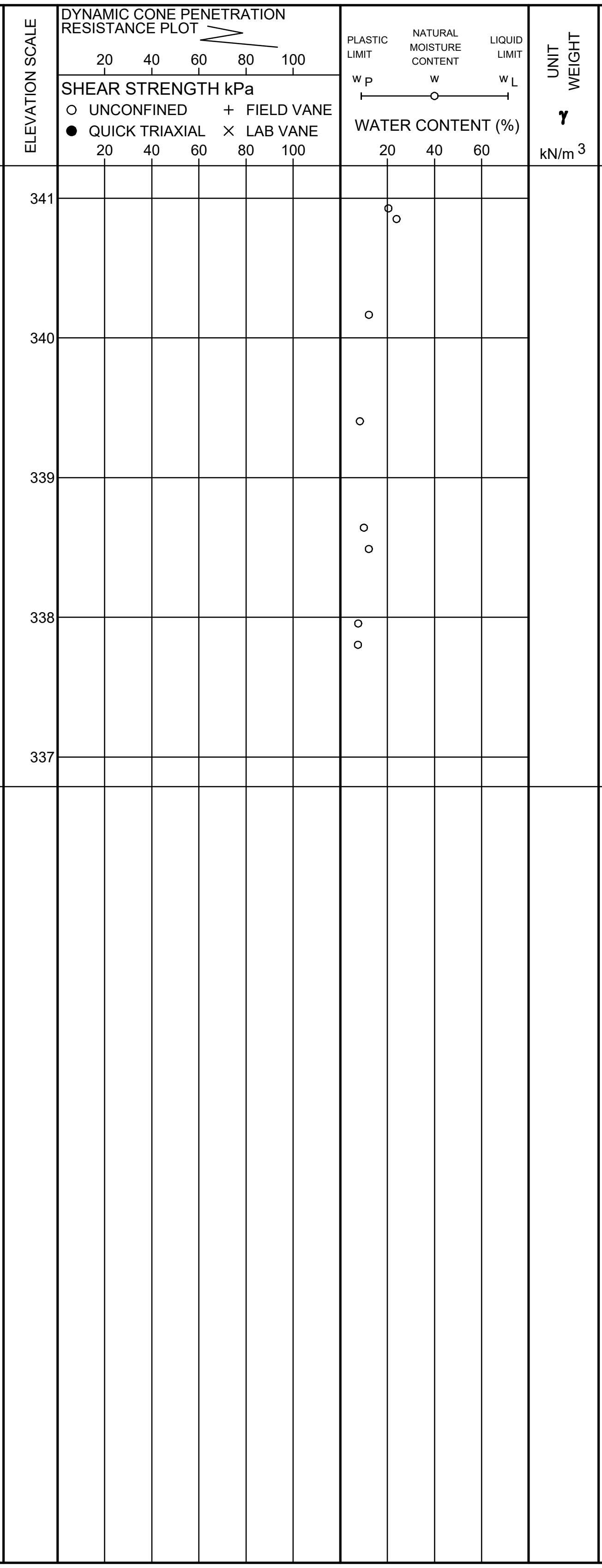
RECORD OF BOREHOLE No WL16-02

1 OF 1

METRIC

GWP# 408-88-00
LOCATION WBL North Approach, MTM NAD 83 Zone 10: N 4 823 686.7 E 240 305.0
ORIGINATED BY MC
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.07 - 2021.04.07
LATITUDE 43.550321
LONGITUDE -80.298190
CHECKED BY JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
341.2	GROUND SURFACE								
0.0	**TOPSOIL:** (175mm)								
0.2	Clayey **SILT**, some sand, trace gravel, occasional rootlets Soft to Firm Brown Moist (FILL)	1	SS	4					
		2	SS	8					
339.8 1.4	Gravelly **SAND**, some silt, trace clay Compact to Dense Brown Moist (FILL)	3	SS	25		25	48	27 (SI+CL)	
338.7 2.5	**SAND** and **SILT**, some gravel to gravelly, trace clay, occasional cobbles Dense to Very Dense Brown Wet (TILL)	4	SS	32	▽				
		5	SS	103/ 0.275					
336.8 4.4	END OF BOREHOLE AT 4.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. INFERRED GROUNDWATER LEVEL AT 2.5m. BOREHOLE OPEN AND WATER LEVEL AT 4.3m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN AUGER CUTTINGS TO SURFACE.	~~6~~	~~SS~~	~~100/~~ 0.025					



+3, ×3: Numbers refer to Sensitivity

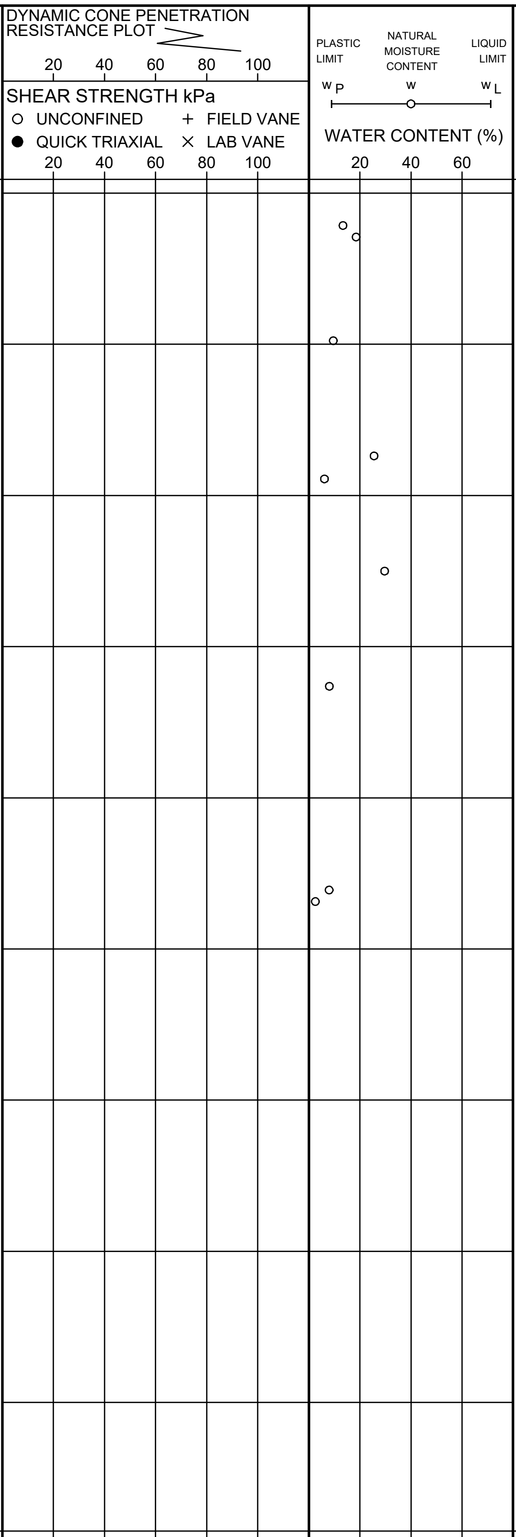
20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/25/21

RECORD OF BOREHOLE No WL16-03 1 OF 2 METRIC

GWP# 408-88-00 LOCATION EBL North Approach, MTM NAD 83 Zone 10: N 4 823 658.6 E 240 294.3 ORIGINATED BY MC
DIST Southwest HWY 7 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.04.08 - 2021.04.08 LATITUDE 43.550068 LONGITUDE -80.298319 CHECKED BY JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.1	GROUND SURFACE							
0.0	**TOPSOIL:** (125mm)					340		
0.1	Clayey **SILT**, trace sand, trace gravel Firm Dark Brown Moist (FILL)	1	SS	6				
339.4 0.7	Silty **SAND**, trace gravel, trace clay, occasional organics Compact Brown Moist (FILL)	2	SS	16		339		5 62 29 4
338.4 1.7	Gravelly **SAND**, some silt, occasional cobbles Compact to Dense Brown Wet	3	SS	39				21 58 21 (SI+CL)
					∇	338		
		4	SS	27				
337.1 3.0	**SAND** and **SILT**, some gravel, trace clay, occasional cobbles Dense Brown Wet (TILL)	5	SS	45		337		
						336		
	Coring started at 4.6m	6	SS	60/ 0.125				
335.5 4.6	**DOLOSTONE,** moderately weathered, very thinly laminated, brown Horizontal fracture at 5.2m, 5.3m, 5.4m, 5.5m, 5.6m, 5.7m, 5.9m, 6.0m, 6.1m, and 6.2m	1	RUN			335 334	FI 3 3 3 1	RUN #1 TCR=93% SCR=89% RQD=43%
	Horizontal fracture 6.4m, 6.5m, 6.7m, 6.8m, 7.0m, 7.1m, 7.2m, and 7.5m Vertical fracture (75mm) at 6.7m	2	RUN			333	8 4 3 3	RUN #2 TCR=100% SCR=90% RQD=60% UCS=66.6MPa
	Horizontal fracture at 7.7m, 7.8m, 8.0m, 8.1m 8.4m, 8.6m, 8.7m, and 8.8m	3	RUN			332	2 2 2 1 3 1	RUN #3 TCR=100% SCR=92% RQD=63%
331.2 8.9	END OF BOREHOLE AT 8.9m. INFERRED GROUNDWATER LEVEL AT 2.3m. BOREHOLE DRY BEFORE SWITCHING TO CORING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m,							



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+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No WL16-03 2 OF 2 METRIC

GWP# 408-88-00
LOCATION EBL North Approach, MTM NAD 83 Zone 10: N 4 823 658.6 E 240 294.3
ORIGINATED BY MC
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers/NQ Coring
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.08 - 2021.04.08
LATITUDE 43.550068
LONGITUDE -80.298319
CHECKED BY JA

SOIL PROFILE			SAMPLES								REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	THEN AUGER CUTTINGS TO SURFACE.													

+ ³, × ³ : Numbers refer to Sensitivity

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/25/21

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Ontario

THURBER

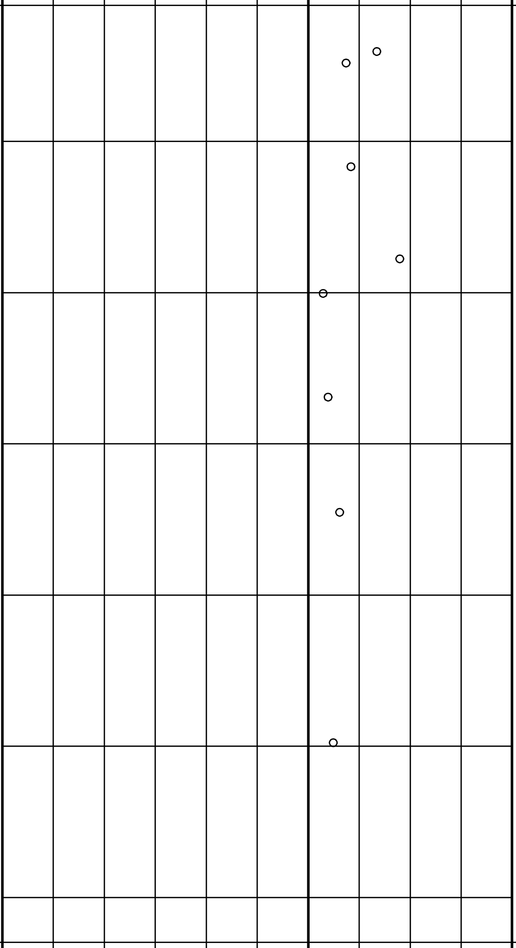
RECORD OF BOREHOLE No WL16-04

1 OF 1 **METRIC**

GWP# 408-88-00
LOCATION WBL North Approach, MTM NAD 83 Zone 10: N 4 823 676.2 E 240 302.2
ORIGINATED BY MC
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers/NQ Coring
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.09 - 2021.04.09
LATITUDE 43.550227
LONGITUDE -80.298224
CHECKED BY JA

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%)
20 40 60



ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.9	GROUND SURFACE							
0.0	**TOPSOIL:** (75mm)							
0.1	Clayey **SILT**, with sand, trace gravel, mixed with organics Firm Dark Brown Moist (FILL)	1	SS	7				
		2	SS	7		340		2 46 43 9
339.2 1.7	**SAND** and **GRAVEL**, some silt, trace clay Compact Brown Moist to Wet (FILL)	3	SS	28		339		
		4	SS	27				37 42 21 (SI+CL)
	Occasional dolostone fragments					338		
337.9 3.0	**SAND** and **SILT**, trace to some gravel, trace clay Compact to Very Dense Brown Moist to Wet (TILL)	5	SS	25				9 42 45 4
					▽	337		
		6	SS	76		336	FI	RUN #1 TCR=89% SCR=22% RQD=22%
335.6 5.3	**DOLOSTONE,** moderately weathered, very thinly laminated Vertical fracture (50mm) at 5.5m Sub-horizontal fracture (125mm) at 5.6m	1	RUN				3 0	
	Horizontal fracture at 5.8m	2	RUN			335	1	RUN #2 TCR=83% SCR=83% RQD=83%
334.7 6.2	Horizontal fracture at 5.9m Horizontal fracture at 6.1m	3	RUN				1	RUN #3 TCR=100% SCR=50% RQD=0%

END OF BOREHOLE AT 6.2m.
INFERRED GROUNDWATER LEVEL AT 4.1m.
BOREHOLE DRY BEFORE SWITCHING TO CORING.
BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m, THEN AUGER CUTTINGS TO SURFACE.

$+^3, \times^3$: Numbers refer to Sensitivity

$\overset{20}{15 \oplus 5}_{10}$ (%) STRAIN AT FAILURE

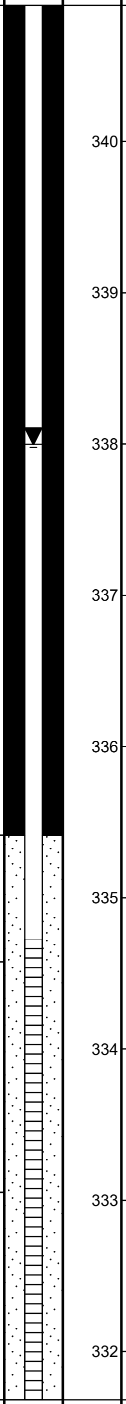
ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/25/21

RECORD OF BOREHOLE No WL16-04B

1 OF 2

METRIC

GWP# 408-88-00
LOCATION WBL North Approach, MTM NAD 83 Zone 10: N 4 823 676.2 E 240 302.2
ORIGINATED BY MC
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers/NQ Coring
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.14 - 2021.04.14
LATITUDE 43.550227
LONGITUDE -80.298224
CHECKED BY JA



ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.9	GROUND SURFACE					
0.0	Borehole augered to 5.5m depth below ground surface for rock coring and monitoring well installation. No soil samples were collected.					
335.4	Coring started at 5.5m				FI	
5.5	**DOLOSTONE,** highly to moderately weathered, beige to brown Horizontal fractures at 5.5m, 5.6m, 5.8m, 5.9m, and 6.0m	1	RUN		3 6 2	RUN #1 TCR=100% SCR=100% RQD=45%
	Sub-horizontal fracture at 5.7m and 6.0m Horizontal fracture at 6.3m, 6.8m, 7.1m, 7.3m, 7.4m, 7.5m, 7.6m, and 7.7m Sub-horizontal fracture (200mm) at 7.5m Vertical fracture at (75mm) at 7.6m	2	RUN		1 3 1 2 1	RUN #2 TCR=97% SCR=92% RQD=63% UCS=115.9MPa
331.7	Horizontal fracture at 8.0m,8.3m, 8.7m, 8.8m, 9.1m Highly fracture zone at 8.5m Vertical fracture (75mm) at 8.7m	3	RUN		1 2 2 4 0	RUN #3 TCR=100% SCR=89% RQD=0%
9.2	END OF BOREHOLE AT 9.2m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 20 40 60

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WL16-04B 2 OF 2 METRIC

GWP# 408-88-00
LOCATION WBL North Approach, MTM NAD 83 Zone 10: N 4 823 676.2 E 240 302.2
ORIGINATED BY MC
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers/NQ Coring
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.14 - 2021.04.14 LATITUDE 43.550227 LONGITUDE -80.298224
CHECKED BY JA

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

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2021.04.14	4.4	336.5
2021.04.16	2.9	338.0

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

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Ontario

THURBER

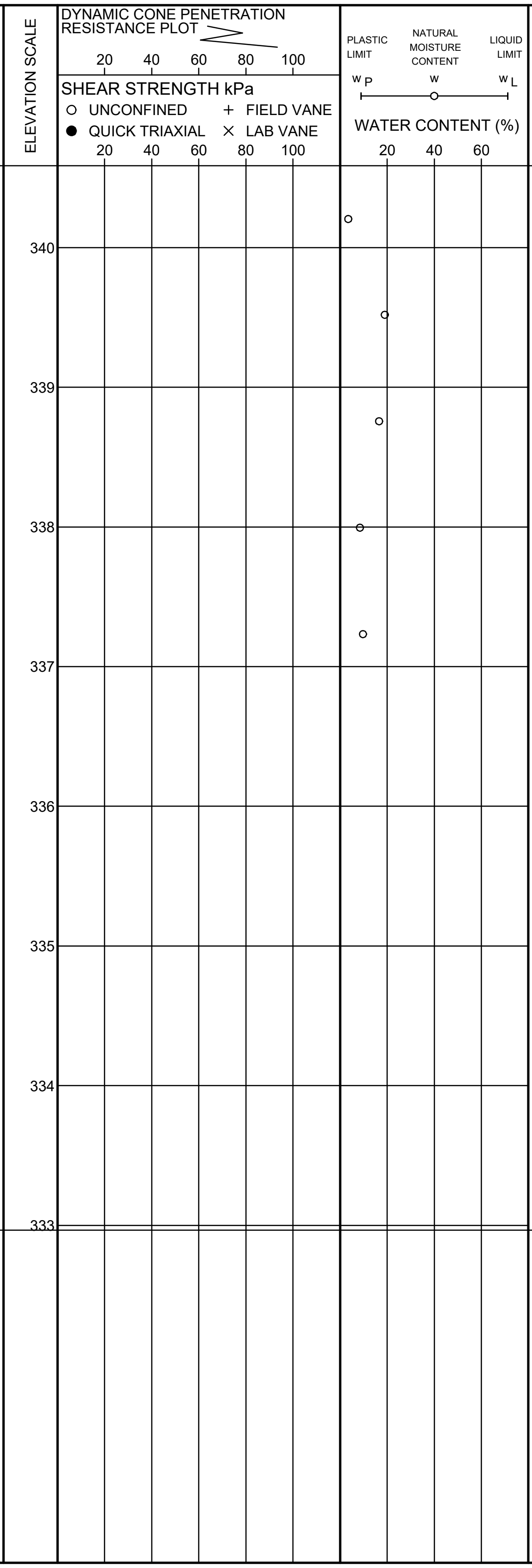
RECORD OF BOREHOLE No WL16-05

1 OF 1

METRIC

GWP# 408-88-00
LOCATION EBL South Abutment, MTM NAD 83 Zone 10: N 4 823 638.1 E 240 342.8
ORIGINATED BY GA
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers/NQ Coring
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.08 - 2021.04.08
LATITUDE 43.549887
LONGITUDE -80.297717
CHECKED BY JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.6	GROUND SURFACE						
0.0	**SAND** and **GRAVEL**, some silt and clay Compact Brown Moist (FILL)	1	SS	18			43 44 13 (SI+CL)
339.9 0.7	Clayey **SILT**, with sand, trace gravel, occasional organics Stiff to Very Stiff Brown Moist (FILL)	2 3	SS SS	16 12	▽		 0 50 36 14
338.4 2.2	Gravelly **SAND**, trace silt Compact Brown Moist (FILL)	4	SS	13			
337.6 3.0	Silty **SAND**, trace gravel, trace clay, occasional dolostone fragments Compact Brown Wet Spoon bouncing at 4.6m. Coring started at 4.6m	5	SS	26		FI	
336.0 4.6	**DOLOSTONE,** highly to moderately weathered, bedded, beige to grey Horizontal joints at 4.7m, 4.9m, 5.0m, 5.1m, 5.2m, 5.4m, 5.6m, and 5.7m Horizontal joints at 6.1m, 6.4m, 6.5m, 6.7m, and 6.8m	~~6~~ 1 2	~~SS~~ RUN RUN	~~50/~~ 0.00		3 3 3 2 8 1 2 4 0 0	RUN #1 TCR=100% SCR=92% RQD=75% UCS=129MPa RUN #2 TCR=100% SCR=100% RQD=85%
333.0 7.6	END OF BOREHOLE AT 7.6m. BOREHOLE OPEN AND WATER LEVEL AT 2.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN SAND AND GRAVEL TO SURFACE.						



