THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
METROLINX RAILWAY BRIDGE FROM WELLINGTON STREET NORTH TO EDNA STREET CONNECTION AND E-S RAMP
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

GEOCRES No. 40P8-278

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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 E-S Ramp and Wellington to Edna Street Connection Road underpass bridge that will pass under the Metrolinx tracks as part of the Highway 7-New Project in the Regional Municipality of Waterloo, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, records of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. Models of the subsurface conditions under the potential foundation footprint were developed from the data obtained in the course of the current and previous investigations.

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, E-S Ramp and Connection Road under CNR Tracks, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P8-166, Report to Ministry of Transportation Ontario Southwestern Region, File: 15-64-17, dated November 10, 2009. (Reference 1).

- Foundation investigation report for C.N.R. Subway, Kitchener-Waterloo Expressway, District #4 (Hamilton), Geocres No. 40P8-45, W.J. 66-F-37, W.P. 636-64, dated July 4, 1966. (Reference 2).

Records of boreholes from the previous reports (Boreholes 08-041 and 08-042) are attached in Appendix B for reference.

2. SITE DESCRIPTION

The site lies on the west side of Kitchener-Waterloo Expressway (KWE), approximately 250 m to the south of Wellington Street and 110 m north of Victoria Street. At this location, the proposed E-S Ramp and Wellington to Edna Connection Road will pass under the existing twin east-west Metrolinx tracks. Approximately 50 m west of the existing Metrolinx bridge over KWE, the double tracks emerge from a Metrolinx yard with a number of tracks as well as a spur line. The Metrolinx yard extends some 980 m west, to Lancaster Street East. The site lies within an area of industrial and commercial lands and is generally flat. Photographs of the site are included in Appendix E.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as the Waterloo Hills, characterized by ridges of sandy till and kames or kame moraines, with outwash sands occupying the intervening hollows.

3. SITE INVESTIGATION AND FIELD TESTING

A detailed site investigation was carried out from July 3, 2018 to August 29, 2019. Eight boreholes, numbered CN16-01 to CN16-08, were drilled near the west and east abutments of the proposed structure. A summary of the borehole locations, designations, borehole termination depths and termination elevations for each borehole is provided in Table 3.1. The boreholes were drilled to depths from 15.8 to 38.3 m (Elevation 310.0 to 282.0). The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets. It should be noted that no borehole was drilled to investigate the railway embankment due to access constraints as well as restrictions imposed by Metrolinx.

The Record of Borehole sheets for the current investigation boreholes are included in Appendix A, and the Record of Borehole sheets for the previous investigation boreholes are included in

Appendix B. The approximate locations of the current and previous boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

Prior to commencing the site investigation, utility clearances were obtained for all borehole locations. The boreholes were drilled using a track-mounted drill rig and advanced with a combination of hollow stem augers and mud rotary drilling. Samples were obtained at selected depth intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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 samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed during the drilling operations. Three piezometers were installed at Boreholes CN16-01, CN16-04 and CN16-07 to permit for longer term monitoring of the groundwater levels. The piezometers consisted of 25 mm or 50 mm diameter PVC pipe with a slotted screen enclosed in filter sand. The piezometers are planned to be decommissioned in the summer of 2020. The completion of the boreholes were carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole	Ground Surface Elevation	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
East Abutment	CN16-01	325.5	15.8/309.7	15.2/310.3	Piezometer with 3.0 m slotted screen installed with sand filter from 15.2 m to 11.6 m, bentonite holeplug from 11.6 m to 9.1 m, grout from 9.1 m to 0.3 m and bentonite holeplug from 0.3 m to ground surface.
	CN16-03	321.3	38.3/283.1	No Installation	Borehole backfilled with grout holeplug.

Foundation Unit	Borehole	Ground Surface Elevation	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
	CN16-05	325.5	38.3/287.3	No Installation	Borehole backfilled with cement and grout, and bentonite holeplug to surface.
	CN16-07	320.8	15.8/305.0	15.2/305.6	Piezometer with 3.0 m slotted screen installed with sand filter from 15.2 m to 11.6 m, bentonite holeplug from 11.6 m to 10.7 m and grout from 10.7 m to ground surface.
	08-042	322.8	20.1/302.7	19.2/303.6	Piezometer with 1.5 m slotted screen installed with sand filter to 17.4 m, holeplug from 17.4 m to 16.8 m, grout from 16.8 m to 0.6 m, then holeplug to surface.
West Abutment	CN16-02	326.1	37.0/289.1	No Installation	Borehole backfilled with cement and grout, and bentonite holeplug to surface.
	CN16-04	323.3	41.3/282.0	41.1/282.2	Piezometer with 3.0 m slotted screen installed with sand filter from 41.1 m to 37.2 m, bentonite pellets from 37.2 m to 36.3 m, grout from 36.3 m to 1.5 m and bentonite holeplug from 1.5 m to ground surface.
	CN16-06	325.9	15.8/310.0	No Installation	Borehole backfilled with cement and grout, and bentonite holeplug to surface.
	CN16-08	322.0	15.8/306.2	No Installation	Borehole backfilled with cement and grout, and bentonite holeplug to surface.
	08-041	326.3	37.2/289.1	No Installation	Grout to 0.6 m then bentonite holeplug to ground surface.

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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 gradation analysis (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets and figures in Appendix A for the current investigation, and Appendix B for the previous investigation.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of silty sand fill was collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and presented in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A and Appendix B and on the “Borehole Locations and Soil Strata” drawings included in Appendix D.

An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the soil stratigraphy at this site consisted of surficial topsoil overlying a cohesionless fill layer, a layer of upper sand, silty clay till, silty clay, a lower sand layer and sandy silt till.

5.1 Topsoil

A layer of topsoil was encountered surficially in nine boreholes drilled at this site, CN16-02 to CN16-08, 08-041 and 08-042. It was generally dark brown in colour. The thickness of the topsoil layer ranged from 40 mm to 300 mm. The topsoil thickness may vary between the borehole locations and in other areas of the site.

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5.2 Fill

Fill was encountered surficially in Borehole CN16-01 and immediately below the topsoil in the other boreholes at this site, Boreholes CN16-02 to CN16-08, 08-041 and 08-042.

The fill generally consisted of silty sand and contained trace gravel to gravelly, trace to some clay, and was generally brown in colour. Zones of sandy silt fill and sand fill were also encountered in Boreholes CN16-06 and 08-041.

A layer of clayey silt fill was also encountered below the sand fill in Borehole 08-041 and contained some sand to sandy and trace gravel. The clayey silt fill was generally brown in colour.

Occasional organics were encountered in the fill in Boreholes CN16-01, CN16-02, CN16-07, CN16-08 and 08-042, and occasional decayed wood fragments were encountered in Borehole CN16-07. Occasional cobbles were encountered in the fill in Boreholes CN16-01, CN16-02, CN16-06 and CN16-07. Auger grinding was noted in the fill in Borehole CN16-01.

The thickness of the fill ranged from 1.2 m to 4.0 m, with the lower boundary of this layer encountered at depths ranging from 1.4 m to 4.1 m (Elevation 324.9 to 317.8).

SPT N-values recorded in the cohesionless fill generally ranged from 6 blows for 0.3 m penetration to 100 blows for 0.25 m penetration, indicating a loose to very dense relative density.

Moisture content of samples of the cohesionless fill generally ranged from 4 percent to 18 percent.

Select samples of the cohesionless fill underwent laboratory gradation analysis. These results are summarized on the Record of Borehole sheets included in Appendix A and the grain size distribution curves for these samples are plotted on Figure A1 of Appendix A. The results of this testing are summarized as follows:

Soil Particles	Fill (%)
Gravel	1 to 24
Sand	38 to 60
Silt	25 to 44
Clay	4 to 14

5.3 Organics

A layer of buried organics was encountered below the silty sand fill layer in Borehole CN16-05, at a depth of 3.5 m (Elevation 322.0).

The thickness of the organics layer was 0.6 m, with the lower boundary of this layer encountered at a depth of 4.1 m (Elevation 321.4).

The organics layer was generally black in colour and contained occasional roots and rootlets.

The moisture content from a sample of the organics layer was measured to be 15 percent.

The organics thickness may vary beyond the borehole location and in other areas of the site.

5.4 Upper Sand

An upper sand layer was encountered below the fill in all the boreholes at this site, except for CN16-05, where the sand was encountered below the buried organics layer.

The upper sand layer was encountered at depths ranging from 1.4 m to 4.1 m (Elevation 324.9 to 317.8).