+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No WL16-06

1 OF 1 **METRIC**

GWP# 408-88-00
LOCATION WBL South Abutment, MTM NAD 83 Zone 10: N 4 823 651.4 E 240 354.8
ORIGINATED BY GA
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers/NQ Coring
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.06 - 2021.04.06
LATITUDE 43.550008
LONGITUDE -80.297570
CHECKED BY JA

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.3	GROUND SURFACE					
0.0 0.1	**TOPSOIL:** (75mm)					
	Gravelly **SAND**, some silt and clay Compact Brown Moist (FILL)	1	SS	16		27 53 20 (SI+CL)
		2	SS	22		
		3	SS	19		
		4	SS	18		
337.4 3.0	Silty **SAND**, trace gravel, trace clay Compact Brown Wet	5	SS	10		1 61 35 3
	Coring started at 4.0m	~~6~~	~~SS~~	~~50/~~ 0.0	FI	
336.4 4.0	**DOLOSTONE,** moderately weathered, bedded, beige to grey Horizontal fractures at 4.1m, 4.4m, 4.5m, 4.6m, 4.7m, 4.9m, and 5.0m	1	RUN		1 2 4 2 2	RUN #1 TCR=100% SCR=100% RQD=81% UCS=25.1MPa
	Horizontal joints 5.2m, 5.7m, and 6.9m	2	RUN		2 0 0 0 2	RUN #2 TCR=100% SCR=98% RQD=87%
333.4 7.0	END OF BOREHOLE AT 7.0m. BOREHOLE OPEN AND WATER LEVEL AT 2.7m UPON COMPLETION Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.					

ELEVATION SCALE: 340, 339, 338, 337, 336, 335, 334

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2021.04.16	2.7	337.6

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

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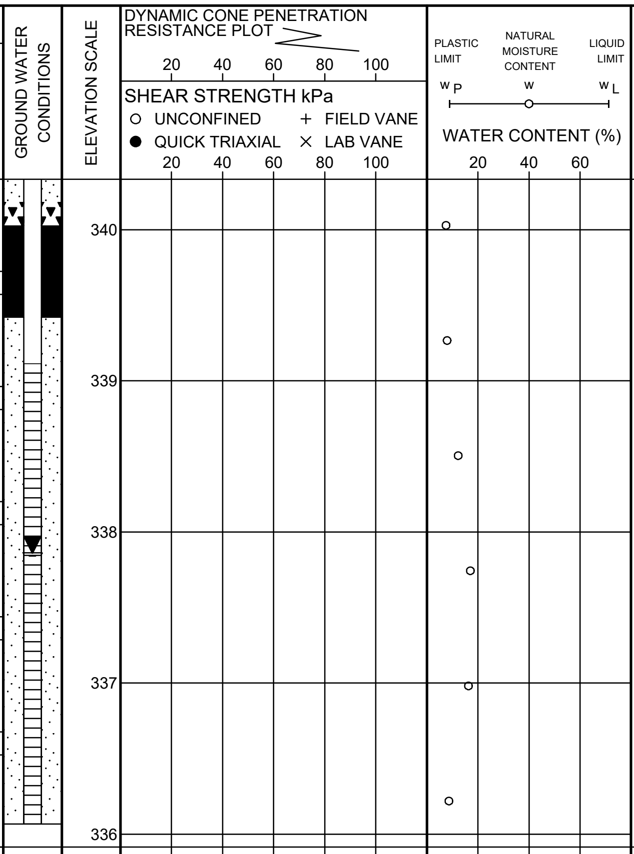
Ontario

THURBER

RECORD OF BOREHOLE No WL16-07 1 OF 1 METRIC

GWP# 408-88-00
LOCATION EBL South Approach, MTM NAD 83 Zone 10: N 4 823 610.7 E 240 330.5
ORIGINATED BY GA
DIST Southwest HWY 7
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY BH
DATUM Geodetic
DATE 2021.04.07 - 2021.04.07
LATITUDE 43.549639
LONGITUDE -80.297866
CHECKED BY JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.3	GROUND SURFACE				
0.0	**TOPSOIL:** (75mm)				
0.1	Gravelly **SAND**, trace silt to silty Compact Brown Moist (FILL)	1	SS	19	
		2	SS	14	
338.9 1.4	Clayey **SILT**, with sand, trace gravel Stiff Brown Moist (FILL)	3	SS	9	0 32 68 (SI+CL)
338.1 2.2	Silty **SAND**, trace gravel, trace clay Compact Brown Wet	4	SS	18	
		5	SS	18	
		6	SS	24	
335.9 4.4	END OF BOREHOLE AT 4.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.				



UNIT WEIGHT γ kN/m³

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2021.04.16	2.5	337.9

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

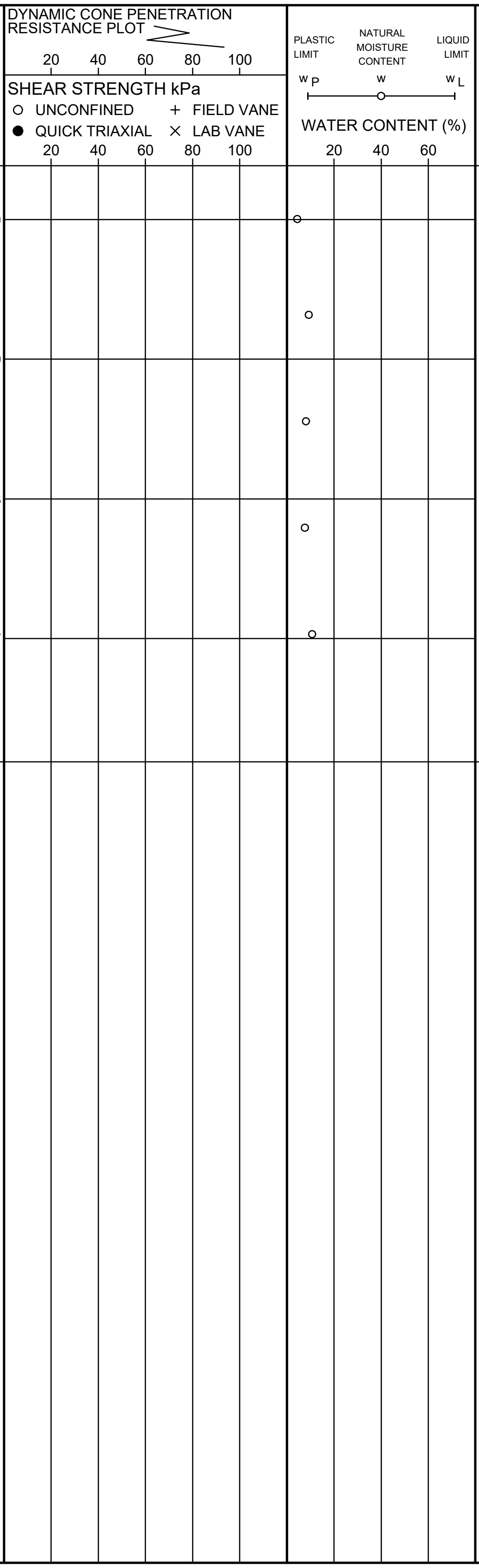
RECORD OF BOREHOLE No WL16-08

1 OF 1

METRIC

GWP# 408-88-00	LOCATION WBL South Approach, MTM NAD 83 Zone 10: N 4 823 638.7 E 240 352.2		ORIGINATED BY GA
DIST Southwest HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY BH
DATUM Geodetic	DATE 2021.04.07 - 2021.04.07	LATITUDE 43.549894 LONGITUDE -80.297601	CHECKED BY JA

SOIL PROFILE			SAMPLES						REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
340.4	GROUND SURFACE											
0.0	**ASPHALT:** (125mm)											
0.1	Gravelly **SAND**, some silt and clay Compact Brown Moist (FILL)		1	SS	21		340					
			2	SS	19							
							339					
			3	SS	20							
							338					
			4	SS	17				25	48	27 (SI+CL)	
337.4 3.0	**SAND**, trace silt, frequent dolostone fragments Compact Brown Wet		5	SS	15	▽	337					
336.1 4.3	END OF BOREHOLE AT 4.3m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 3.4m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.5m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.											

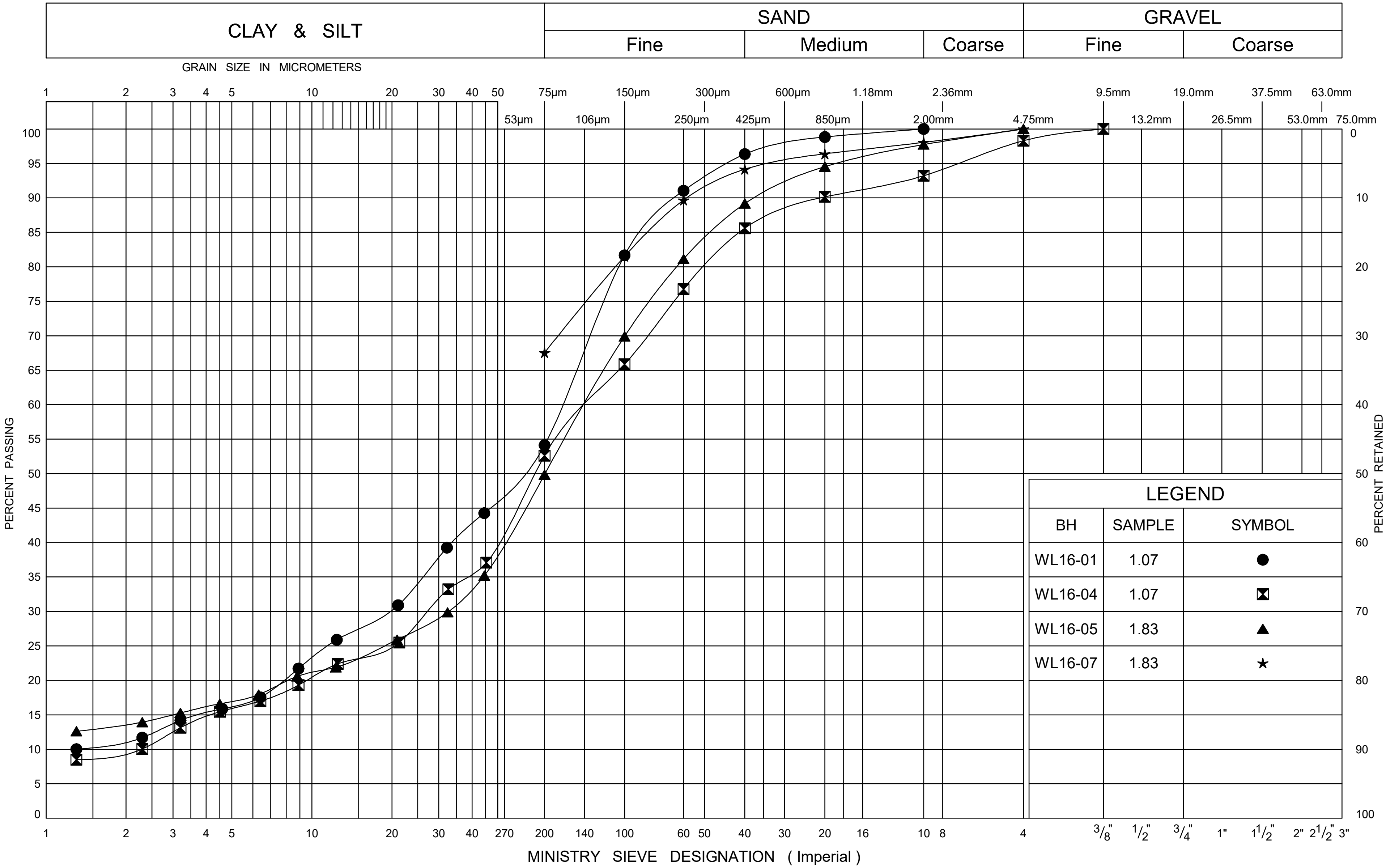


+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/25/21

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
WL16-01	1.07	●
WL16-04	1.07	⊠
WL16-05	1.83	▲
WL16-07	1.83	★

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GRAIN SIZE DISTRIBUTION

Clayey SILT to SILT FILL

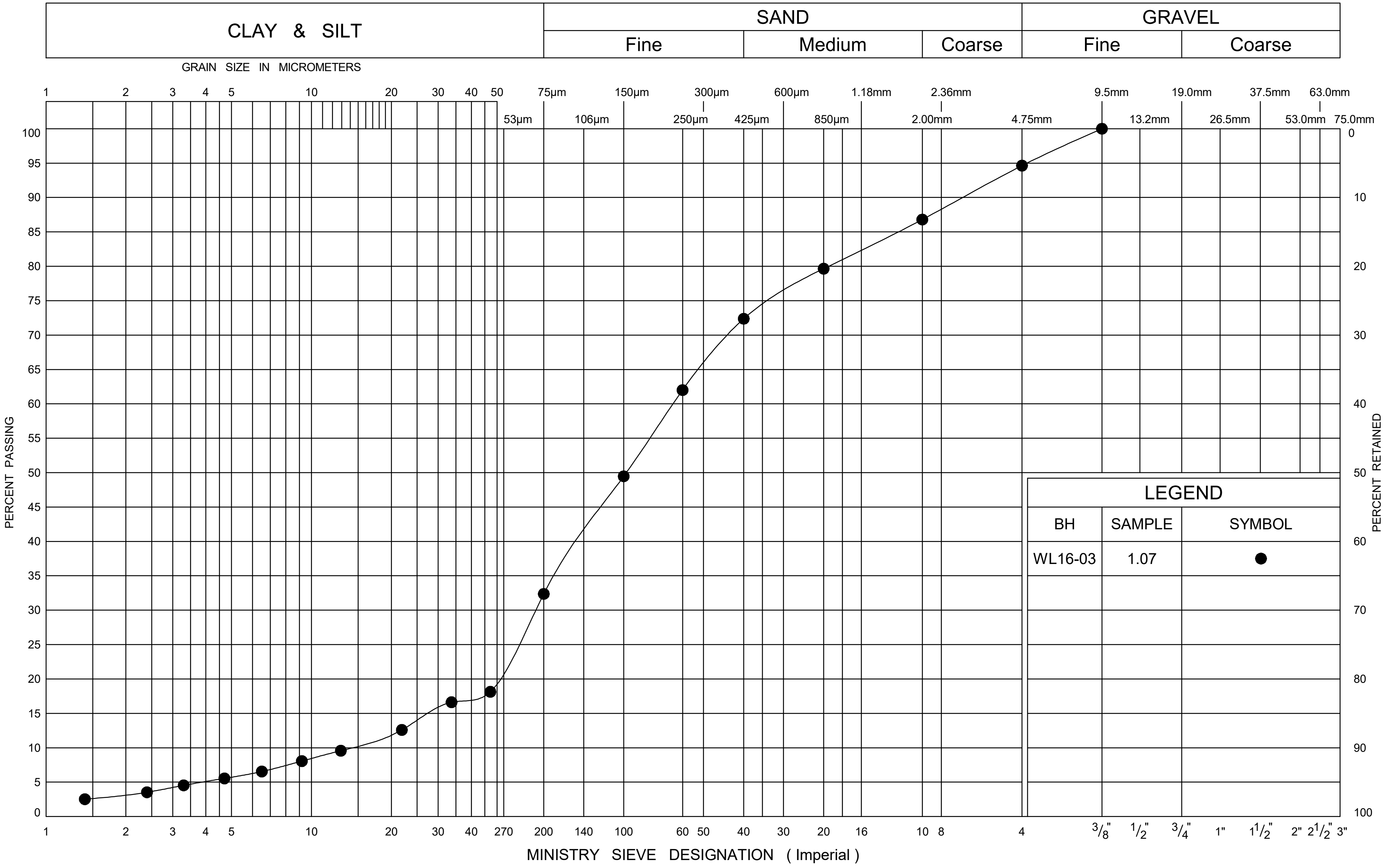
FIG No A1

W P 408-88-00

Woodlawn Road Overpass

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 6/17/21

78 12 M



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Ontario

GRAIN SIZE DISTRIBUTION

Silty SAND FILL

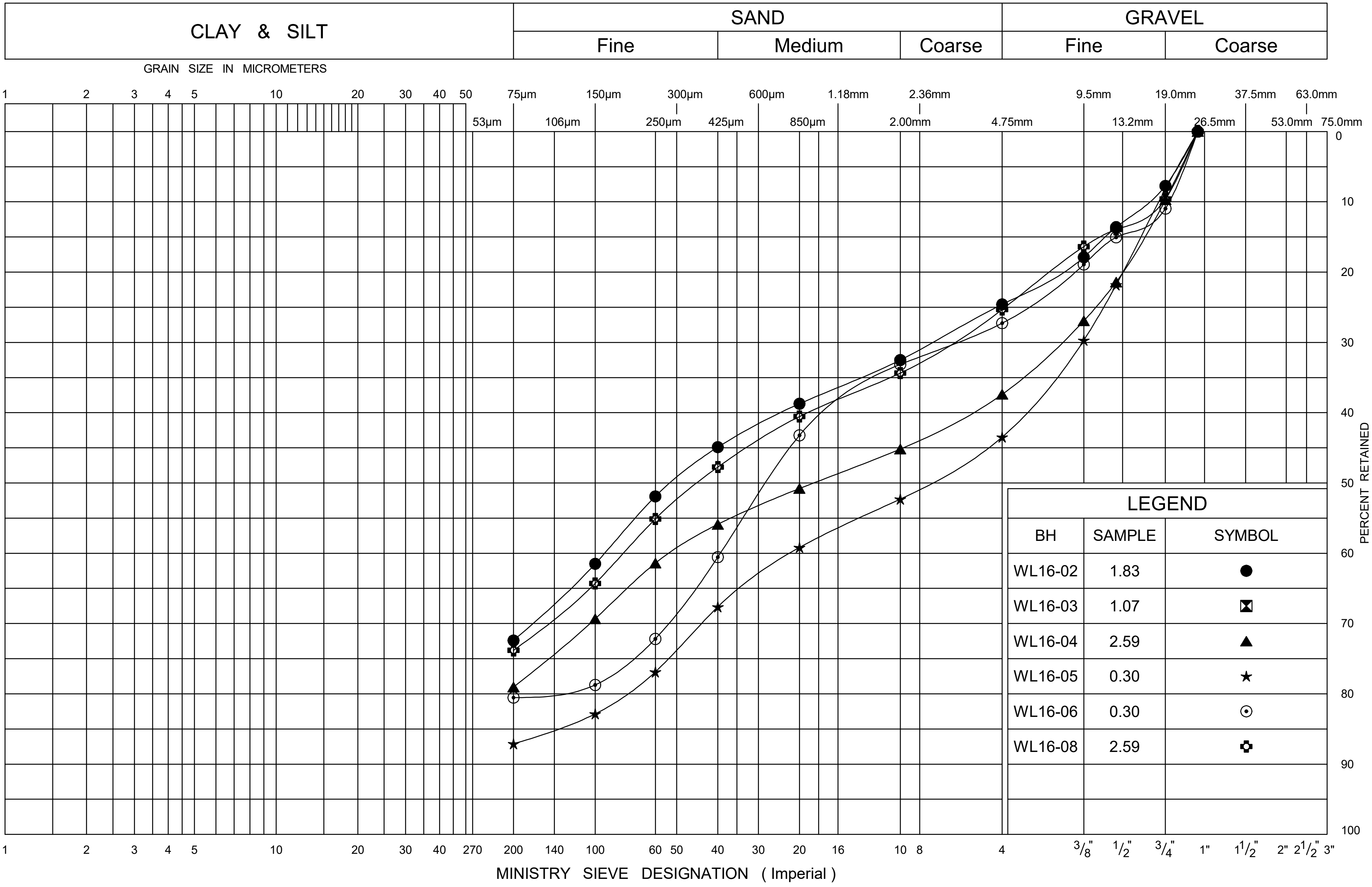
FIG No A2

W P 408-88-00

Woodlawn Road Overpass

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 6/17/21

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
WL16-02	1.83	●
WL16-03	1.07	☒
WL16-04	2.59	▲
WL16-05	0.30	★
WL16-06	0.30	⊙
WL16-08	2.59	✤

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GRAIN SIZE DISTRIBUTION

Gravelly SAND to SAND and GRAVEL FILL

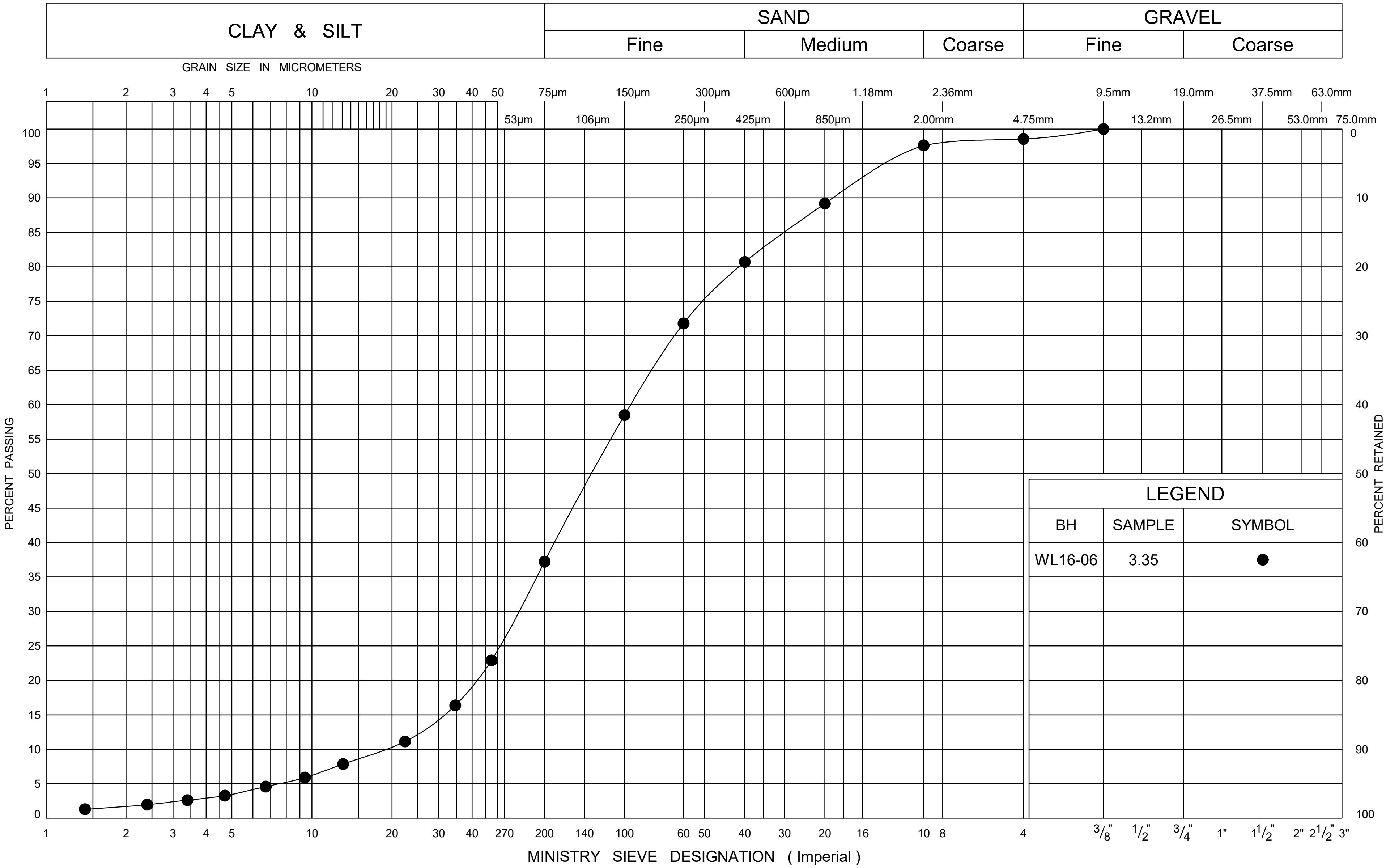
FIG No A3

W P 408-88-00

Woodlawn Road Overpass

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 6/17/21

78 12 M



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Ontario

GRAIN SIZE DISTRIBUTION

Silty SAND to SAND

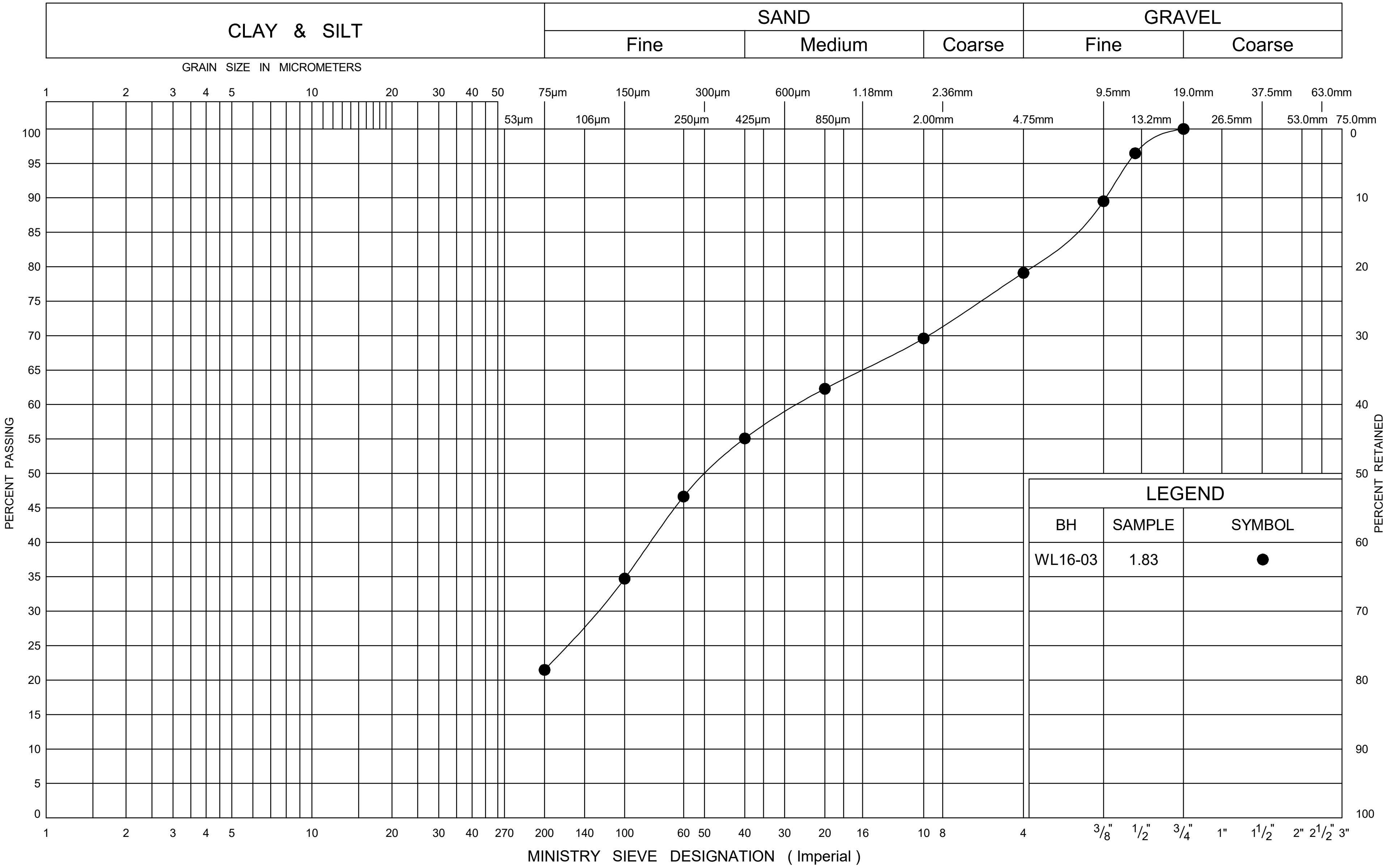
FIG No A4

W P 408-88-00

Woodlawn Road Overpass

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 6/17/21

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
WL16-03	1.83	●

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 6/17/21

Ministry of
Transportation
Ontario

GRAIN SIZE DISTRIBUTION

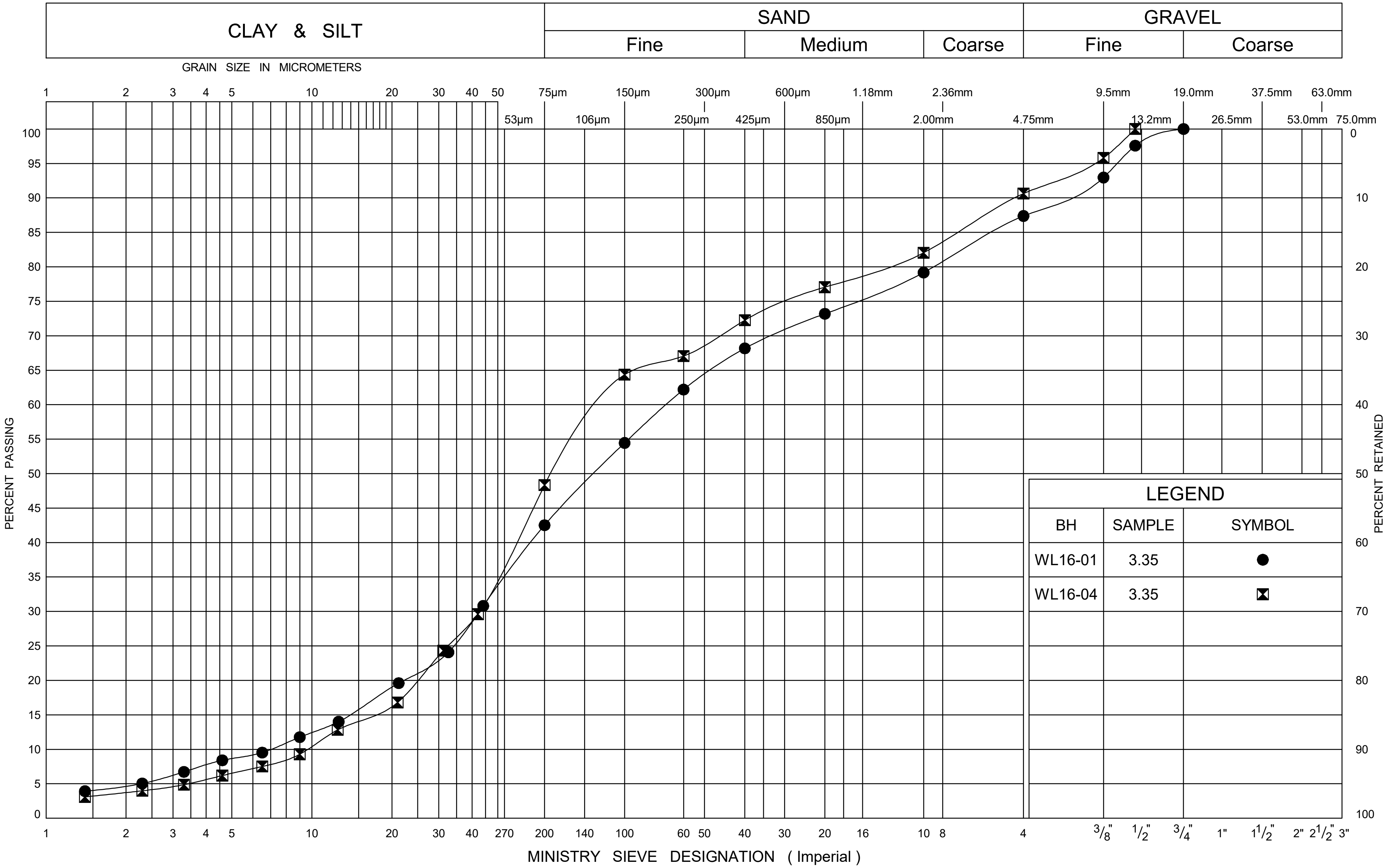
Gravelly SAND to SAND and GRAVEL

FIG No A5

W P 408-88-00

Woodlawn Road Overpass

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
WL16-01	3.35	●
WL16-04	3.35	☒

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GRAIN SIZE DISTRIBUTION

SAND and SILT to Sandy SILT TILL

FIG No A6

W P 408-88-00

Woodlawn Road Overpass

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 6/17/21

THURBER ENGINEERING LTD.