The upper sand layer was brown to grey in colour and contained trace gravel to gravelly, trace to some silt and trace clay. Occasional organics were encountered in the sand layer in Borehole CN16-02, and occasional cobbles were encountered in Boreholes CN16-02 and CN16-06.

The thickness of the upper sand layer ranged from 1.1 m to 10.4 m, with the lower boundary of the sand layer encountered at depths ranging from 4.1 m to 11.8 m (Elevation 318.5 to 314.5).

SPT N-values recorded in the upper sand ranged from 4 blows for 0.3 m penetration to 100 blows for 0.175 m penetration, indicating a loose to very dense relative density.

Moisture content of samples of the upper sand generally ranged from 3 percent to 28 percent.

Select samples of the upper sand underwent laboratory gradation analysis. These results are summarized on the Record of Borehole sheets included in Appendix A and B and the grain size distribution curves for these samples are plotted on Figure A2 and A3 and Figure B1. The results of this testing are summarized as follows:

Soil Particles	Upper Sand (%)
Gravel	0 to 27
Sand	64 to 97
Silt and Clay	2 to 22

5.5 Silty Sand to Sandy Silt

A silty sand pocket was encountered below the silty clay till in Borehole CN16-06 at a depth of 13.3 m (Elevation 312.6). The silty sand pocket contained some clay and trace gravel, with a thickness of 2.4 m and a lower boundary at 15.7 m (Elevation 310.2).

A sandy silt pocket was also encountered within the silty clay in Borehole CN16-03 at a depth of 14.8 m (Elevation 306.5). The sandy silt pocket contained some clay, with a thickness of 0.9 m and a lower boundary at 15.7 m (Elevation 305.6).

SPT N-Values recorded in the silty sand and sandy silt ranged from 39 blows to 90 blows for 0.3 m penetration, indicating a dense to very dense relative density.

Moisture content of samples of the silty sand to sandy silt generally ranged from 16 percent to 19 percent.

One sample of silty sand underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure A4.

Soil Particles	Silty Sand (%)
Gravel	6
Sand	59
Silt	20
Clay	15

5.6 Silty Clay Till

A layer of silty clay till was encountered below the upper sand layer in all boreholes at this site, at depths ranging from 4.1 m to 11.8 m (Elevation 318.5 to 314.5).

The silty clay till was generally grey in colour and contained some sand to sandy and trace gravel.

The thickness of the silty clay till ranged from 3.0 m to 8.2 m, with the lower boundary encountered at depths ranging from 10.0 m to 20.0 m (Elevation 313.8 to 306.3).

SPT N-values recorded in the silty clay till ranged from 15 blows for 0.3 m penetration to 100 blows for 0.2 m penetration, indicating a very stiff to hard consistency.

Moisture content of samples of the silty clay till generally ranged from 8 percent to 26 percent.

Select samples of the silty clay till underwent laboratory gradation analysis and Atterberg Limits testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and Appendix B and the grain size distribution curves for these samples are plotted on Figure A5 and Figure B2. The results of the Atterberg Limits tests are plotted on Figure A11 and B5.

Soil Particles	Silty Clay Till (%)
Gravel	1 to 3
Sand	16 to 30
Silt	47 to 55
Clay	19 to 35

Index Property	
Liquid Limit	22 to 28
Plastic Limit	13 to 16
Plasticity Index	9 to 13

The above results indicate that the silty clay till is of low plasticity with a group symbol of CL.

It should be noted that glacial tills are known to contain cobbles and boulders.

5.7 Sandy Gravel

A pocket of sandy gravel was encountered below the silty clay till in Borehole CN16-05 at a depth of 14.8 m (Elevation 310.7). The sandy gravel was generally grey in colour and contained trace silt and clay and occasional cobbles.

The thickness of the sandy gravel pocket was 1.5 m, with the lower boundary encountered at a depth of 16.3 m (Elevation 309.2).

The SPT-N value recorded in the sandy gravel was 55 blows for 0.3 m penetration, indicating a very dense relative density.

The moisture content of the sample of the sandy gravel was 12 percent.

One sample of the sandy gravel underwent laboratory gradation analysis, the results which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure A6.

Soil Particles	Sandy Gravel (%)
Gravel	51
Sand	30
Silt and Clay	19

5.8 Silty Clay

A thick layer of silty clay was encountered below the silty clay till layer in Boreholes CN16-01 to CN16-04, CN16-07, CN16-08, 08-041 and 08-042. Silty clay was also encountered below the sandy gravel pocket in CN16-05 and the silty sand pocket in CN16-06.

The silty clay layer was encountered at depths ranging from 10.0 m to 20.0 m (Elevation 313.8 to 306.3).

The silty clay was generally grey in colour and contained trace sand to sandy and trace gravel. Occasional cobbles were encountered in Borehole CN16-05.

Boreholes CN16-01, CN16-02, CN16-06 to CN16-08 and 08-042 were terminated in the silty clay layer at depths ranging from 15.8 m to 37.0 m (Elevation 310.0 to 289.1).

In Boreholes CN16-03 to CN16-05 and 08-041, the thickness of the silty clay ranged from 14.4 m to 27.4 m, with the lower boundary encountered at depths ranging from 33.7 m to 40.7 m (Elevation 291.9 to 282.6).

SPT N-values recorded in the silty clay ranged from 19 blows for 0.3 m penetration to 100 blows for 0.1 m penetration, indicating a very stiff to hard consistency.

Moisture content of samples of the silty clay generally ranged from 12 percent to 39 percent.

Select samples of the silty clay underwent laboratory gradation analysis and Atterberg Limits testing, the results of which are summarized below. These results are also presented on the

Record of Borehole sheets in Appendix A and Appendix B and the grain size distribution curves for these samples are plotted on Figure A7 and A8 and Figure B3. The results of the Atterberg Limits tests are plotted on Figure A12, A13 and B6.

Soil Particles	Silty Clay (%)
Gravel	0 to 3
Sand	0 to 36
Silt	24 to 57
Clay	16 to 66

Index Property	
Liquid Limit	22 to 48
Plastic Limit	12 to 21
Plasticity Index	10 to 27

The above results indicate that the silty clay is of low to intermediate plasticity with a group symbol of CL – CI.

5.9 Lower Sand

A lower sand pocket was encountered within the silty clay in Borehole CN16-02 at a depth of 34.4 m (Elevation 291.6).

The lower sand was generally grey in colour and contained some silt and trace clay.

The thickness of the lower sand pocket was 1.7 m, with the lower boundary encountered at a depth of 36.1 m (Elevation 290.0).

The SPT-N value recorded in the lower sand was 100 blows for 0.3 m penetration, indicating a very dense relative density.

The moisture content of the sample of the lower sand was 21 percent.

One sample of the lower sand underwent laboratory gradation analysis, the results which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curve for this sample is plotted on Figure A9.

Soil Particles	Lower Sand (%)
Gravel	0
Sand	77
Silt	16
Clay	7

5.10 Sandy Silt Till

A sandy silt till layer was encountered below the silty clay in Boreholes CN16-03 to CN16-05 and 08-041, at depths ranging from 33.7 m to 40.7 m (Elevation 291.9 to 282.6).

The silt till was generally grey in colour, and contained some sand to sandy, trace to some gravel, trace to some clay, with occasional cobbles encountered in Borehole CN16-05.

Boreholes CN16-03 to CN16-05 and 08-041 were terminated in the silt till at depths from 37.2 to 41.3 m (Elevation 289.1 to 282.0).

All SPT N-values recorded in the silt till were above 100 blows for 0.3 m penetration, indicating a very dense relative density.

Moisture content of samples of the silt till generally ranged from 13 percent to 26 percent.

Two samples of the silt till underwent laboratory gradation analysis. These results are summarized on the Record of Borehole sheets included in Appendix A and B and the grain size distribution curves for these samples are plotted on Figure A10 and B4. The results of this testing are summarized as follows:

Soil Particles	Silt Till (%)
Gravel	0 to 6
Sand	19 to 28
Silt	50 to 75
Clay	6 to 16

It should be noted that glacial tills are known to contain cobbles and boulders.

5.11 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Three standpipe piezometers were installed at this site, in Borehole CN16-01, CN16-04 and CN16-07, to monitor water levels after completion of drilling. One piezometer was installed in the previous investigation, in Borehole 08-042. The water levels measured in the piezometers are summarized in Table 5.1, along with the measurements in the open boreholes upon completion of drilling.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
CN16-01	Aug 31, 2018 Aug 08, 2019 Aug 29, 2019	8.3 8.1 8.3	317.2 317.4 317.2	Piezometer
CN16-02	July 04, 2019	-	-	Water level upon completion not available due to mud rotary drilling method.
CN16-03	Aug 26, 2019	-	-	Water level upon completion not available due to mud rotary drilling method.
CN16-04	Aug 29, 2019	16.8	306.6	Piezometer
CN16-05	July 08, 2019	-	-	Water level upon completion not available due to mud rotary drilling method.
CN16-06	July 08, 2019	-	-	Water level upon completion not available due to mud rotary drilling method.
CN16-07	Aug 31, 2019	5.8	315.0	Piezometer
CN16-08	Aug 29, 2019	-	-	Water level upon completion not available due to mud rotary drilling method.
08-041	Aug 11, 2008	-	-	Water level upon completion not available.