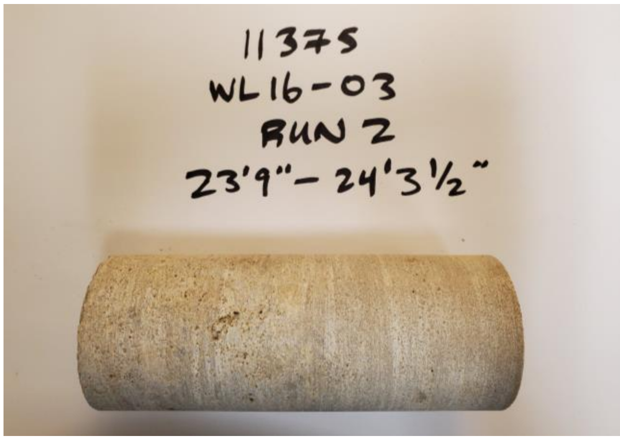
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

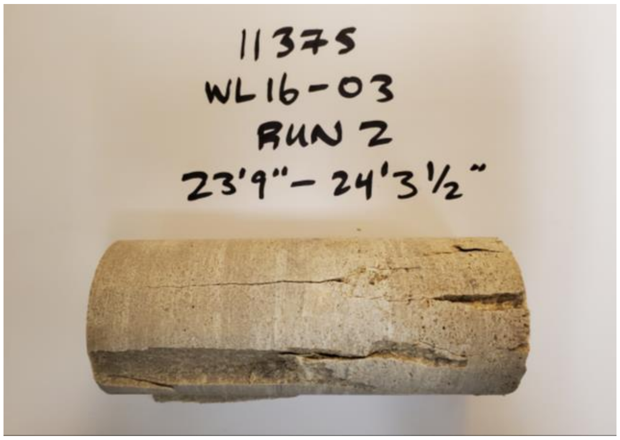
CLIENT:	WSP Canada Group Ltd.	FILE NUMBER:	11375
PROJECT NAME:	Hwy 7 New PD and DD Foundations	REPORT DATE:	5-May-21
BOREHOLE No.:	WL16-03	TEST DATE:	4-May-21
SAMPLE No.:	HQ Run 2		
SAMPLE DEPTH:	23'9" - 24'3.5"		
DESCRIPTION:	Dolostone		

Avg. Height (cm):	14.5	Weight (g):	1205.9
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,668
H. to Dia. Ratio**:	2.3:1	Dry Density (kg/m^3):	2,668
Cross Sectional Area (cm^2):	31.17	Moisture Content* (%):	N/A
Sample Volume (cm^3):	452.00		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.0% / min
MAXIMUM COMPRESSIVE LOAD:	207.7 kN
UNCONFINED COMPRESSIVE STRENGTH:	66.6 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

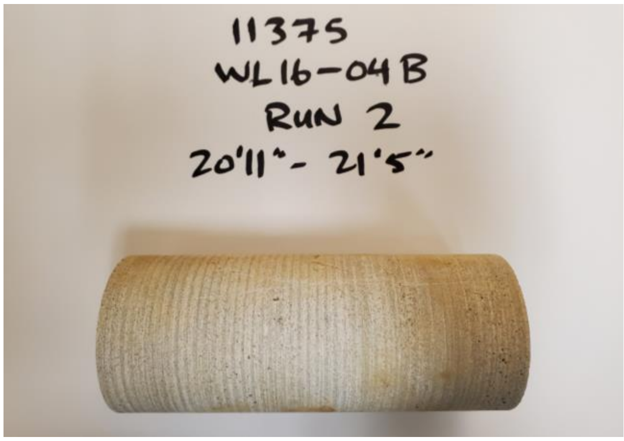
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

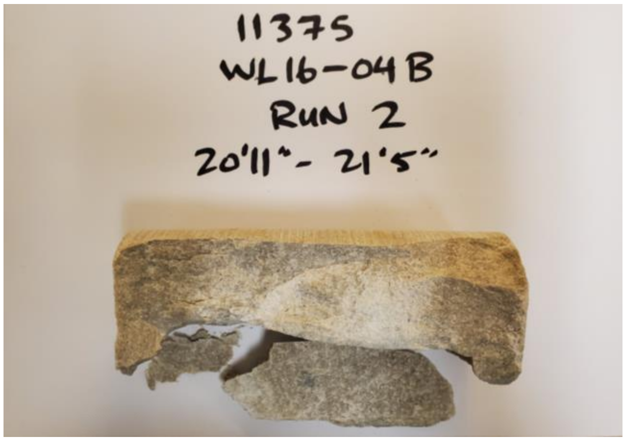
CLIENT:	WSP Canada Group Ltd.	FILE NUMBER:	11375
PROJECT NAME:	Hwy 7 New PD and DD Foundations	REPORT DATE:	5-May-21
BOREHOLE No.:	WL16-04B	TEST DATE:	4-May-21
SAMPLE No.:	HQ Run 2		
SAMPLE DEPTH:	20'11" - 21'5"		
DESCRIPTION:	Dolostone		

Avg. Height (cm):	14.0	Weight (g):	1181.6
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,708
H. to Dia. Ratio**:	2.2:1	Dry Density (kg/m^3):	2,708
Cross Sectional Area (cm^2):	31.17	Moisture Content* (%):	N/A
Sample Volume (cm^3):	436.41		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.1% / min
MAXIMUM COMPRESSIVE LOAD:	361.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	115.9 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

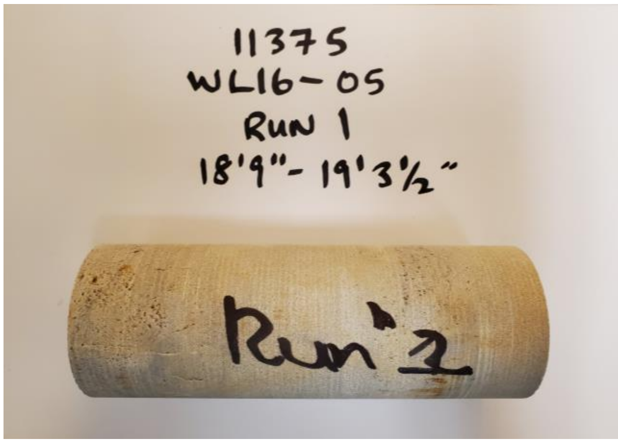
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

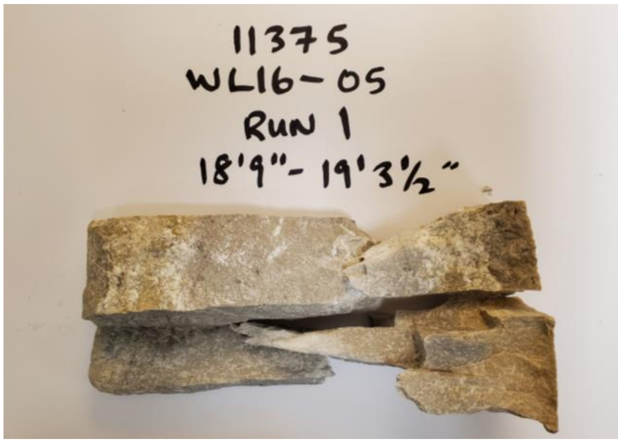
CLIENT:	WSP Canada Group Ltd.	FILE NUMBER:	11375
PROJECT NAME:	Hwy 7 New PD and DD Foundations	REPORT DATE:	5-May-21
BOREHOLE No.:	WL16-05	TEST DATE:	4-May-21
SAMPLE No.:	HQ Run 1		
SAMPLE DEPTH:	18'9" - 19'3.5"		
DESCRIPTION:	Dolostone		

Avg. Height (cm):	16.0	Weight (g):	1367.2
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,741
H. to Dia. Ratio**:	2.5:1	Dry Density (kg/m^3):	2,741
Cross Sectional Area (cm^2):	31.17	Moisture Content* (%):	N/A
Sample Volume (cm^3):	498.76		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.9% / min
MAXIMUM COMPRESSIVE LOAD:	402.2 kN
UNCONFINED COMPRESSIVE STRENGTH:	129.0 MPa

Note: * Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

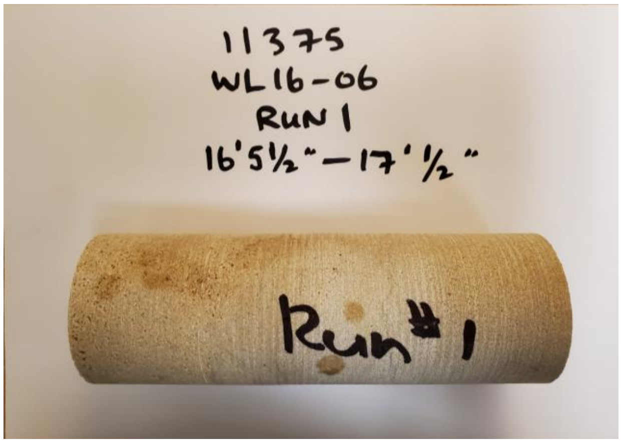
ASTM D7012-14

CLIENT: WSP Canada Group Ltd.
FILE NUMBER: 11375
PROJECT NAME: Hwy 7 New PD and DD Foundations
REPORT DATE: 5-May-21

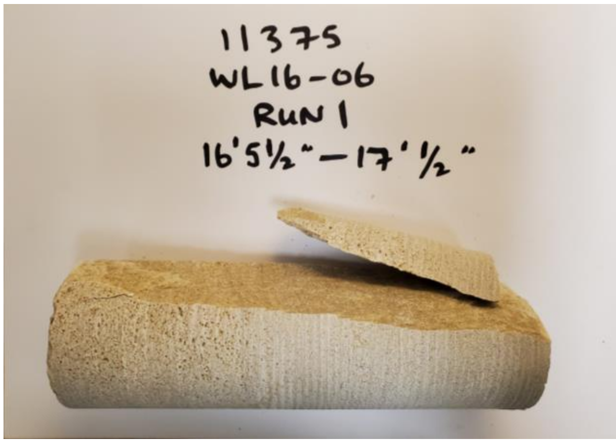
BOREHOLE No.: WL16-06
TEST DATE: 4-May-21
SAMPLE No.: HQ Run 1
SAMPLE DEPTH: 16'5.5" - 17'0.5"
DESCRIPTION: Dolostone

Avg. Height (cm):	17.0	Weight (g):	1367.7
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,581
H. to Dia. Ratio**:	2.7:1	Dry Density (kg/m^3):	2,581
Cross Sectional Area (cm^2):	31.17	Moisture Content* (%):	N/A
Sample Volume (cm^3):	529.93		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE: 0.9% / min
MAXIMUM COMPRESSIVE LOAD: 78.2 kN
UNCONFINED COMPRESSIVE STRENGTH: 25.1 MPa

Note: * Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	11375			**Client :**	WSP
				Date Drilled :	08-Apr-20
Project Name :	Woodlawn Road Interchange Project			**Date Tested :**	21-Apr-20
Core Size :	HQ	**BH No :**	WL 16-03	**Tester :**	GP

Test No.	**Run No.**	**Depth (m)**	**Axial or Diametral**	**Gauge (MPa)**	**Diameter (mm)**	**Length (mm)**	**UCS (MPa)**	**Rock Type**	**Notes**
1	1	5.1	D	22.0	63.2	139.1	139.5	Dolostone	Very Strong
2	1	5.8	A	8.2	63.1	62.6	43.5	Dolostone	Medium Strong
3	1	6.3	A	6.3	63.2	67.8	31.4	Dolostone	Medium Strong
4	2	6.5	A	20.2	63.2	61.1	108.7	Dolostone	Very Strong
5	2	7.0	D	17.4	63.3	130.0	109.8	Dolostone	Very Strong
6	2	7.5	A	18.4	63.3	72.8	86.6	Dolostone	Strong
7	3	7.7	A	8.8	63.3	60.1	47.7	Dolostone	Medium Strong
8	3	8.3	D	7.3	63.2	123.3	46.4	Dolostone	Medium Strong
9	3	8.8	A	21.4	63.3	67.8	106.2	Dolostone	Very Strong
10									
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	11375	**Client :**	WSP
		Date Drilled :	14-Apr-20
Project Name :	Woodlawn Road Interchange Project	**Date Tested :**	21-Apr-20
Core Size :	HQ **BH No :** WL 16-04B	**Tester :**	GP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	5.7	A	17.3	63.2	67.8	85.9	Dolostone	Strong
2	1	6.2	D	19.2	63.3	135.2	121.6	Dolostone	Very Strong
3	2	6.7	A	17.3	63.3	67.3	86.6	Dolostone	Strong
4	2	6.8	D	8.2	63.3	140.1	51.9	Dolostone	Strong
5	2	7.5	A	6.2	63.3	62.8	32.7	Dolostone	Medium Strong
6	3	8.0	D	5.7	63.3	142.4	36.0	Dolostone	Medium Strong
7	3	8.6	A	8.1	63.3	72.5	38.0	Dolostone	Medium Strong
8	3	9.1	A	6.2	63.3	66.1	31.4	Dolostone	Medium Strong
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Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

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THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	11375			**Client :**	WSP
				Date Drilled :	08-Apr-20
Project Name :	Woodlawn Road Interchange Project			**Date Tested :**	21-Apr-20
Core Size :	HQ	**BH No :**	WL 16-05	**Tester :**	GP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	4.9	A	16.4	63.3	70.6	78.9	Dolostone	Strong
2	1	5.3	D	24.3	63.3	113.5	153.5	Dolostone	Very Strong
3	1	6.0	A	20.0	63.3	61.1	107.9	Dolostone	Very Strong
4	2	6.3	D	23.9	63.2	121.0	151.2	Dolostone	Very Strong
5	2	6.9	A	13.8	63.3	63.9	71.9	Dolostone	Strong
6	2	7.5	D	11.9	63.3	104.6	75.3	Dolostone	Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
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THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	11375	**Client :**	WSP
		Date Drilled :	06-Apr-20
Project Name :	Woodlawn Road Interchange Project	**Date Tested :**	21-Apr-20
Core Size :	HQ **BH No :** WL 16-06	**Tester :**	GP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	4.1	A	13.44	47.6	64.7	86.4	Dolostone	Strong
2	1	4.8	D	14.40	47.6	111.8	141.5	Dolostone	Very Strong
3	1	5.4	A	15.58	47.3	71.6	92.9	Dolostone	Strong
4	2	5.7	D	13.06	47.1	104.5	130.4	Dolostone	Very Strong
5	2	6.4	A	24.46	47.4	64.8	157.3	Dolostone	Very Strong
6	2	6.8	D	6.21	47.4	101.6	61.4	Dolostone	Strong
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FINAL REPORT

CA14856-APR21 R1

11375,, Woodlawn Rd

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada
Contact	Joshua Alexander
Telephone	613-606-7303
Facsimile	
Email	jalexander@thurber.ca
Project	11375,, Woodlawn Rd
Order Number	
Samples	Soil (6)

LABORATORY DETAILS

Project Specialist	Jill Campbell, B.Sc.,GISAS
Laboratory	SGS Canada Inc.
Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	2165
Facsimile	705-652-6365
Email	jill.campbell@sgs.com
SGS Reference	CA14856-APR21
Received	04/19/2021
Approved	04/26/2021
Report Number	CA14856-APR21 R1
Date Reported	04/26/2021

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:007526

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Jill Campbell, B.Sc.,GISAS

Jill Campbell

TABLE OF CONTENTS

PACKAGE: **- Corrosivity Index** (SOIL)

			Sample Number	5	6	7	8	9	10
			Sample Name	RW 20-01, SS4	WL 16-05, SS5	RW 20-04, SS3	WL 16-03, SS3B	WL 16-06, SS2	WL 16-04, SS6
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	15/04/2021	08/04/2021	13/04/2021	08/04/2021	06/04/2021	08/04/2021
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index									
Corrosivity Index	none	1		3	5	13	3	13	3
Soil Redox Potential	mV	-		198	192	163	112	284	230
Sulphide (Na2CO3)	%	0.04		< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
pH	pH Units	0.05		9.26	9.48	8.87	9.27	8.78	9.32
Resistivity (calculated)	ohms.cm	-9999		5850	2290	245	6760	1230	10500

PACKAGE: **- General Chemistry** (SOIL)

			Sample Number	5	6	7	8	9	10
			Sample Name	RW 20-01, SS4	WL 16-05, SS5	RW 20-04, SS3	WL 16-03, SS3B	WL 16-06, SS2	WL 16-04, SS6
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	15/04/2021	08/04/2021	13/04/2021	08/04/2021	06/04/2021	08/04/2021
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
General Chemistry									
Conductivity	uS/cm	2		171	436	4080	148	814	95

PACKAGE: **- Metals and Inorganics** (SOIL)

			Sample Number	5	6	7	8	9	10
			Sample Name	RW 20-01, SS4	WL 16-05, SS5	RW 20-04, SS3	WL 16-03, SS3B	WL 16-06, SS2	WL 16-04, SS6
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	15/04/2021	08/04/2021	13/04/2021	08/04/2021	06/04/2021	08/04/2021
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics									
Moisture Content	%	0.1		0.3	0.4	0.6	0.4	1.2	0.4
Sulphate	µg/g	0.4		4.8	7.6	20	4.8	11	8.7

PACKAGE: **- Other (ORP)** (SOIL)

			Sample Number	5	6	7	8	9	10
			Sample Name	RW 20-01, SS4	WL 16-05, SS5	RW 20-04, SS3	WL 16-03, SS3B	WL 16-06, SS2	WL 16-04, SS6
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	15/04/2021	08/04/2021	13/04/2021	08/04/2021	06/04/2021	08/04/2021
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Other (ORP)									
Chloride	µg/g	0.4		48	190	1400	88	350	60

PACKAGE: **- UNDEFINED** (SOIL)

			Sample Number	5	6	7	8	9	10
			Sample Name	RW 20-01, SS4	WL 16-05, SS5	RW 20-04, SS3	WL 16-03, SS3B	WL 16-06, SS2	WL 16-04, SS6
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	15/04/2021	08/04/2021	13/04/2021	08/04/2021	06/04/2021	08/04/2021
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
UNDEFINED									
	-	-		1	1	1	1	1	1

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0375-APR21	µg/g	0.4	<0.4	2	20	97	80	120	109	75	125
Sulphate	DIO0375-APR21	µg/g	0.4	<0.4	2	20	97	80	120	95	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0054-APR21	%	0.04	< 0.04	ND	20	112	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0405-APR21	uS/cm	2	< 2	0	20	100	90	110	NA		

FINAL REPORT

QC SUMMARY

pH

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0405-APR21	pH Units	0.05	NA	0		101			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS	Insufficient sample for analysis.
RL	Reporting Limit.
↑	Reporting limit raised.
↓	Reporting limit lowered.
NA	The sample was not analysed for this analyte
ND	Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. “Temperature Upon Receipt” is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act” published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

No: 007526

Page ____ of ____

Laboratory Information Section - Lab use only

Received By: Majeed AL-mandalawi
Received Date (mm/dd/yyyy): 04 19 2021 (mm\dd\yy)
Received Time: 1 0 : 0 5
Received By (signature): Majeed AL-mandalawi
Custody Seal Present: ☐
Custody Seal Intact: ☑
Cooling Agent Present: ☐ icepack
Temperature Upon Receipt (°C) ~~Icepack~~ 9C, 9C 9c
LAB LIMS #: CA14856-Apr21

REPORT INFORMATION

Company: Thurber
Contact: Josh Alexander
Address: 103-2010 Winston Park Dr. Oakville
Phone: 613-606-7303
Email: jalexander@thurber.ca
Email: glay@thurber.ca

INVOICE INFORMATION

☐ (same as Report Information)
Company:
Contact:
Address:
Phone:
Email: accountingON@thurber.ca

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 11375
Site Location/ID: Woodlawn Rd.

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:
Rush Confirmation ID:

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153/04:
☐ Table 1 ☐ R/P/I
☐ Table 2 ☐ I/C/C
☐ Table 3 ☐ A/O
☐ Table ____

Soil Texture:
☐ Coarse
☐ Medium
☐ Fine

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH ☐ ABN ☐ SVOC(all) ☐	PCB Total ☐ Aroclor ☐	PHC F1-F4 ☐ VOC ☐ BTEX ☐ BTEX/F1 ☐ F2-F4 ☐	VOC ☐ BTEX ☐ THM ☐	Pesticides OC ☐ OP ☐	TCLP M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit. ☐	Water Pkg Gen. ☐ Ext. ☐	Sewer Use:	Corrosivity					COMMENTS:
1	RW20-01, SS4	04/15/21	—	1	Soil											X					
2	WL 16-05, SS5	04/08/21	—	1	↓											X					
3	RW 20-04, SS3	04/13/21	—	1												X					
4	WL16-03, SS3B	04/08/21	—	1												X					
5	WL 16-06, SS2	04/08/21	—	1												X					
6	WL16-04, SS6	04/08/21	—	1												X					
7																					
8																					
9																					
10																					
11																					
12																					

Observations/Comments/Special Instructions

Sampled By (NAME):	Signature:	Date: ___/___/___	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Joshua Alexander	Signature:	Date: 04/16/21	(mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.1
Date of Issue: 04 April, 2018

Appendix B

Record of Borehole Sheets (Previous investigation)
Geotechnical Test Results (Previous investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample   WS Wash Sample   AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample   TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure   PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight   RC Rock Core   SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

---

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	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	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
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 structure are preserved.

SYMBOLS

▨	CLAYSTONE
▤	SILTSTONE
░	SANDSTONE
■	COAL
▩	Bedrock (general)

DISCONTINUITY SPACING

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

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 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength**		**Field Estimation of Hardness***
	(MPa)	(psi)	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

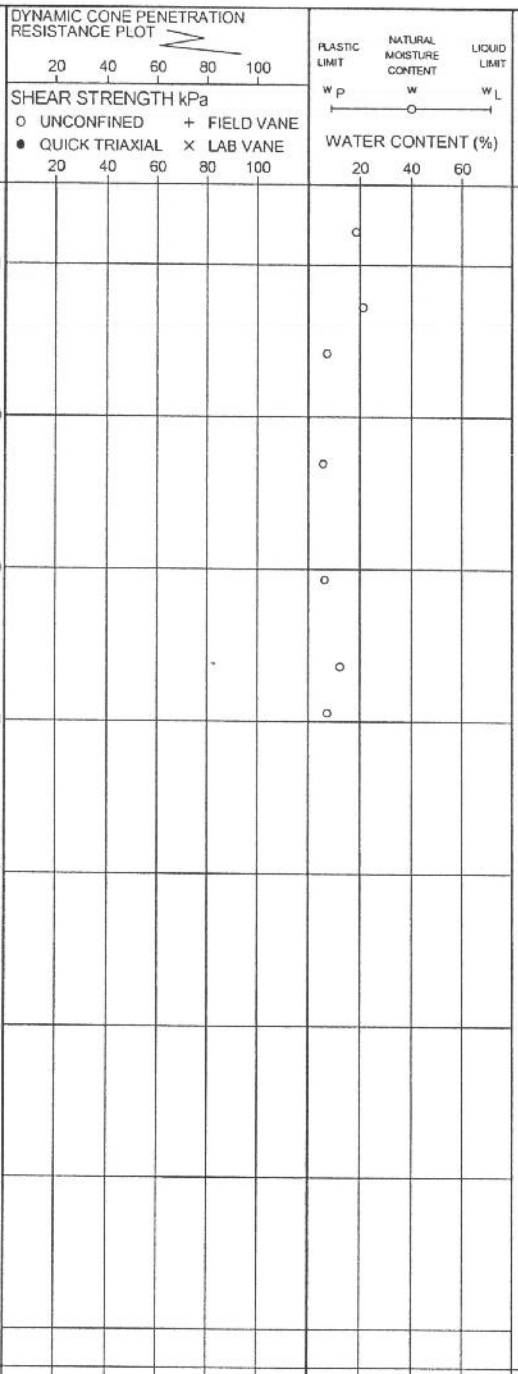
Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-236

1 OF 1 **METRIC**

G.W.P. 408-88-00
LOCATION N 4 823 685.76 E 240 320.65
ORIGINATED BY SA
HWY 7
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY ES
DATUM Geodetic
DATE 2008.06.18 - 2008.06.18
CHECKED BY RPR

SOIL PROFILE			SAMPLES						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
341.4 0.0	**SILT**, mixed with topsoil, occasional roots Loose Dark brown Moist (FILL)		1	SS	2		341		
340.6 0.8	**SAND and GRAVEL**, some silt, trace clay Compact to very dense Brown Moist (FILL) Cobbles		2	SS	25		340		
			3	SS	53				33 43 24 (SI+CL)
	Auger grinding, split spoon bouncing		4	SS	75		339		
338.4 3.0	Sandy **SILT**, numerous cobbles Very dense Grey Moist (TILL)		5	SS	88		338		0 45 48 7
						▼	337		
336.8 4.6	Coring started at 4.62m		1	RUN				FI 0	RUN 1#
	DOLOSTONE Slightly to moderately weathered White		2	RUN				10 10	TCR=100%, SCR=100%, RQD=33%
			3	RUN			336	10 12 1	RUN 2# TCR=100%, SCR=100%, RQD=46%
			4	RUN			335 334	1 1 3 2 4	RUN 3# TCR=86%, SCR=86%, RQD=26%, UCS=130MPa RUN 4# TCR=100%, SCR=100%, RQD=90%, UCS=130MPa
333.7 7.8	END OF BOREHOLE AT 7.8m. WATER OBSERVED AT 4.0m DURING DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG TO 4.6m THEN BENTONITE SEAL TO 0.6m THEN GROUT TO SURFACE.								



+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 20 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-237

1 OF 1 **METRIC**

G.W.P.	408-88-00	LOCATION	N 4 823 653.07 E 240 355.32
HWY	7	BOREHOLE TYPE	Hollow Stem Augers
DATUM	Geodetic	DATE	2008.06.20 - 2008.06.20

ORIGINATED BY SA
COMPILED BY ES
CHECKED BY RPR

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
339.5 0.0	**SAND** and **GRAVEL**, silty, trace clay, numerous cobbles Dense to very dense Brown Moist (FILL) Possible boulders				339	
		1	SS	50/ .100		
	Wet, gas odour	2	SS	37	338	32 43 25 (SI+CL)
		3	SS	63	337	
335.8		4	SS	57	336	38 43 19 (SI+CL)
3.7	END OF BOREHOLE AT 3.66m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. WATER OBSERVED AT 2.4m DURING DRILLING. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.07.15 2.3 337.2					

STRAT PLOT — GROUND WATER CONDITIONS

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

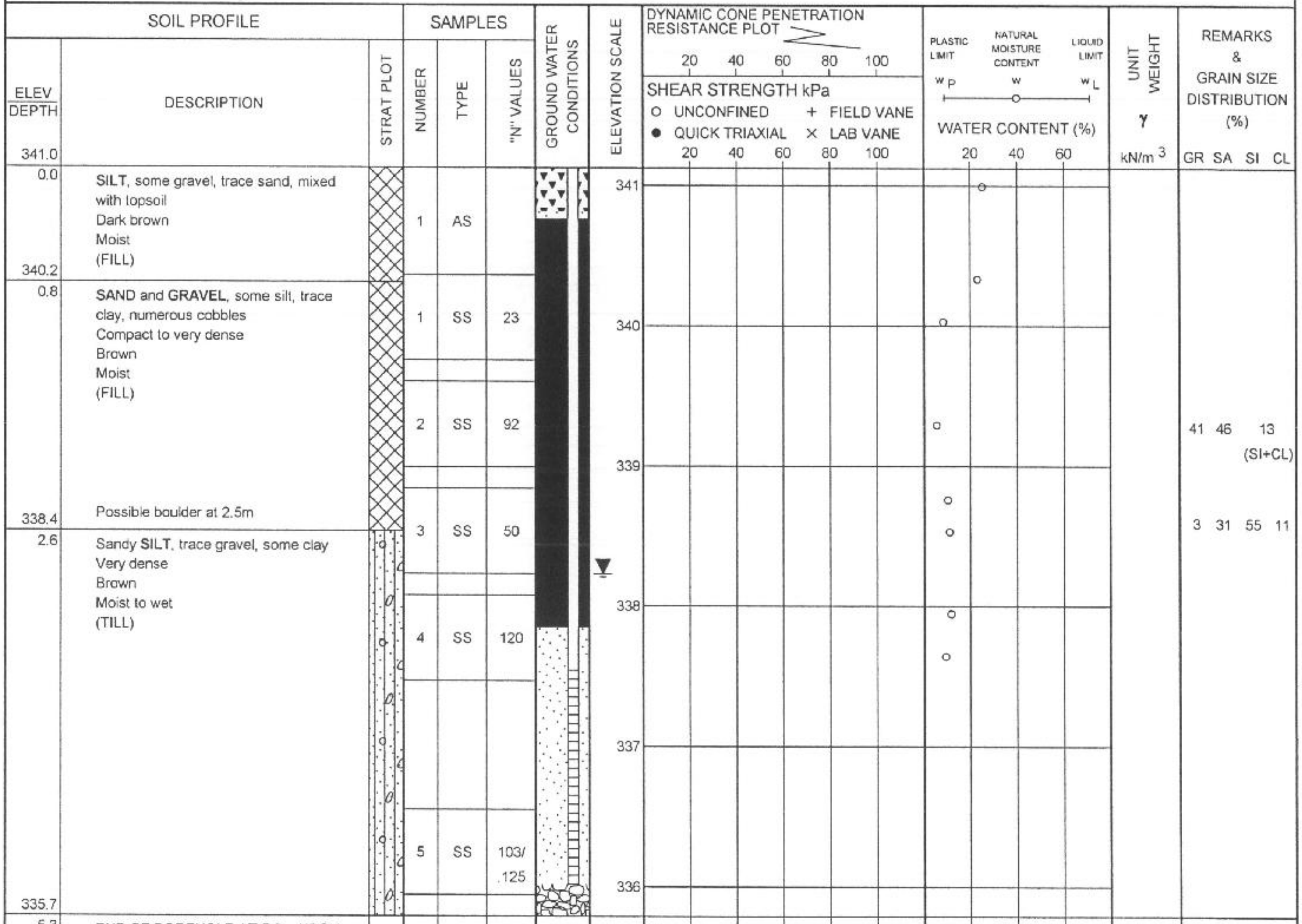
+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-238

1 OF 1 **METRIC**

G.W.P. 408-88-00
LOCATION N 4 823 655.45 E 240 290.22
ORIGINATED BY SA
HWY 7
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY ES
DATUM Geodetic
DATE 2008.06.18 - 2008.06.20
CHECKED BY RPR



ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
341.0								
0.0	**SILT**, some gravel, trace sand, mixed with topsoil Dark brown Moist (FILL)	1	AS					
340.2 0.8	**SAND** and **GRAVEL**, some silt, trace clay, numerous cobbles Compact to very dense Brown Moist (FILL)	1	SS	23				
		2	SS	92	41	46	13 (SI+CL)	
338.4	Possible boulder at 2.5m	3	SS	50	3	31	55	11
2.6	Sandy **SILT**, trace gravel, some clay Very dense Brown Moist to wet (TILL)	4	SS	120				
		5	SS	103/ .125				
335.7 5.3	END OF BOREHOLE AT 5.3m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. WATER OBSERVED AT 2.7m DURING DRILLING.							

Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen.

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2008.07.15	2.9	338.1

$+^3, \times^3$: Numbers refer to Sensitivity

$\overset{20}{15\text{-}\oplus\text{-}5}_{10}$ (%) STRAIN AT FAILURE

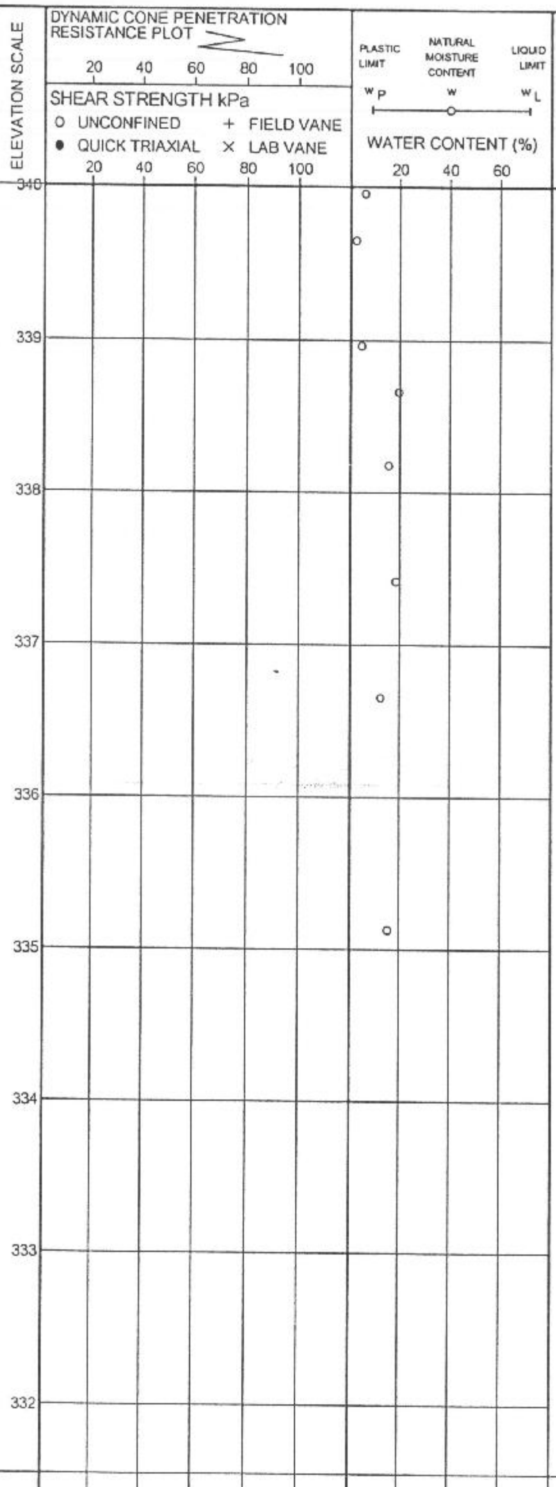
Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-239

1 OF 1 **METRIC**

G.W.P. 408-88-00	LOCATION N 4 823 617.26 E 240 315.41	ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY ES
DATUM Geodetic	DATE 2008.06.19 - 2008.06.19	CHECKED BY RPR

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
339.9							
0.0 0.1	**SILT**, mixed with topsoil, roots Dark brown Moist (FILL)	1	SS	35			
	SAND and **GRAVEL**, trace silt Dense Brown Moist (FILL)	2	SS	46			
338.4 1.5	Silty, organic, gas odour Dark brown						
	Silty **SAND**, trace gravel, some clay, gas odour Compact	3	SS	13			1 49 39 11
337.8 2.1	Brown Moist				▼		
	SAND, fine grained, some gravel, trace silt, trace clay, numerous cobbles Dense Brown Wet	4	SS	42			
		5	SS	43			20 58 22 (SI+CL)
336.3 3.7	Sandy **SILT**, trace gravel, trace clay Very dense Brown Wet (TILL)	6	SS	58			3 34 54 9
334.6 5.3	**DOLOSTONE** Coring started at 5.3m Slightly to moderately weathered White	1	RUN			FI 2	RUN 1# TCR=100%, SCR=100%, RQD=100%
		2	RUN			10 10	
		3	RUN			2 10 10	RUN 2# TCR=100%, SCR=100%, RQD=80%, UCS=140MPa RUN 3# TCR=100%, SCR=100%, RQD=69%, UCS=130MPa
		4	RUN			2 >10 >10 5 4	RUN 4# TCR=100%, SCR=100%, RQD=25%, UCS=105MPa
331.5 8.5	END OF BOREHOLE AT 8.46m. WATER OBSERVED AT 2.1m DURING DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG TO 5.2m, BENTONITE BENSEAL TO 0.6m THAN HOLEPLUG TO SURFACE.						