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
08-042	Aug 20, 2008	7.9	314.9	Piezometer

The above values are short-term readings and seasonal fluctuations of the groundwater level 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

A sample of the silty sand fill from Borehole CN16-04 (depth of 2.6 m) was 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 C.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Test Results
		CN16-04 (SS4 at 2.6 m) (Soil Sample)
Soil Redox Potential	mV	312
Sulphide	%	< 0.02
pH	pH Units	8.29
Chloride	µg/g	7.8
Sulphate	µg/g	12
Conductivity	uS/cm	317

Parameter	Units (Soil)	Test Results CN16-04 (SS4 at 2.6 m) (Soil Sample)
Resistivity (calculated)	ohms.cm	3200

7. MISCELLANEOUS

Landshark Drilling of Brantford, Ontario supplied a rubber track mounted B-57 drill rig and conducted the drilling, sampling and in-situ testing operations for the investigation.

The coordinates and elevations for the boreholes were provided by WSP.

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

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

Overall supervision of the field program for the investigation was conducted by Dr. Nancy Berg, P.Eng. Interpretation of the data and preparation of the report was carried out by Ms. Judy Mei, EIT, and Dr. Nancy Berg, P.Eng.

Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, 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 an 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 a new structure to carry the Metrolinx dual tracks over the proposed Wellington Street North to Edna Street Connection and E-S ramp roadways to be located west of the KWE and the existing Metrolinx bridge in the Regional Municipality of Waterloo, Ontario.

The General Arrangement (GA) drawing provided by WSP, dated April 2015, indicates that the new Metrolinx bridge over Wellington Street to Edna Street Connection and E-S Ramp will be a two span rigid frame structure supported by two abutments and a pier with proposed strut beams connecting the base of the abutments to the pier. The proposed length of the structure is 28 m, with each span being 14 m in length and the width is 10.0 m. The new Metrolinx Railway Wellington Street to Edna Street Connection and E-S ramp roadways will be constructed in a cut through the Metrolinx embankment and native ground ranging from 7.5 m to 8 m in total depth, and the final grade within the zone of the proposed Metrolinx bridge will be at approximate Elevations ranging from 319.5 to 319.7. Metrolinx tracks, within the structure limits, will be maintained at the existing Elevation ranging from 326.9 to 326.7.

Subject to discussions with Metrolinx, construction of the structure will likely have to be done in stages in order to keep at least one track in operation. Track protection will be required for this stage of construction.

It is understood that the new Metrolinx bridge will be constructed approximately 40 to 50 m west of the existing west abutment of the rail bridge over Highway 85.

This foundation investigation and design report, with the interpretation and recommendations, is 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.

The discussions and recommendations presented in this report are based on the information provided by WSP/MTO and on the factual data obtained in the course of this investigation.

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 changes, the geotechnical assessment and recommendations will need to be reviewed and revised as necessary. Since the bridge will be used to carry rail tracks, foundation recommendations have also considered AREMA guidelines.

10. STRUCTURE FOUNDATION

The stratigraphy identified in the geotechnical investigation consisted primarily of loose to compact silty sand fill over native compact to very dense sand, overlying very stiff to hard silty clay till. An extensive deposit of hard silty clay was contacted below the silty clay till. Underlying the silty clay, very dense sandy silt till was contacted. The groundwater level is expected to range from 8.1 m to 16.8 m below the ground surface (Elevation 317.5 to 306.6) based on piezometer measurements.

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

1. Spread footings bearing on native soil
2. Spread footings on engineered fill
3. Augered caissons (drilled shafts)
4. Steel H-piles or steel pipe piles driven into the very dense glacial till soils

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix G.

10.1 Spread Footing on Native Soil

Spread footings bearing on native soil are generally a cost-effective form of foundation and are feasible at this site, however approximately 9 m to 10 m deep temporary excavations will be required to construct the footings. The proposed base of the abutment footing is at approximately Elev. 318.0 based on the centerline roadway elevation being at approximate elevation 319.5 to 319.7.

The existing fill is not considered suitable for the support of spread footings, and the spread footings should bear on native undisturbed dense to very dense sand and very stiff to hard silty clay till. Provided a minimum footing width of 2 m is maintained, the spread footings may be designed in accordance with the elevations and bearing resistances given in Table 10.1.

Table 10.1 – Geotechnical Resistances for Spread Footings

Foundation Unit	Borehole	Approximate Highest Founding Elevation (m)	Founding Stratum	Factored ULSf (kPa)	Factored SLSf (up to 25 mm settlement) (kPa)
West Abutment	CN16-02 CN16-04	318.5	Dense Sand	500	350
Pier	CN16-02 CN16-03 CN16-08	318.0	Dense Sand	500	350
East Abutment	CN16-01 CN16-05 CN16-07	318.0	Dense Sand	500	350

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 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions. Based on AREMA guidelines, an allowable bearing capacity of 350 kPa should be used for footing design.

The bearing resistances in Table 10.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2019) Clauses 6.10.2 to 6.10.5.

The geotechnical SLS values, as well as the allowable bearing capacity value, given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure or between foundation elements.

The sliding resistance of cast-in-place concrete placed on the native, undisturbed soils may be computed based on an ultimate coefficient of friction, tan δ, 0.35 for the very stiff silty clay and 0.45 for dense to very dense sand. A resistance Factor of 0.6 for cohesive soils and 0.8 for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

The groundwater level measured in the two piezometers ranged from 8.1 m to 16.8 m below the ground surface (Elevation 317.5 to 306.6). There may be a perched water table in the fill. Local groundwater control, as discussed in Section 17, may be required to construct the footing in the dry and to prevent disturbance and base heave of the footing base.

The bases of the foundation excavations should be inspected by a Foundation Specialist to confirm that the exposed subgrade surface conforms to the design requirements and has been adequately prepared to receive concrete. Once approved, the subgrade should be protected by a working mat with a minimum thickness of 100 mm and consisting of concrete of the same strength and class as that of the footing. Where sub-excavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using the same concrete.

10.2 Spread Footing on Engineered Fill

Spread footings can also be founded on Granular "A" engineered fill pads, where this is beneficial to the overall design and are feasible at this site. However, this option will involve deep temporary excavation to construct the engineering fill pad.

If an engineered fill pad is used, all topsoil, organics or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. Subexcavation of existing surficial fill soils will be required. The engineered fill will bear on native very stiff silty clay or clayey silt till and the highest permitted founding/base elevation at which engineered fill pads may be placed, is given in Table 10.2.

Table 10.2 – Highest Founding Elevations for Engineered Fill Pads

Foundation Unit	Borehole	Highest Founding Elevation (m)
West Abutment	CN16-02 CN16-04	318.5
Pier	CN16-02 CN16-03 CN16-08	318.5
East Abutment	CN16-01 CN16-05 CN16-07	318.0

Provided a minimum footing width of 2 m is maintained footings bearing on the well compacted engineered fill pad, at least 2-m thick, may be designed for the following geotechnical resistances:

Factored Geotechnical Resistance at ULS	900 kPa
Factored Geotechnical Resistance at SLS	350 kPa

These resistance values are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC Clauses 6.10.2 to Clause 6.10.5. Based on AREMA guidelines, an allowable bearing capacity of 350 kPa may be used for footing design.

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 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

Temporary excavations required to construct the engineered fill pad is expected to be just above the water table. However, there may be perched water in the fill. Local groundwater control, as discussed in Section 17, may be required to construct the engineered fill pad in the dry and to prevent disturbance of the engineered fill pad base.

For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is expected to not exceed 25 mm. Differential settlements are not expected to exceed 20 mm across the width of the structure.

The sliding resistance of cast-in-place concrete placed on the engineered fill may be computed based on an ultimate coefficient of friction, tan δ, of 0.55. A resistance Factor of 0.6 for cohesive soils and 0.8 for cohesionless soils should be applied, as indicated in Table 6.2 in the CHBDC (2019).

The bases of the foundation excavations should be inspected by a Foundation Specialist to confirm that the exposed surface conforms to the design requirements and has been adequately prepared to place the engineered fill. The Granular A for the engineered fill pad must be compacted to 100% Standard proctor maximum dry density (SPMDD) at optimum moisture content of ±2%,and placed in 300 mm lifts. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix F.

10.3 Augered Caissons (Drilled Shafts)

Drilled shaft foundations founded on very dense sandy silt till were considered for the support of structural loads at this site. However, augered caissons (drilled shafts) are not recommended for use as foundation support at this site, due to the depth to suitable bearing material, greater than 20 m, and potential caisson installation difficulties including basal boiling and heave within the water bearing sand and sandy silt till deposit below the silty clay layer. Sealing of the caisson liner into the founding stratum may be difficult.

10.4 Steel H-Piles and Steel Pipe Piles

From a foundation engineering perspective, it is feasible to support the structure on steel H-piles driven to practical refusal in the very dense sandy silt till. Open ended steel pipe piles may also be considered as an alternate foundation option. It should be noted that pipe piles driven into very dense sandy silt till deposit are more prone to pile tip damage in comparison to H-piles.

It is recommended that the H-piles be driven to achieve resistance in the very dense sandy silt till encountered at this site.

10.4.1 Axial Resistance

The axial resistances of HP 310 X 110 and HP 360 x 132 steel piles, and 324 mm diameter and 356 mm diameter steel piles driven to refusal in very dense cohesionless till were assessed based on the subsurface conditions encountered at the abutment locations. The estimated Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS), as well as the recommended pile tip elevations are summarized in Tables 10.3 and 10.4.

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Table 10.3 – Estimated Axial Resistance and Pile Tip Elevation for H-Piles

Foundation Unit	Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section HP 310 X 110		Pile Section HP 360 X 132	
				Factored ULS (kN)	Factored SLS_f (kN)	Factored ULS (kN)	Factored SLS_f (kN)
West Abutment	CN16-04	282.0	36.0	1,500	1,300	1,650	1,450
Pier	CN16-03	284.0	34.0	1,500	1,300	1,650	1,450
East Abutment	CN16-05	287.0	31.0	1,500	1,300	1,650	1,450

Table 10.4 – Estimated Axial Resistance and Pile Tip Elevation for pipe piles

Foundation Unit	Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section 324 mm diameter Wall Thickness 12.7 mm		Pile Section 356 mm diameter Wall Thickness 12.7 mm	
				Factored ULS (kN)	Factored SLS_f (kN)	Factored ULS (kN)	Factored SLS_f (kN)
West Abutment	CN16-04	282.0	36.0	1,200	1,050	1,400	1,200
Pier	CN16-03	284.0	34.0	1,200	1,050	1,400	1,200
East Abutment	CN16-05	287.0	31.0	1,200	1,050	1,400	1,200

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 SLS values correspond to a maximum pile settlement of 25 mm. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions. Based on AREMA guidelines, allowable pile capacity values equivalent to the above SLS values for respective pile types may be used for pile design.

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

10.4.2 Downdrag

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

10.4.3 Lateral Resistance

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (k_s) and the ultimate lateral resistance (P_{ult}) as follows:

Silty Clay (cohesive soils)

k_s = $67\ C_u / B$ (kN/m^3)

p_{ult} = $9\ C_u$ (kPa) at and below a depth of 3B reduced to zero at ground surface

where p_{ult} = ultimate lateral resistance mobilized by a pile, kPa

C_u = undrained shear strength of cohesive soils, kPa

γ = unit weight of soil, kN/m^3

B = width of pile, m

Sand and Sand, Sandy Silt Till (cohesionless soils)

k_s = $n_{h.}\ z / B$ (kN/m^3)

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

where z = depth of embedment of pile, m

B = pile width, m

n_h = coefficient related to soil density, kN/m^3 , Table 10.5

γ' = Bouyant unit weight of soil, kN/m^3, Table 10.5

K_p = passive earth pressure coefficient, Table 10.5

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance.

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

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 10.5 below.

Table 10.5 – Recommended Geotechnical Parameters for Lateral Resistance Design

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
West Abutment	CN16-04	323.3 to 320.3	-	20	2.9	2,200	Loose to compact silty sand fill
		320.3 to 317.5	-	21	3.3	5,500	Compact to Dense sand
		317.5 to 316.2	-	11*	3.5	5,500	Dense sand
		316.2 to 310.1	180	10*	-	-	Very stiff to hard silty clay till
		310.1 to 282.6	200	10*	-	-	Hard silty clay
		282.6 to 282.0	-	11*	3.8	8,000	Very dense sandy silt till
Pier	CN16-02	326.0 to 323.1	-	20	2.9	2,200	Loose to compact silty sand fill
		323.1 to 317.5	-	21	3.3	5,500	Compact to Dense sand
		317.5 to 315.0	-	11*	3.3	3,500	Compact to Dense sand
		315.0 to 311.3	180	10*	-	-	Very stiff to hard silty clay till

		311.3 to 291.6	200	10*	-	-	Hard silty clay
		291.6 to 290.0	-	11*	3.8	8,000	Very Dense Sand
		290.0 to 289.1	200	10*	-	-	Hard silty clay
East Abutment	CN16-05	325.5 to 321.4	-	20	2.9	2,200	Loose to compact silty sand fill (with organics removed)
		321.4 317.5	-	21	3.4	6,500	Dense sand
		317.5 to 316.0	-	11*	3.6	6,500	Dense to very dense sand
		316.0 to 310.7	180	10*	-	-	Very stiff to hard silty clay till
		310.7 to 309.2	-	11*	3.8	8,000	Very Dense Sand and Gravel
		309.2 to 287.9	200	10*	-	-	Hard silty clay
		287.9 to 287.3	-	11*	3.8	8,000	Very dense sandy silt till

* Bouyant unit weight below water table

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.22, C6.23 and C6.24 of the CHBDC (2019), S6:19 (Commentary).

10.4.4 Pile Installation

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

At this site, the piles will have to be driven through hard silty clay till and silty clay into very dense sandy silt till.

Pile driving must be controlled in accordance with Standard Provision SS103-11 (Hiley Formula) and an ultimate pile resistance must be specified by the designer. The Hiley formula does not need to be used until the pile tip is within 2 m of the design tip elevation. The appropriate pile driving note to be shown on the contract drawing is "Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of R kN per pile" where "R" must have a minimum value of twice the factored design load at ULS. It is recommended that Pile Driving Analysis (PDA) testing be conducted in conjunction with the Hiley tests at this site, to ensure the integrity of the pile and to verify pile ultimate geotechnical resistance. PDA testing should be completed for 10 percent the piles for each foundation element or a minimum of 2 piles tested at each foundation element, whichever is more.

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

Glacially derived soils inherently contain cobbles and boulders. Hard driving conditions through the very dense sandy silt till should be expected. In order to minimize pile damage while driving through boulders, cobbles and dense zones to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point) or equivalent.

Pile tip protection should be provided for open ended pipe piles.

The Contract Documents must contain a NSSP alerting the Bidders to the presence of cobbles and boulders in the glacial tills. Suggested texts for the NSSP's are included in Appendix I. The NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

10.5 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 the integral abutment manual for details of this system. Piles should be driven first before pouring in loose uniform sand between the CSP surround and the pile.

It is recognized that the rigid frame bridge will probably be constructed in accordance with AREMA and with conventional abutments as per the GA drawing.

10.6 Frost Cover

The design depth of frost penetration for this site is 1.4 m. All footing bases and undersides of pile caps/abutment stems must be provided with at least 1.4 m of soil cover.

10.7 Recommended Foundation

From a geotechnical perspective, and based on available information, the recommended foundations at this site are the following:

- For integral abutments, it is recommended that the abutments be supported on steel H-piles driven into the very dense sandy silt till.
- For non-integral abutments (e.g. rigid frame structure proposed in the GA drawing), it is recommended that the abutments be supported on spread footings founded on native undisturbed very stiff silty clay or dense to very dense sand. The abutments and piers for a rigid frame structure may also be founded on steel H-piles driven into the very dense sandy silt till.

11. RETAINING WALLS

The GA drawing dated April 2015 indicates that construction of four concrete retaining walls are planned at each corner of the proposed structure to retain the existing railway embankment fill and native soils. The locations and lengths of the proposed retaining walls are presented in Table 11.1. Further details of the retaining walls were not provided.

Table 11.1 – Geotechnical Resistances and Founding Strata and Elevations for Retaining Walls

Location relative to the structure	Borehole	Length (m)	Height (m)
Northeast	CN16-01 CN-16-05	15	1 to 7
Northwest	CN16-02	15	1 to 7
Southeast	CN16-07	15	1 to 7
Southwest	CN16-04	15	1 to 7

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To provide an acceptable foundation performance, the retaining walls must be founded on native compact silty sand/sandy silt/sand or very stiff silty clay. The highest recommended base levels for the retaining walls are as presented in Table 11.2.