+ ³, × ³ : Numbers refer to Sensitivity

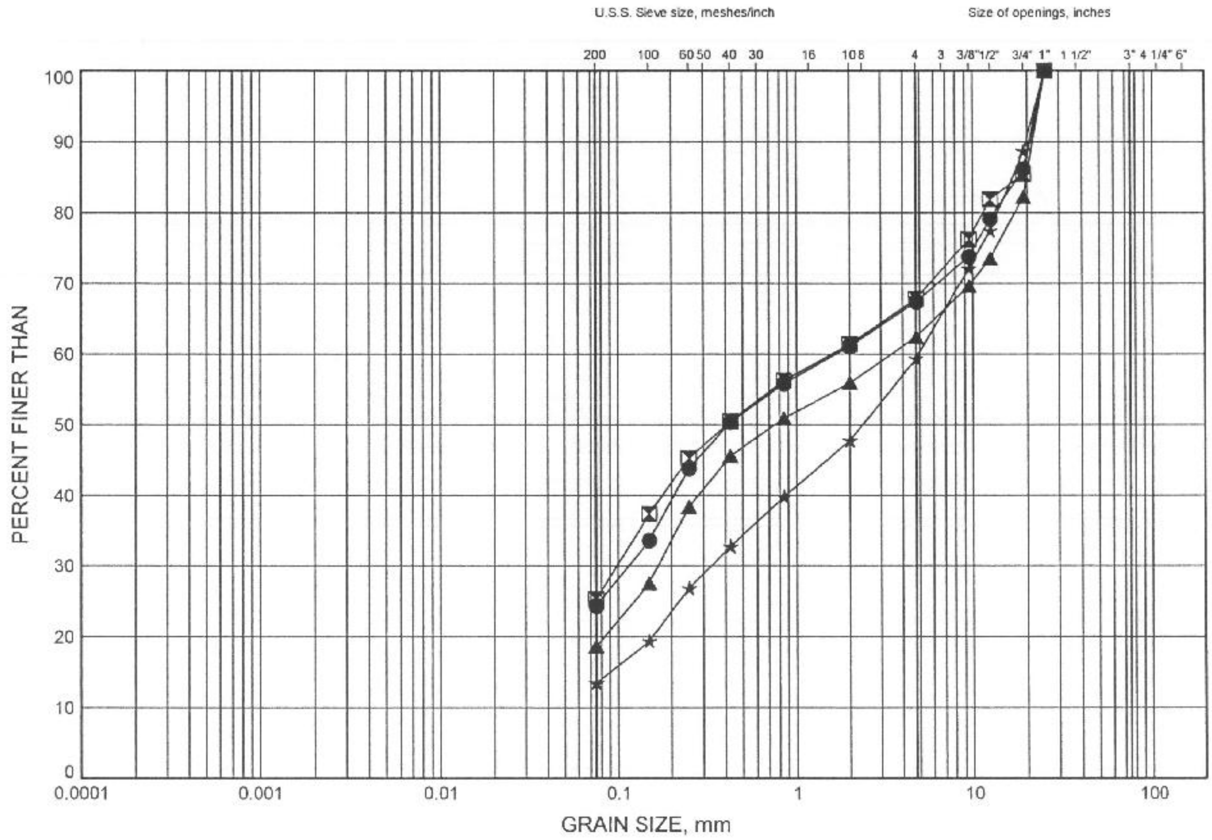
$15\overset{20}{\underset{10}{\oplus}}5$ (%) STRAIN AT FAILURE

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand and Gravel Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-236	1.83	339.61
☒	08-237	1.83	357.71
▲	08-237	3.35	356.19
☆	08-238	1.83	339.21

W.P.# 408-88-00

Prepared By SA

Checked By RPR

THURBER

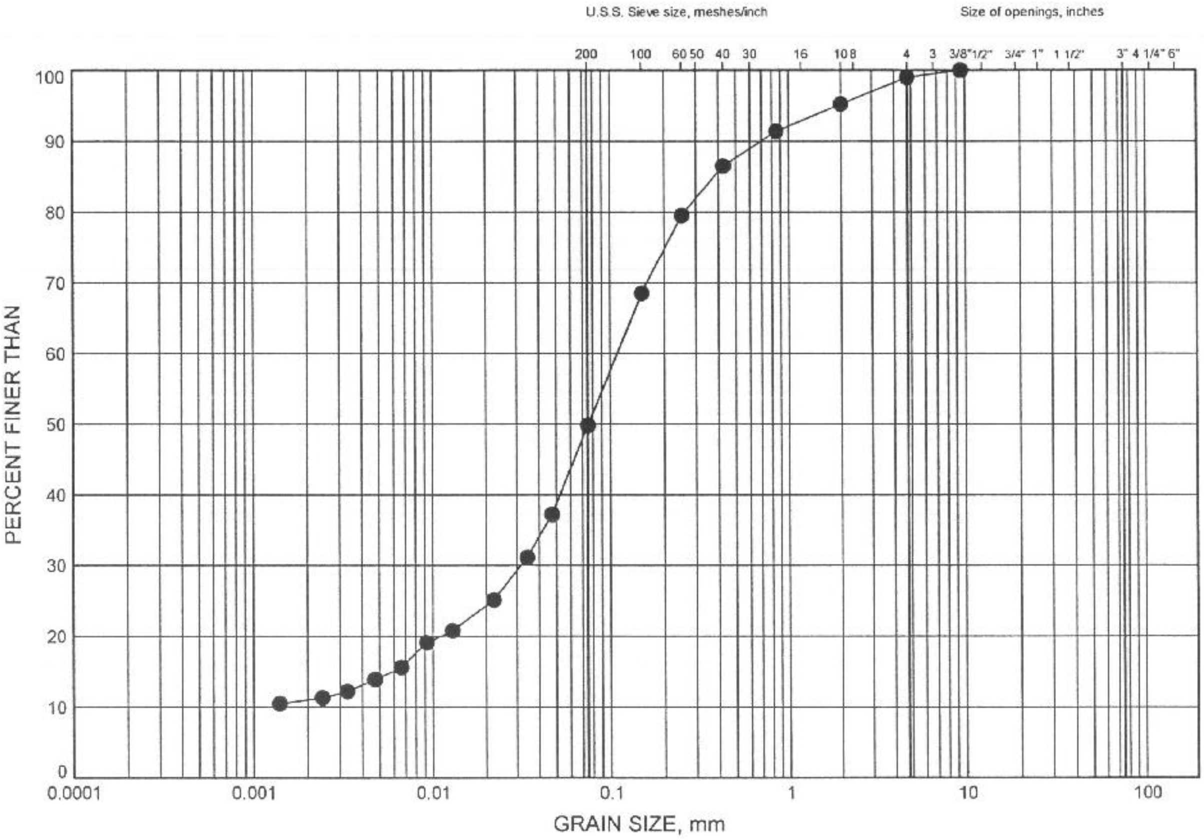
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/23/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-239	1.83	338.09

W.P.# 408-88-00
Prepared By SA
Checked By RPR

GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/23/08

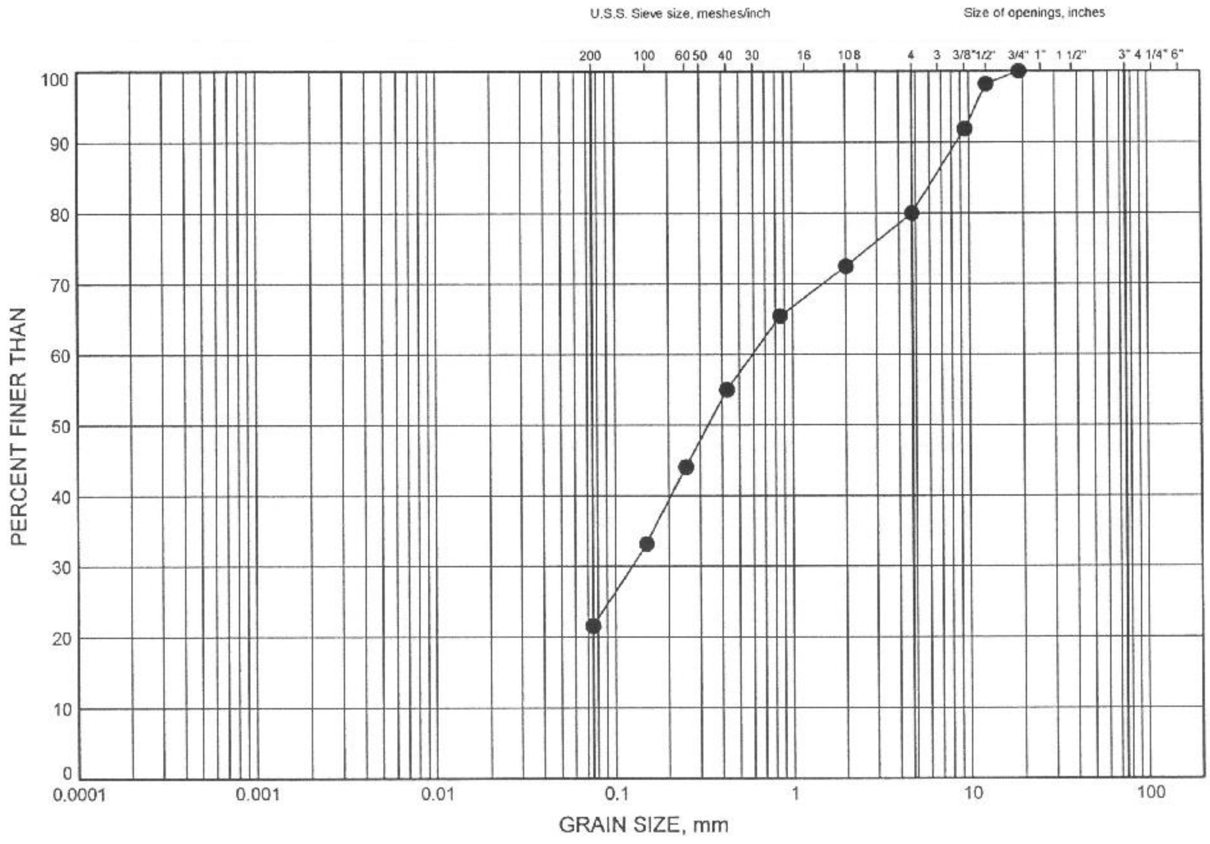
THURBER

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-239	3.35	336.57

GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/23/08

W.P.# 408-88-00
Prepared By SA
Checked By RPR

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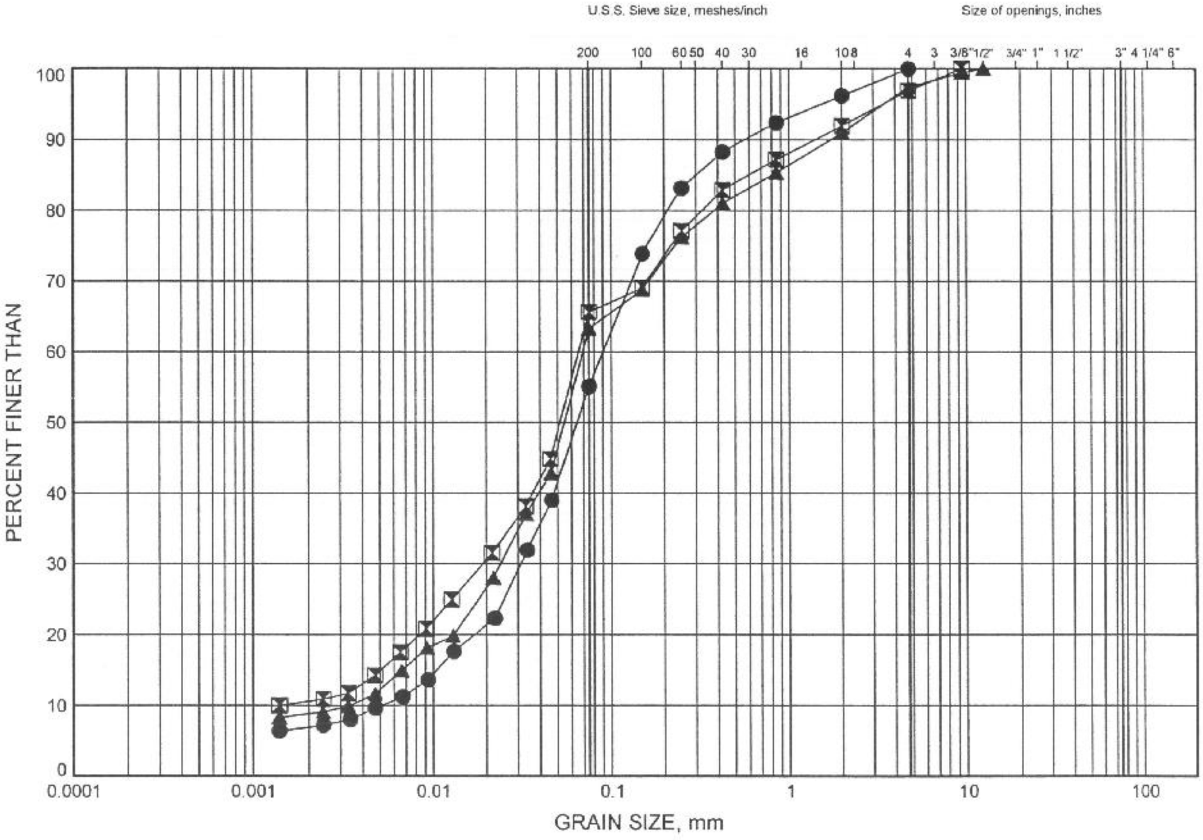
Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-236	3.16	338.27
☒	08-238	2.51	338.52
▲	08-239	4.88	335.04

W.P.# 408-88-00
Prepared By SA
Checked By RPR

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GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/23/08

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Appendix C

Rock Core Photographs

PHOTOGRAPHS OF ROCK CORES – BOREHOLE WL16-03 (Dry)

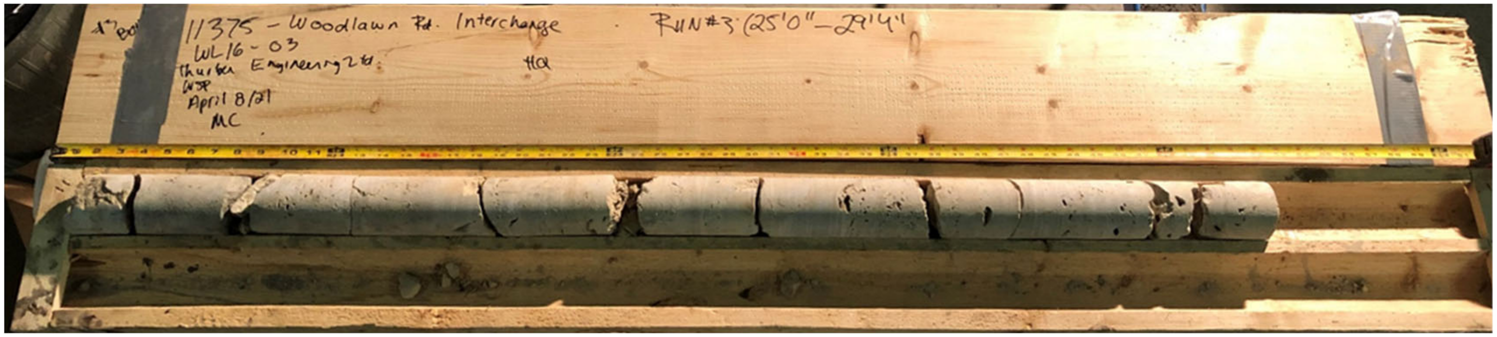
RUNS 1-3

BOTTOM

Run 1

Run 2

Run 3



TOP

Run #	Depth (ft)	Depth (m)
1	16’6” – 21’0”	5.03 – 6.40
2	21’0” – 25’0”	6.40 – 7.62
3	25’0” – 29’4”	7.62 – 8.93

PHOTOGRAPHS OF ROCK CORES – BOREHOLE WL16-04B (Dry)

RUNS 1-3

TOP

Run 3

Run 2

Run 1

BOTTOM

Run #	Depth (ft)	Depth (m)
1	18’0” – 20’9”	5.49 – 6.17
2	20’9” – 25’9”	6.17 – 7.01
3	25’9” – 30’3”	7.85 – 9.22

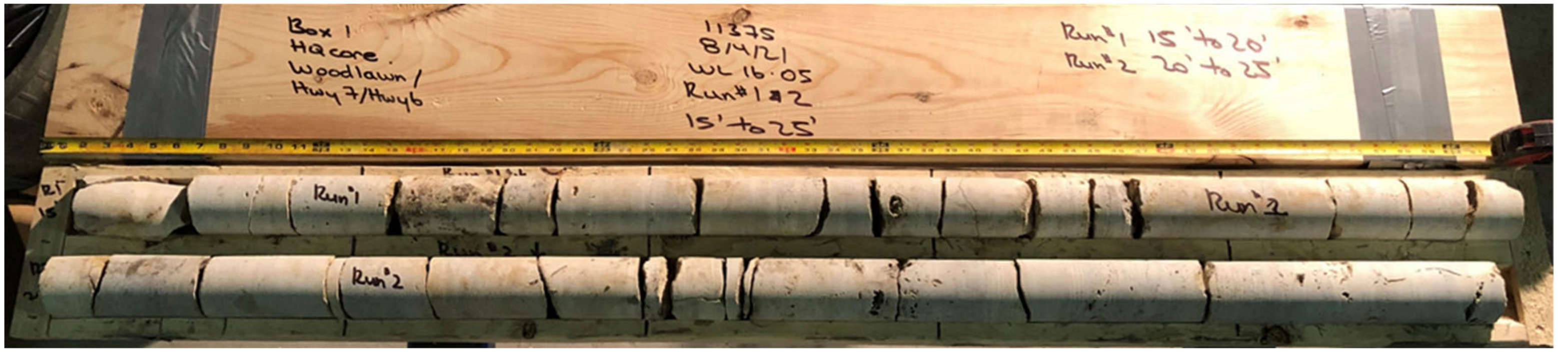
PHOTOGRAPHS OF ROCK CORES – BOREHOLE WL16-05 (Dry)

TOP

RUNS 1-2

Run 1

Run 2



BOTTOM

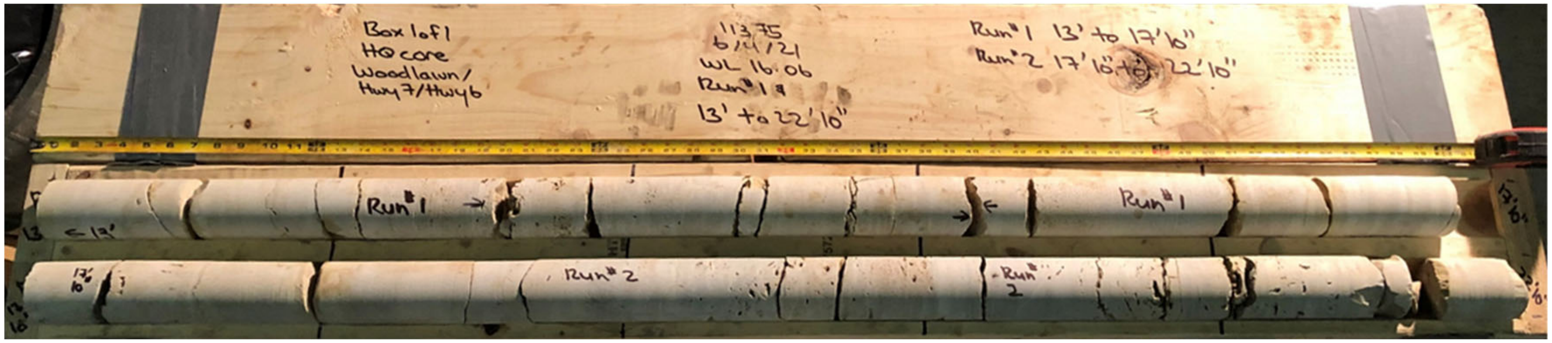
Date Drilled: April 8, 2021

Run #	Depth (ft)	Depth (m)
1	15'0" – 20'0"	4.57 – 6.09
2	20'0" – 25'0"	6.09 – 7.62

PHOTOGRAPHS OF ROCK CORES – BOREHOLE WL16-06 (Dry)

TOP

RUNS 1-2



Run 1

Run 2

BOTTOM

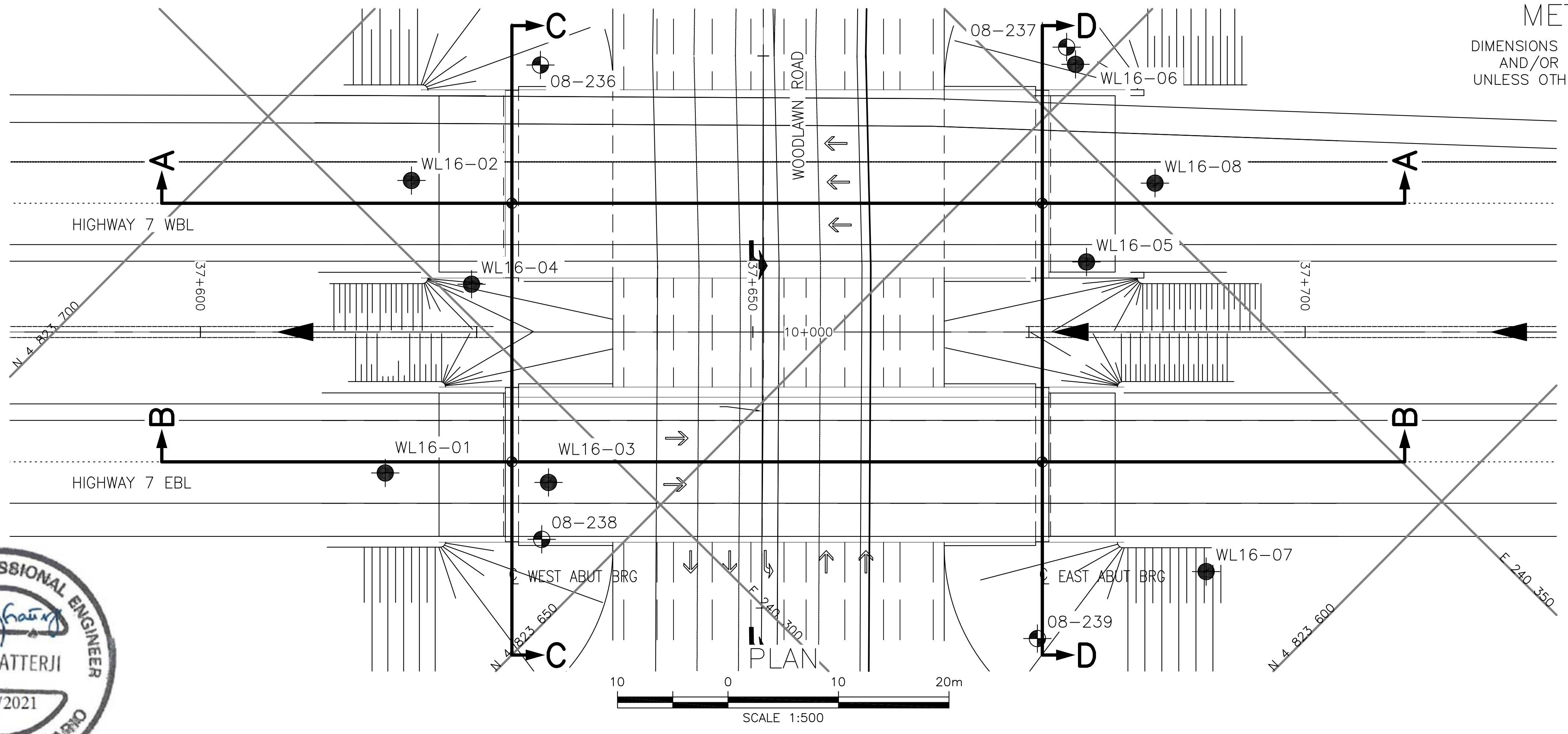
Date Drilled: April 6, 2021

Run #	Depth (ft)	Depth (m)
1	13'0" – 17'6"	3.96 – 5.33
2	17'6" – 22'10"	5.33 – 6.96

THURBER

Appendix D

Borehole location and Soil Strata Drawing



METRIC
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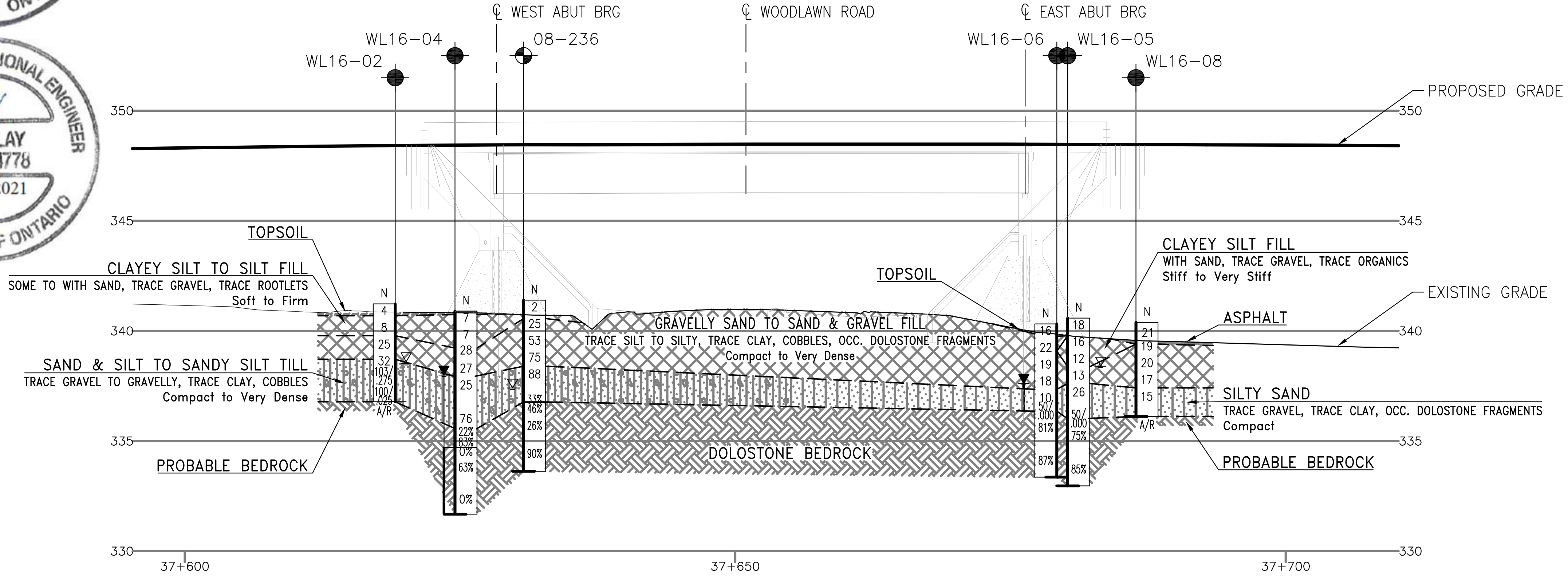
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

P. K. CHATTERJI
06/25/2021

G. R. LAY
100194778
06/25/2021



PROFILE A–A ALONG ℄ HIGHWAY 7 WBL

10 0 10 20m H 1:500

5 0 5 10m V 1:250

CONT No
GWP No 408–88–00

HIGHWAY 7
WOODLAWN ROAD
PROPOSED EBL & WBL OVERPASSES
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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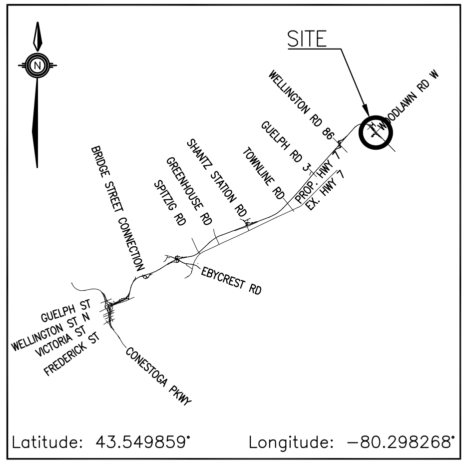

Latitude: 43.549859° Longitude: –80.298268°

KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (Previous 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
WL16–01	340.3	4 823 669.7	240 284.5
WL16–02	341.2	4 823 686.7	240 305.0
WL16–03	340.1	4 823 658.6	240 294.3
WL16–04	340.9	4 823 676.2	240 302.2
WL16–05	340.6	4 823 638.1	240 342.8
WL16–06	340.3	4 823 651.4	240 354.8
WL16–07	340.3	4 823 610.7	240 330.5
WL16–08	340.4	4 823 638.7	240 352.2
08–236	341.4	4 823 685.8	240 320.6
08–237	339.5	4 823 653.1	240 355.3
08–238	341.0	4 823 655.5	240 290.2
08–239	339.9	4 823 617.3	240 315.4

-NOTES-

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

GEOCRES No.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN GL	CHK PKC	CODE	LOAD	DATE JUN 2021
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FILENAME: H:\Drafting\11000\11375\2020\TED–11375–BHPP–WR.dwg
PLOTDATE: 6/25/2021 2:46 PM

MINISTRY OF TRANSPORTATION, ONTARIO

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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

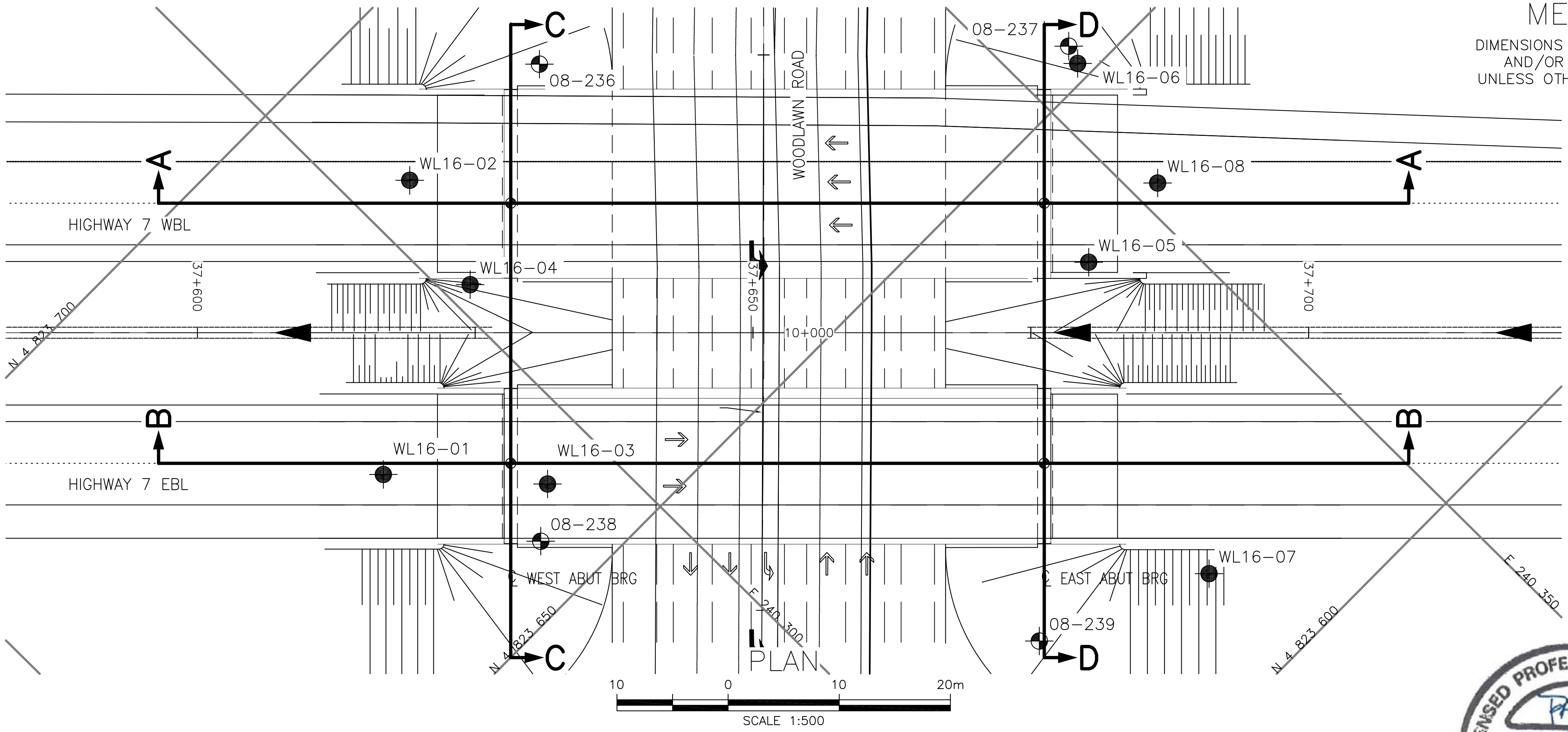
CONT No
GWP No 408-88-00

HIGHWAY 7
WOODLAWN ROAD
PROPOSED EBL & WBL OVERPASSES
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

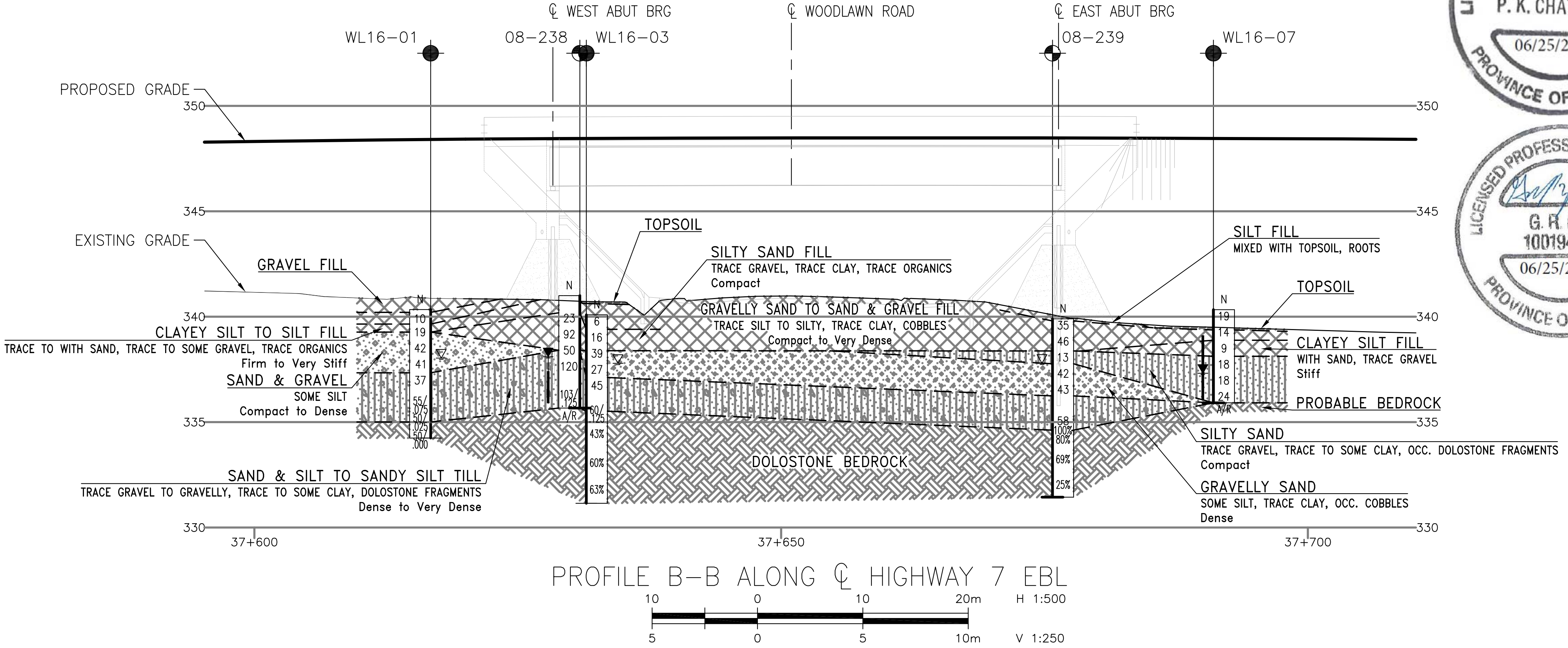
THURBER ENGINEERING LTD.



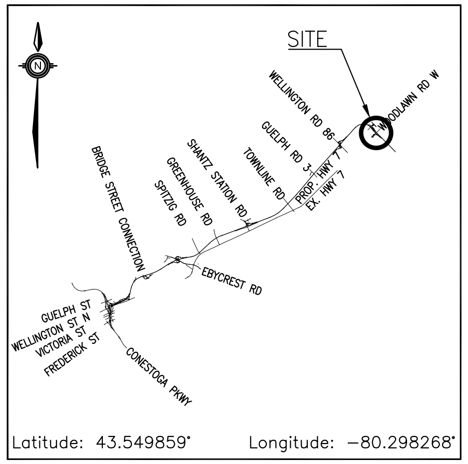
PLAN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
06/25/2021
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
G. R. LAY
100194778
06/25/2021
PROVINCE OF ONTARIO



PROFILE B-B ALONG ℄ HIGHWAY 7 EBL



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KEYPLAN

L E G E N D

●	Borehole (Current Investigation)
⊕	Borehole (Previous 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
WL16-01	340.3	4 823 669.7	240 284.5
WL16-02	341.2	4 823 686.7	240 305.0
WL16-03	340.1	4 823 658.6	240 294.3
WL16-04	340.9	4 823 676.2	240 302.2
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WL16-07	340.3	4 823 610.7	240 330.5
WL16-08	340.4	4 823 638.7	240 352.2
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GEOCRES No.