Table 11.2 – Geotechnical Resistances and Founding Elevations for Retaining Walls

Retaining Wall Location	Borehole	Highest Founding Elevation (m)	Founding Stratum	Factored ULS_f (kPa)	Factored SLS_f (up to 25 mm settlement) (kPa)
Northeast	CN16-01 CN-16-05	318.0	Dense to Very dense silty sand/sand	500	350
Northwest	CN16-02	320.0	Dense Sand	500	350
Southeast	CN16-07	318.0	Dense Sand	500	350
Southwest	CN16-04	318.5	Dense Sand	500	350

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC (2019) Clauses 6.10.2 to 6.10.5. The geotechnical SLS values given above are based on an estimated total settlement not exceeding 25 mm. Based on AREMA guidelines, allowable bearing capacity values equivalent to the above factored SLS values should be used for retaining wall foundation design for the North and South retaining walls respectably.

The sliding resistance of cast-in-place concrete placed on the native, undisturbed soils may be computed based on an ultimate coefficient of friction, tan δ, 0.45 for the compact to dense silty sand, and sand. A resistance Factor of 0.6 should be applied for cohesive soils and, 0.8 for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

A 600-mm thick layer of organics was encountered at 3.5 m depth (Elevation 322.0) in Borehole CN16-05. This layer must be removed within the retaining wall footprint before construction of the retaining wall foundations.

If required, the retaining wall may be founded on engineered fill founded on the compact to dense silty sand/sandy silt/sand/sand/gravelly sand and hard silty clay. Engineered fill placed under the retaining wall to achieve the design founding level must consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum.

The sliding resistance of cast-in-place concrete placed on the engineered fill may be computed based on an ultimate coefficient of friction, tan δ, of 0.55. A resistance Factor of 0.8 should be applied for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

Topsoil, organics, loose fill, and any soft/wet material must be stripped from the footprint of the retaining wall. The subgrade under the retaining wall foundation should be inspected and any soft/loose spots should be sub-excavated and replaced with compacted granular materials prior to placing fill. The subgrade preparation for the retaining wall and placement and compaction of the granular fill must be carried out in the dry. Dewatering may be required to prepare the founding base.

Lateral earth pressures acting on the walls should be computed as described in Section 12. If the wall is retaining sloping backfill, appropriate earth pressure parameters for sloping backfill should be used.

The concrete retaining walls must be designed in accordance with American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering and METROLINX General Guidelines for Design of Railway Bridges and Structures (November 2018). These guidelines are adapted from CN Engineering Guidelines for Design of Railway Structures as per the agreement between METROLINX and CN on March 28, 2013.

11.1 Slope Stability of the Retaining Walls

Preliminary analysis of the global stability was conducted to assess stability of retaining walls founded on compact to dense silty sand/ sand and very stiff silty clay till.

The global stability of the retaining walls must be revisited if the final locations and/or detail configurations of the walls are changed.

Global stability analyses were carried out for the retaining walls utilizing the commercially available slope stability analysis program Slope/W (Version 2019) 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 from standpipe piezometer.

The stability of the embankment was also checked under seismic loading assuming an acceleration of 0.097 g.

Results of the stability analyses are presented on Figures H1 to H3 in Appendix H. The results are also summarized in Table 11.3 below.

Table 11.3 - Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix G)
Retaining wall		
Static Drained	1.6	H1
Static Undrained	1.6	H2
Seismic = 0.097 g	1.3	H3

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term conditions and for total stress (undrained) conditions. A F.S. of 1.5 is acceptable for long term (drained) conditions. Under the assumed seismic loading, the minimum acceptable factor of safety is 1.1. In the case of static loading, the factors of safety against global failure was 1.6 for drained conditions and 1.6 for undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.3. These factors of safety are considered to be acceptable for the proposed retaining wall bearing on the dense native soils encountered at this site.

11.2 Settlement of the Retaining Walls

The construction of the retaining walls, with heights of up to 7.0 m with new granular backfill behind the walls will induce immediate (elastic) settlement in the underlying compact to very dense sand/silty sand, and very stiff to hard silty clay till.

The immediate settlements were assessed using elastic methods. Based on these analyses, the settlement is estimated to be less than 25 mm. This settlement will be immediate and essentially complete when construction of the retaining wall is completed.

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12. LATERAL EARTH PRESSURES

Earth pressures acting on a structure (e.g. abutment or retaining wall), may be assumed to be triangular 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. The bridge end of the retaining wall near the railway may be subjected to live train loads.

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 $\phi = 35°$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°$, $\gamma = 21.2$ 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	-

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.

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

The factors 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 and the retaining walls. Reference may be made to OPSD 3102.100 where appropriate.

13. NORTH/SOUTH APPROACH - PERMANENT CUT

Permanent earth cuts are required near and through the existing Railway embankment to construct the Wellington Street North to Edna Street Connection and E-S Ramp at this site. Based on available information and GA drawing, the maximum proposed permanent cut for the connection roads will be approximately 3 to 6.5 m below the surrounding grade. Within the zone of the proposed Metrolinx bridge, the base of cut will be at approximate Elevation 319.5 at the centreline of the roadway. Permanent cuts will extend north and south of the proposed Metrolinx rail bridge with the depth of the permanent cut ranging from approximately 4 m to 8 m. It is anticipated that the soils at the base of the cut will consist of compact to very dense silty sand/sandy silt. The earth cut will be formed through loose to compact silty sand to sand fill, loose to dense silty sand/sand. Part of the earth cut will be through the existing railway embankment. The fill type for the embankment is unknown. Additional borehole drilling should be completed to determine the soil conditions of the railway embankment. The groundwater level measured in the piezometers was 8.1 to 16.8 m below the ground surface (Elevation 317.5 to 306.6). Permanent cuts will have stable side slopes at inclinations no steeper than 2H:1V.

Although not investigated, railway embankment fill typically contains obstructions such as cobbles and boulders and other obstructions.

Based on the provided GA drawing the permanent cut slopes near the existing railway embankment will be supported by the abutment walls and retaining walls.

Drainage will be required in the depressed section of the cut to remove water originating from:

- Storm runoff
- Seepage from the sides of the cut
- Cut below ground water level

Temporary drainage of the cuts should be provided to maintain a relatively dry, stable excavation. Permanent drainage of the cuts must be provided. Permanent positive drainage of the permanent cuts and road base must be provided.

The cohesionless soils encountered at this site above the silty clay till deposit (i.e. mostly above Elev. 316) are considered to be generally permeable and consequently seepage from the soil into the cut is expected to occur. It is recommended that this seepage be drained by means of the drains incorporated behind the abutments and by subdrains installed along each side of the connection road. The subdrains along the proposed road must be placed 1.4 m below the finished grade and must lead to a positive frost free outlet.

It is also recommended that all permanent and temporary 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 as necessary to maintain slope stability.

Further recommendations for temporary cut and excavation are presented in Section 15.

If space is limited, temporary protection (shoring) will be required for the temporary excavation operations in the proximity of the tracks. Recommendations for temporary protection (shoring) are presented in Section 18 of this report.

14. EAST/WEST RAILWAY APPROACH EMBANKMENTS

Within the area of the proposed Wellington to Edna Connection and E-S ramp bridge structure, the road connection grade will be near Elevation 319.5 at the centreline and Metrolinx tracks will be at Elevation 326.9 to 326.7. Currently, at the site, the twin tracks are built on an embankment which is approximately 1 to 5 m high from north to south. It is not anticipated that new fill will be placed to change the slope of the existing railway embankment based on the GA.

Due to access constraints and restrictions imposed by Metrolinx, no boreholes were advanced through the existing railway embankment. For this reason, the material that would be encountered while excavating through the existing embankment is unknown and boreholes should be advanced through the railway embankment prior to design of the temporary protection/support systems by the party responsible for this work to obtain sufficient subsurface information. Obstructions such as cobbles, boulders, and railway ties may be encountered during excavation within the railway embankment fill. Boreholes should not only extend through the railway embankment. They should be drilled deep enough to confirm footing base elevation and design pile tip elevation. Embankments constructed using granular material, select subgrade material, or clean earth fill will have stable side slopes at inclinations of up to 2H:1V.

All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206, OPSS.PROV 501, and AREMA Section 27.6.1 requirements and the clean earth fill must not contain medium or high plastic clay.

The embankment surface and the track level and alignment should be monitored throughout and after construction to identify any construction induced settlement. The Contractor must be prepared to work with Metrolinx to restore the track base and alignment if track settlement or movement is detected.

14.1 Slope Stability of Side Slope

The side slopes of the existing Railway embankments are not expected to be changed during the construction of the proposed Metrolinx Wellington Street to Edna Street Connection and E-S ramp. If the existing slope is cut into or the slope angle is changed during construction a global slope stability analysis will need to be completed.

The global, internal and surficial stability of the approach embankment fills will depend on the slope geometry and also to a large degree on the material used to construct the embankments. Embankments constructed using granular material, select subgrade material or clean earth fill will have stable side slopes at inclinations of no steeper than 2H:1V.

14.2 Settlement

No settlement is expected since no new fill is expected to be placed on the approach embankments. If new fill is required to be placed to change the slopes of the existing railway embankment a settlement analysis will need to be completed.

15. TEMPORARY EXCAVATION

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 and SP 105S09.

Excavation for foundation construction will be extended through the loose to compact sandy silt fill and silty sand fill and native compact to very dense silty sand/sand. For the purposes of the OHSA, the native soils above the water table are classified as Type 3 soil. The native very stiff to hard silty clay and silty clay till deposit is classified as Type 2 soil. Cohesionless soils below the water table and fills are classified as Type 4 soil. A layer of organics was contacted below the cohesionless fill in Borehole CN16-05, and this soil layer is classified as Type 4 soil.

Obstructions such as cobbles, ballast and railway ties may be encountered during excavation within the railway embankment fill. The information provided by the borehole investigation is limited and therefore the potential presence of obstructions in the railway embankment must be anticipated. Procedures to penetrate or remove these potential obstructions must be developed prior to the start of construction.

Development of the construction/excavation methodology must be carried out in consultation with Metrolinx. Selection of the appropriate construction technique must take into account the need to avoid settlement and loss of ground below the rail tracks. The embankment surface and the track level and alignment should be monitored before, throughout and after cut/excavation to identify any induced settlement.

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. Excavations should regularly be 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.

All excavations must be carried out in a manner that avoids destabilising the foundations of the existing bridge, slopes and tracks.

16. BACKFILL TO ABUTMENTS

For backfilling immediately behind the new abutment wall, 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, Granular B Type I or clean earth fill may be used.

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 3102.100.

17. GROUNDWATER AND SURFACE WATER CONTROL

Piezometric levels obtained at this site indicate that the groundwater level ranged from 8.1 to 16.8 m below the ground surface (Elevation 317.5 to 306.6). Seasonal fluctuations of the groundwater level are to be expected.

Excavation for footing/pile caps construction will be just above the groundwater level. Seepage or perched water from the granular layers is to be expected, which may require dewatering. Excavation of the cohesionless native soils below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work. Suitable systems that might be considered to maintain an unwatered condition at this site, include pumping from filtered sumps for nominal penetration below the groundwater level, sheeted excavation (cofferdam) or vacuum well-points for deeper excavations. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final footing/pile cap grade throughout construction.

Based on the grain size distribution curves, the coefficients of permeability (k) of the native soils are as follows:

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Soil	Permeability, k (cm/sec)
Sand/Sandy Gravel	6×10^{-2} to 1×10^{-4}
Silty clay	1×10^{-8}
Silty clay till	1×10^{-7}

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), and OPSS. PROV 902 and SP 105S09. It is recommended that a pre-construction condition survey of existing structures within 100 m of the site be carried out prior to commencement of construction. It is recommended that a Professional Engineer with greater than 5 years of experience in designing dewatering systems be retained by the Contractor. The dewatering plan must be signed/sealed by the P.Eng.

The design of the dewatering system that may be required is the responsibility of the Contractor, and the Contract Documents must alert him to this responsibility.

The groundwater and surface runoff must be controlled during construction to maintain a stable excavation and to allow concrete to be placed in a dewatered excavation. Placement of concrete or compacting engineered fill must be done in the dry. Dewatering must remain operational and effective until the footings are constructed and backfilled. Suggested wording for an NSSP in the regard is included in Appendix I.

18. RAIL TRACK PROTECTION AND SHORING

18.1 Rail Track Protection

Where open cut excavation is carried out, track protection should be supplied and designed in accordance with AREMA Section 28.1.5. Discussions with the railway authorities should be carried out to determine the required performance level of protection. Metrolinx Rail may require a more stringent performance level for railway protection.

It is anticipated that full closure of the twin rail tracks might not be an alternative for construction of the new bridge. Therefore, consideration should be given to develop and implement a staged construction plan at this site, which allows to maintain at least one of the rail tracks operating during construction of the new bridge. The design of railway protection should be the responsibility of the Contractor. However, potential options for use as temporary shoring/railway protection at this site include the installation of a caisson wall, soldier pile and lagging or sheet pile wall to support the rail tracks during construction. Potential obstructions in the existing embankment fill may result in difficulty driving sheet piles. The type and construction method of the rail track protection selected must consider constructability aspects, the impact on the railway tracks, and the risks associated with track movement during excavation under an operating railway. This would be achieved through the following possible construction sequence:

1. Install the rail track protection system below the existing twin rail tracks to support them during excavation of permanent cut and/or excavation and bridge construction.
2. Close one of the twin tracks, and maintain one of them operating.
3. Construct half portion of the new bridge in the zone were the tracks are closed.
4. Once this half of the bridge is completed, proceed to switch to the other rail track (open the rail tracks that were closed, and close the rail tracks that were open).
5. Built the second half of the bridge.

If closing of one track at a time is not an option at this site, then tunnelling should be considered such as a jack/push box tunnel.

The number of construction stages should be kept to a minimum in order to reduce the bridge cost, construction duration and any disruption to the rail operations.

All rail track protection should be designed by a Professional Engineer experienced in such designs.

18.2 Preliminary Geotechnical Parameters for Temporary Shoring

The design of track protection should be the responsibility of the Contractor. The material supported by the structure walls will consist of the existing embankment fills. Due to drilling constrains within the rail corridor, soil information was not able to be obtained for the existing embankment fill. It is recommended that additional boreholes through the embankments be advanced by the party responsible for the design of the temporary protection/support systems to obtain sufficient subsurface data prior to the design. Preliminary lateral earth pressures may be calculated using the parameters given below, however, it must be noted that boreholes will need to be drilled to confirm the consistency and strength of the railway embankment fill. The below given values are for flat ground behind the shoring. If there is any sloping fill behind the shoring the lateral earth pressures must be revisited.

γ	=	20 kN/m^3(Fills above GWL)
	=	21 kN/m^3(Native cohesionless soils above GWL)
γ_w	=	10 kN/m^3 (Fills below GWL)
	=	11 kN/m^3 (Native cohesionless soils below GWL)
	=	9 kN/m^3 (Native cohesive soils below GWL)
K_a	=	0.35 (Embankment fills)
	=	0.33 (Loose to compact silty sand to sand fill)
	=	0.30 (Compact to very dense native sand, silty sand)
	=	0.33 (Very stiff to hard silty clay/silty clay till)
K_o	=	0.52 (Embankment fills)
	=	0.50 (Loose to compact silty sand to sand fill)
	=	0.46 (Compact to very dense native sand, silty sand)
	=	0.50 (Very stiff to hard silty clay/silty clay till)
K_p	=	2.9 (Embankment fills)
	=	3.0 (Loose to compact silty sand to sand fill)
	=	3.4 (Compact to very dense native sand, silty sand)
	=	3.0 (Very stiff to hard silty clay/silty clay)

The design water level of Elevation 317.5 m is recommended.

The actual pressure distribution acting on the shoring system is a function of the construction sequence, and the relative flexibility of the wall and these factors must be considered when designing the shoring system. The design of all members of the shoring system should include the effects of surcharge loads such as those imposed by construction equipment and railway traffic (e.g. train loading). All shoring systems must be designed by a Professional Engineer experienced in such designs.

19. 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. The stratigraphy of the site consists of embankment fill over loose to compact silty sand to sand fill, overlying native compact to very dense silty sand so sandy silt. Below the cohesionless soils, an extensive deposit of very stiff to hard silty clay/silty clay till was contacted, underlain by very dense sandy silt till. This would correspond to a Seismic Site Class D 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 0.075 g as per the National Building Code of Canada (NBCC). Since this site is classified as Class D, the factored PGA for a 2% in 50-year probability of exceedance at this site is 0.097 g.

In accordance with Clause 6.14.7 of the CHBDC 2019, bridge abutments and retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 19.1 may be used:

Table 19.1 – 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/m^3	OPSS Granular B Type I ϕ = 32°, γ = 21.2 kN/m^3
Active (K_{AE})*	0.31	0.35
Passive (K_{PE})	3.6	3.1
At Rest (K_{OE})**	0.55	0.6

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

Based on review of the SPT data, seismically induced liquefaction of foundation soils is not considered to be a concern at this site.