REVISIONS		
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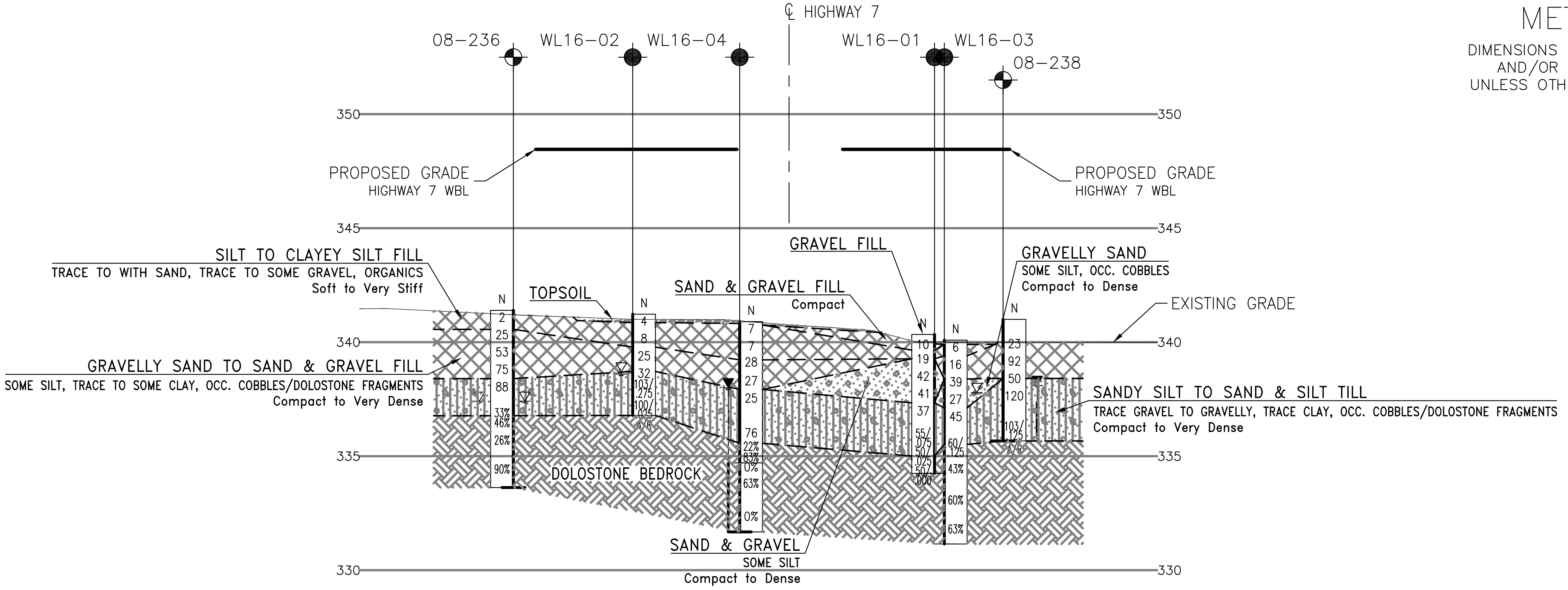

SECTION C–C ALONG ℄ W. ABUTMENT

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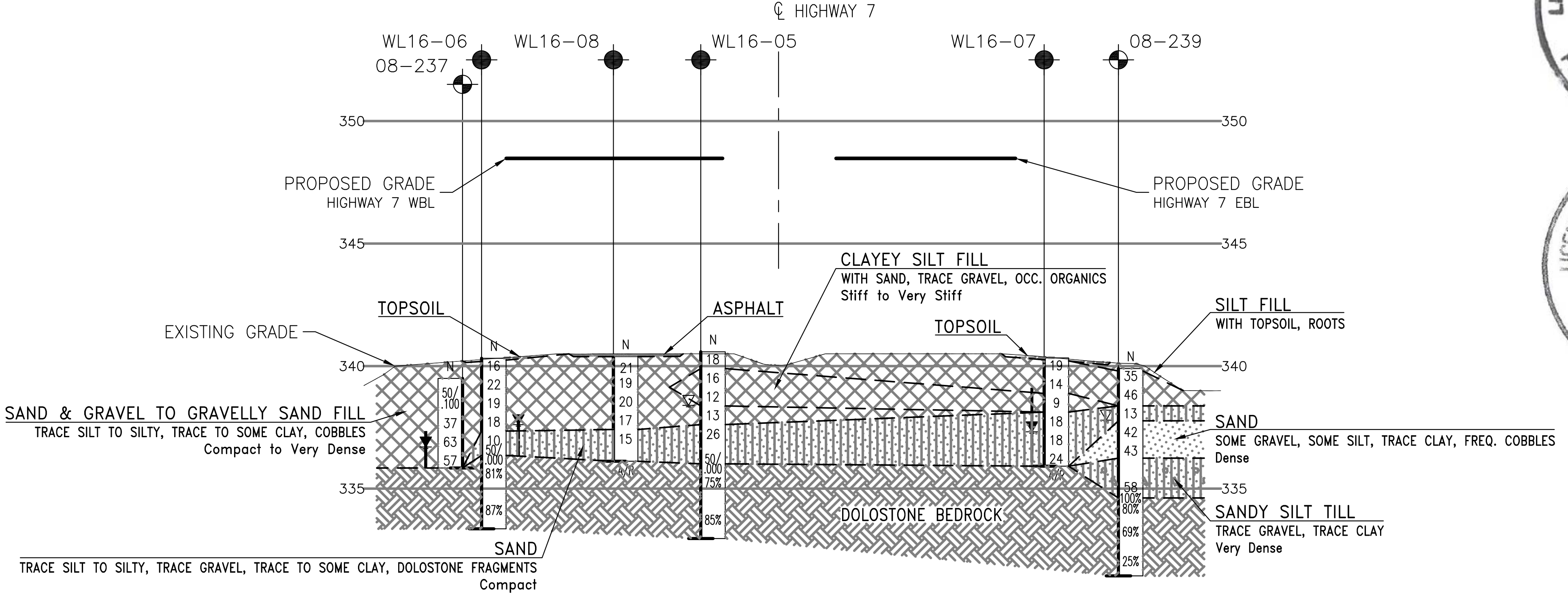
5 0 5 10m V 1:250



SECTION D–D ALONG ℄ E. ABUTMENT

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METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

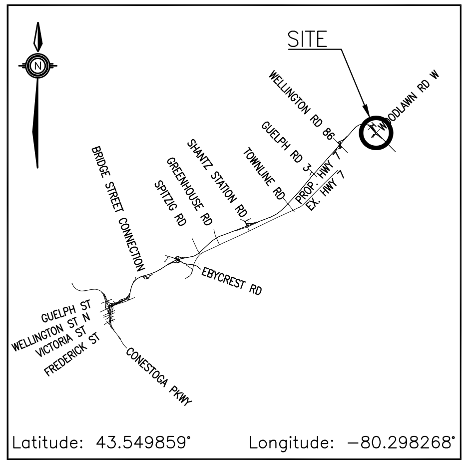
CONT No
GWP No 408–88–00

HIGHWAY 7
WOODLAWN ROAD
PROPOSED EBL & WBL OVERPASSES
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.



Latitude: 43.549859° Longitude: –80.298268°

KEYPLAN

P. K. CHATTERJI
06/25/2021

G. R. LAY
100194778
06/25/2021

L E G E N D

●	Borehole (Current Investigation)
⊕	Borehole (Previous 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
WL16–01	340.3	4 823 669.7	240 284.5
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WL16–05	340.6	4 823 638.1	240 342.8
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WL16–07	340.3	4 823 610.7	240 330.5
WL16–08	340.4	4 823 638.7	240 352.2
08–236	341.4	4 823 685.8	240 320.6
08–237	339.5	4 823 653.1	240 355.3
08–238	341.0	4 823 655.5	240 290.2
08–239	339.9	4 823 617.3	240 315.4

-NOTES-

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

GEOCRES No.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN GL	CHK PKC	CODE	LOAD	DATE JUN 2021
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Appendix E

Foundation Comparison

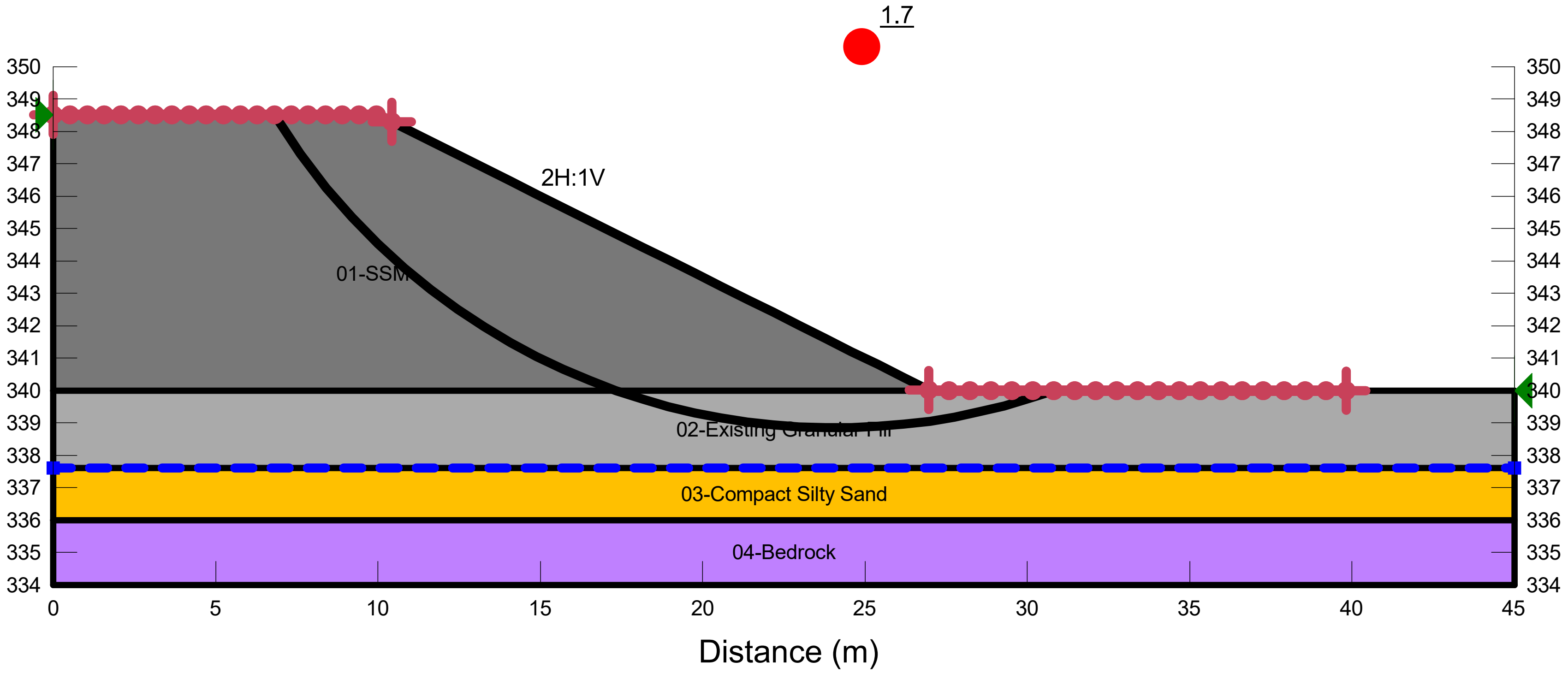
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caissons
Abutments	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. High geotechnical resistances available on the compact to very dense native soils or bedrock. ***Disadvantages:*** i. Dewatering will be required. ii. Relatively deep excavations would be required to bear footings on competent soils. iii. Not suitable for integral abutments	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native. ***Disadvantages:*** **iii.** Dewatering will be required, depending on the depth of the excavation.	***Advantages:*** i. High geotechnical resistance available by driving piles to achieve resistance in the bedrock. ii. Permits integral abutment design. iii. Readily installed. iv. Installation less influenced by weather and groundwater/river water than spread footings. v. Installation of piles could continue in freezing weather. vi. May require less volume of excavation than footings. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. Very dense soils may require pre-augering to desire pile tip elevation. iii. When driven into hard/very dense till deposits and bedrock H-pile are prone to pile tip damage, therefore pile tip protection is required.	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on bedrock. ***Disadvantages:*** i. Higher cost than spread footings. ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table. iii. Potential difficulty in cleaning and inspecting bases.
	NOT RECOMMENDED	**NOT RECOMMENDED**	**RECOMMENDED**	**NOT RECOMMENDED**

Appendix F

Slope Stability Outputs

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	01-SSM	Mohr-Coulomb	21.5	0	31
▨	02-Existing Granular Fill	Mohr-Coulomb	21	0	32
🟨	03-Compact Silty Sand	Mohr-Coulomb	21	0	31
🟪	04-Bedrock	Bedrock (Impenetrable)			



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Global Stability
HWY 7 EBL & WBL Overpasses

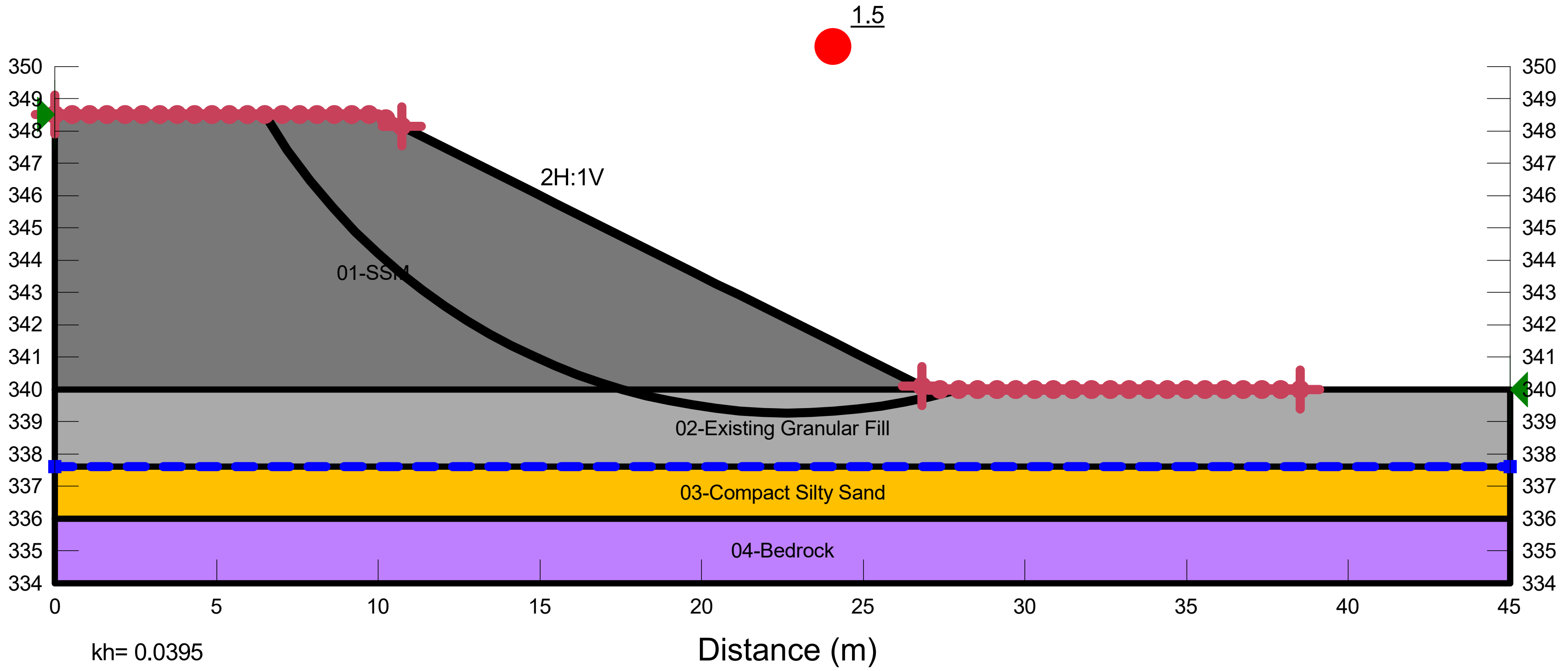
Long Term (Drained) Conditions

11375- Woodlawn Road

June 18, 2021

Appendix F-Figure F1

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	01-SSM	Mohr-Coulomb	21.5	0	31
■	02-Existing Granular Fill	Mohr-Coulomb	21	0	32
🟨	03-Compact Silty Sand	Mohr-Coulomb	21	0	31
🟪	04-Bedrock	Bedrock (Impenetrable)			



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Global Stability
HWY 7 EBL & WBL Overpasses

Pseudo Static Analysis

11375- Woodlawn Road

June 18, 2021

Appendix F- Figure F2

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Appendix G

List of OPSS Documents and NSSP Wording

1. List of Special Provisions and OPSS Documents Referenced in this Report

OPSS PROV 206	Construction specification for grading
OPSS PROV 501	Construction specification for compacting
OPSS.PROV 517	Construction specification for dewatering
SP 517F01	Amendment to OPSS 517
OPSS PROV 539	Construction specification for temporary protection systems
OPSS PROV 804	Construction specification for seed and cover
OPSS PROV 902	Construction specification for excavating and backfilling - Structures
OPSS PROV 903	Construction specification for deep foundations
OPSS.PROV.1010	Material specification for aggregates - base, subbase, select subgrade, and backfill material
OPSD 3102.100	Walls Abutment, Backfill drain
OPSD 3101.150	Walls Abutment, Backfill minimum granular requirement
OPSD 3000.100	Foundation piles – Steel H-Pile driving shoe

2. Suggested text for a NSSP on Pile Installation

The presence of hard/very dense zones, cobbles, and boulders will potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The hard/very dense zones, cobbles, and boulders may impede the driving of the piles resulting in more arduous driving in the very dense soils.
- Appropriate equipment and construction procedures will be required to penetrate or remove obstructions, such as cobbles and boulders, to permit pile installation.
- Pile driving must be controlled according to the criteria specified for the site.

The Contractor must be prepared to remove, dislodge or otherwise penetrate these obstructions to advance the piles to the design tip elevations on bedrock while meeting the specified deflection tolerances.

Should a pile achieve the design ultimate geotechnical resistance or refusal at a tip elevation higher than that indicated in the contract, the Contract Administrator (CA) shall be informed immediately who should consult with the design team for resolution. Over-driving must be avoided to minimize the risk of damaging the pile.

3. Suggested Text for NSSP on Piles Driven to Bedrock

- The piles must be driven to bedrock. The tips of all driven H-piles must be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent. Pile driving should be terminated before the pile is damaged by overdriving.

4. Suggested Text for NSSP on Groundwater Control

Water seepage due to perched water in the slope, random fill, surface runoff and precipitation should be expected. For temporary excavations at this site, groundwater control will likely be limited to diverting surface runoff and preventing precipitation from entering the excavations supplemented by sump pumping and use of perimeter ditches where required. Filtered sumps must be designed properly so that construction drainage water containing eroded soil and fines do not flow onto the existing roadways. Dewatering systems must be installed and made operational prior to excavation starts.