20. ADJACENT STRUCTURES, RAIL TRACKS, AND BURIED UTILITIES

The potential presence of underground utilities at the site must 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 replacement 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.

Monitoring of the railway as well as any nearby underground utility and structures must be carried out during construction to identify any areas of settlement. A settlement monitoring program for construction under the Metrolinx right-of-way will need to be designed and implemented in accordance with Metrolinx's requirements. This program must be developed prior to construction for Metrolinx's review and approval. The monitoring of track settlement should be accomplished by means of surface and subsurface settlement monitoring points.

If pile driving is required close to adjacent structure(s), the following recommendations should be carried out prior to commencement of foundation construction:

- Implement a vibration and settlement monitoring program during and after construction of the new abutments to assess any potential adverse impact on the existing operating structure or railway tracks.
- Inspection of the existing structure during foundation construction to monitor if there is any movement or distress.
- The structural designers should assess the magnitude of settlement or horizontal displacement that would constitute a concern for the stability or serviceability of the existing operational structures. These limits should be incorporated into the monitoring program as review and alert levels.
- Carry out post-construction condition survey.

21. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the existing native silty sand, indicates the following conditions at the location tested:

- The potential for sulphate attack on concrete foundations from the surrounding soils is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested. The selection of class of concrete should consider the effects of the road de-icing salts.
- The potential for soil corrosion on metal is considered to be moderate.
- 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.

22. CONSTRUCTION CONCERNS

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

1. Protection of the Existing Rail Tracks

   It is anticipated that during the staged construction of the new bridge, one of the twin tracks will remain in service. The Contractor must provide adequate protection/support to ensure that the rail tracks are protected and their performance is not compromised.

2. Pile Installation

   Occasional cobbles and boulders were encountered in the boreholes during drilling operations (e.g. tri-cone grinding). Glacial till deposits inherently contain cobbles and boulders. Hard driving conditions through the hard/very dense soils should be expected. Pile tips should be reinforced with Titus steel (Standard H-point) to protect the driven piles from damage.

3. Excavation

   Hydraulic equipment is expected to be capable of excavating to the required depths at this site. If excavations advance below the existing groundwater level, groundwater control measures will have to be implemented in order to maintain stables sides and base in the excavation.

   The glacial tills contain cobbles and boulders. Equipment selected for excavation must be capable of penetrating, handling and/or removing these obstructions.

   No boreholes were drilled through the railway embankment and therefore it is unknown what material the embankment is comprised of. Boreholes are recommended to be drilled through the railway embankment by the party responsible for the design of the temporary protection/support systems before the design is carried out.

4. Impact of excavation on the rail tracks and embankment

   Daily visual inspection and settlement monitoring of the rail tracks and rail track embankment must be carried out in the vicinity of the construction works. If any soil loss, track damage or settlement is observed to occur, these matters must immediately be brought to the attention of the Metrolinx CA for determining if further action is required. The Contractor must be prepared to work with Metrolinx to restore the track base and alignment if movement is detected.

5. Groundwater Control and Impacts

   Seepage and perched groundwater will be encountered within the cohesionless fill and native sand/silty sand above the cohesive deposit. The impact of seepage or surface water could destabilize the sides and or base of the excavation. The Contractor's dewatering plan must be available for rapid implementation should the need arise. Proper groundwater and surface water control measures must be in place prior to commencing footing excavation. All footings/pile caps must be constructed in the dry. Groundwater control measures such as perimeter ditches and pumping from filtered sumps for nominal penetration below the groundwater level. For deeper excavation, sheeted excavation (cofferdam) or vacuum well-points should be implemented to remove any accumulation of water from the pile cap base/or footings prior to placing concrete. Surface runoff and precipitation should be diverted away from the excavations at all times. The Contractor's unwatering plan must be in place prior to commencing excavation. All footings/pile cap must be constructed in the dry.

The potential impact of drainage of the permanent cuts on the local groundwater table must be addressed by a hydrogeologist, who should also consider whether it is necessary to apply for an MOE Permit to Take Water (PTTW).

6. Existing Slopes and Cut Slopes

   The railway embankment side slopes should be inspected after construction for surficial disturbance. Where necessary, remedial measures such as re-vegetation and/or placement of gravel sheeting may be required.

   For temporary earth cut, the slopes should be inspected for surficial disturbance.

7. Removal of Organics

The thickness and presence of organic deposit were investigated at the borehole location only. The organics layer encountered at a depth of 3.5 m in borehole CN16-05 near the northeast retaining wall may extend to greater depths or be encountered at other locations beyond the borehole location. Careful inspection is crucial to confirm that the all organics within the footprint of the embankments, proposed retaining wall and bridge foundations and road base in the permanent cut have been excavated prior to construction.

23. CLOSURE

Engineering analysis and preparation of the report were carried out by Dr. Nancy Berg, 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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Principal/Senior Geotechnical Engineer

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Review Principal, Designated MTO Contact

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Appendix A

Record of Borehole Sheets and Laboratory Test Results

Present 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.

<u>UNIFIED SOILS CLASSIFICATION</u>

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

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RECORD OF BOREHOLE No CN16-01

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 134.5 E 226 136.6 | ORIGINATED BY SB

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY MP

DATUM Geodetic | DATE 2018.07.13 - 2018.07.13 | LATITUDE ____ | LONGITUDE ____ | CHECKED BY JPL

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
325.5	GROUND SURFACE					
0.0	Silty **SAND**, some clay, trace gravel, occasional organics, occasional cobbles Dense to Very Dense Brown Moist (FILL)	1	SS	31	325	
		2	SS	64	324	Auger grinding Auger grinding
	Loose	3	SS	6		3 56 27 14
		4	SS	30	323	
322.5 3.0	**SAND**, some silt, trace clay Loose to Compact Brown Moist	5	SS	51	322	
		6	SS	11	321	Switch to tricone
		7	SS	4	320, 319	
	Very Dense	8	SS	80	318	0 84 16 (SI+CL)
316.8 8.7	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)	9	SS	37	317, 316	

Continued Next Page

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

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/8/20

RECORD OF BOREHOLE No CN16-01

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 134.5 E 226 136.6 | ORIGINATED BY SB

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY MP

DATUM Geodetic | DATE 2018.07.13 - 2018.07.13 | LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty CLAY, some sand Very Stiff Grey Moist (TILL)				315	
		10	SS	24		
313.8 11.7	Silty **CLAY**, trace sand Very Stiff to Hard Grey Moist				314	
		11	SS	19	313	
					312	
		12	SS	26	311	
		13	SS	32	310	0 3 34 63
309.7 15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.					

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.08.31	8.3	317.2
2019.08.08	8.1	317.4
2019.08.29	8.3	317.2

Column headings: SOIL PROFILE; SAMPLES; 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/m³

$+^3, \times^3$: Numbers refer to Sensitivity   20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CN16-02

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 122.9 E 226 124.1 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.07.03 - 2019.07.04 | LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
326.1	GROUND SURFACE				326		
0.0	**TOPSOIL:** (100mm)						
0.1	Silty **SAND**, gravelly, trace clay, occasional cobbles, occasional organics, Compact, Brown, Moist (FILL)	1	SS	14		~4	
		2	SS	13	325	~5	24 38 30 8
		3	SS	12	324	~4	
	Dense	4	SS	42		~3	
323.1 / 3.0	**SAND**, some gravel to gravelly, trace silt and clay, occasional cobbles, occasional organics, Compact to Dense, Brown, Dry to Moist	5	SS	19	323	~7	Switch to tricone
	Wet	6	SS	32	322 / 321	~7	27 64 9 (SI+CL)
	Very Dense	7	SS	52	320 / 319	~8	
		8	SS	44	318	~8	
317.4 / 8.7	**SAND**, trace gravel, trace silt and clay, Dense, Brown, Wet	9	SS	39	317	~10	1 97 2 (SI+CL)

Chart headings: 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; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CN16-02

METRIC

GWP# 408-88-00 LOCATION MTM NAD 83 Zone 10: N 4 814 122.9 E 226 124.1 ORIGINATED BY BL

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH

DATUM Geodetic DATE 2019.07.03 - 2019.07.04 LATITUDE LONGITUDE CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.0	**SAND**, trace gravel, trace silt and clay Compact Brown Wet	10	SS	15	
311.0	Silty **CLAY**, some sand Very Stiff to Hard Grey Moist (TILL)	11	SS	40	
		12	SS	40	
311.3 14.8	Silty **CLAY**, trace sand Hard Grey Moist	13	SS	44	0 4 43 53
		14	SS	34	
		15	SS	38	

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (316, 315, 314, 313, 312, 311, 310, 309, 308, 307); 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.

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+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/8/20

RECORD OF BOREHOLE No CN16-02

METRIC

GWP# 408-88-00 LOCATION MTM NAD 83 Zone 10: N 4 814 122.9 E 226 124.1 ORIGINATED BY BL

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH

DATUM Geodetic DATE 2019.07.03 - 2019.07.04 LATITUDE LONGITUDE CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	Silty **CLAY**, trace sand, trace gravel Hard Grey Moist	16	SS	53	306	Tricone grinding
					305	
					304	
		17	SS	100/ 0.250	303	
					302	Tricone grinding
		18	SS	100/ 0.300		
					301	
		19	SS	100/ 0.300	300	
					299	
		20	SS	74		
					298	
					297	

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O 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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-02

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 122.9 E 226 124.1 | ORIGINATED BY BL

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.07.03 - 2019.07.04 | LATITUDE ___ | LONGITUDE ___ | CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY** Hard Grey Moist						296				
			21	SS	56						0 0 38 62
							295				
							294				
							293				
			22	SS	100/ 0.225						
	100mm thick silt layer at 33.8m						292				
291.6 34.4	**SAND**, some silt, trace clay Very Dense Grey Moist						291				
			23	SS	100/ 0.275						0 77 16 7
290.0 36.1	Silty **CLAY**, sandy, trace gravel Hard Grey Moist						290				
			24	SS	100/ 0.275						
289.1 37.0	END OF BOREHOLE AT 37.0m. CAVED-IN DEPTH AND WATER LEVEL NOT AVAILABLE DUE TO USE OF MUD ROTARY DRILLING. BOREHOLE BACKFILLED WITH GROUT AND CEMENT, THEN BENTONITE HOLEPLUG TO SURFACE.										

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-03

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 090.7 E 226 146.6 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.25 - 2019.08.26 | LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

ELEV DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (approx.)	GR	SA	SI	CL	REMARKS
321.3	GROUND SURFACE										
0.0 / 0.1	**TOPSOIL:** (75mm)										
	Silty **SAND**, trace clay, trace gravel; Loose to Compact; Brown; Moist; (FILL)	1	SS	15	321	~4					
		2	SS	13		~5	1	59	34	6	
		3	SS	7	320	~5					
319.1 / 2.2	**SAND**, trace to some silt, trace clay, trace, gravel; Compact to Dense; Brown; Dry to Moist	4	SS	35	319	~1					
		5	SS	47	318	~6	1	87	12 (SI+CL)		Switch to tricone
	Very Dense; Wet	6	SS	64	317 / 316	~8					
315.7 / 5.6	Silty **CLAY**, some sand to sandy; Hard; Grey; Moist; (TILL)	7	SS	32	315	~20					
		8	SS	33	314 / 313	~20					
		9	SS	37	312	~13 (wP ~13, wL ~18)	2	18	55	25	

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

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-03

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 090.7 E 226 146.6 | ORIGINATED BY BL

DIST ______ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.25 - 2019.08.26 | LATITUDE ______ | LONGITUDE ______ | CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					311	
		10	SS	56	310	
309.6 / 11.7	Silty **CLAY**, trace sand Hard Grey Moist	11	SS	33	309	
					308	
		12	SS	33	307	
306.5 / 14.8	Sandy **SILT**, some clay Very Dense Grey Moist	13	SS	90	306	
305.6 / 15.7	Silty **CLAY**, trace sand Hard Grey Moist				305	Tricone grinding
		14	SS	72	304	0 1 38 61
					303	
		15	SS	90	302	

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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

+³, ×³: Numbers refer to Sensitivity

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

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/8/20

RECORD OF BOREHOLE No CN16-03

METRIC

GWP# 408-88-00	LOCATION MTM NAD 83 Zone 10: N 4 814 090.7 E 226 146.6		ORIGINATED BY BL
DIST	HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone	COMPILED BY BH
DATUM Geodetic	DATE 2019.08.25 - 2019.08.26	LATITUDE / LONGITUDE	CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY**, trace sand Hard Grey Moist	hatched	16	SS	72		301	~23		
							300			
							299			
			17	SS	51		298	~24		
							297			
							296			
			18	SS	62		295	~25		
							294			
							293			
			19	SS	51		292	~26		

Continued Next Page

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

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

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

RECORD OF BOREHOLE No CN16-03 METRIC

GWP# 408-88-00 LOCATION MTM NAD 83 Zone 10: N 4 814 090.7 E 226 146.6 ORIGINATED BY BL

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH

DATUM Geodetic DATE 2019.08.25 - 2019.08.26 LATITUDE LONGITUDE CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page								
						291			
						290			
		20	SS	97		289			
						288			
287.6									Tricone grinding
33.7	Sandy **SILT**, some clay, trace gravel Very Dense Grey Moist (TILL)								
						287			
		21	SS	100/ 0.150					
						286			
						285			
		22	SS	100/ 0.125					6 28 50 16
						284			Tricone grinding
283.1 / 38.3	END OF BOREHOLE AT 38.3m. CAVED-IN DEPTH AND WATER LEVEL NOT AVAILABLE DUE TO USE OF MUD ROTARY DRILLING. BOREHOLE BACKFILLED WITH GROUT HOLEPLUG.								

Chart headings: 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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-04

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 089.0 E 226 130.4 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.23 - 2019.08.24 LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.3	GROUND SURFACE						
0.0 / 0.1	**TOPSOIL:** (50mm)						
	Silty **SAND**, some gravel, trace clay, Loose to Compact, Brown, Dry to Moist (FILL)	1	SS	15	323		
		2	SS	8	322		
		3	SS	6			18 52 25 5
		4	SS	7	321		
320.3 / 3.0	**SAND**, trace to some gravel, trace silt, trace clay, Dense, Brown, Moist						Switch to tricone
		5	SS	14	320		
		6	SS	32	319		6 79 15 (SI+CL)
	75mm thick gravel layer at 6.4m	7	SS	37	318 / 317		17 73 10 (SI+CL)
316.2 / 7.2	Silty **CLAY**, some sand, trace gravel, Very Stiff to Hard, Brown, Moist (TILL)				316		
		8	SS	23	315		
		9	SS	35	314		

Plot headings: 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; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CN16-04

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 089.0 E 226 130.4 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.23 - 2019.08.24 | LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)				313					
		10	SS	35		~18				
					312					
					311					
		11	SS	48		~20				
310.1 13.3	Silty **CLAY**, trace sand Hard Grey Moist				310					
		12	SS	40		~18 (wP ~18, wL ~40)	0	2	43	55
					309					
					308					
		13	SS	37		~25				
					307					
		14	SS	48		~28				
					306					
					305					
		15	SS	39		~20				
					304					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (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; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Groundwater level symbol shown at approx. elev. 306.6.

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-04

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 089.0 E 226 130.4 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.23 - 2019.08.24 LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m3	GR	SA	SI	CL
	Silty **CLAY**, trace sand Hard Grey Moist		16	SS	76		303							
							302							
							301							
			17	SS	98		300							
							299							
							298							
			18	SS	58		297				0	2	42	56
							296							
							295							
			19	SS	49		294							

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No CN16-04

METRIC

GWP# 408-88-00	LOCATION MTM NAD 83 Zone 10: N 4 814 089.0 E 226 130.4		ORIGINATED BY BL
DIST HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY BH
DATUM Geodetic	DATE 2019.08.23 - 2019.08.24	LATITUDE LONGITUDE	CHECKED BY JPL

SOIL PROFILE: ELEV/DEPTH; DESCRIPTION; STRAT PLOT. SAMPLES: 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. REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL.

Continued From Previous Page

Silty **CLAY**, some sand to sandy, trace gravel
Hard
Grey
Moist

Elevation	Description	Sample No.	Type	"N" Values	Remarks	GR	SA	SI	CL
293									
292									
291		20	SS	75					
290					Tricone grinding				
289									
288	Silt seams	21	SS	62					
287					Tricone grinding				
286									
285		22	SS	100/ 0.125					
284									
		23	SS	100/		0	19	51	30

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CN16-04

METRIC

GWP# 408-88-00	LOCATION MTM NAD 83 Zone 10: N 4 814 089.0 E 226 130.4		ORIGINATED BY BL
DIST HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY BH
DATUM Geodetic	DATE 2019.08.23 - 2019.08.24	LATITUDE LONGITUDE	CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page				0.250		283				
282.6 40.7	Sandy **SILT**, trace gravel Very Dense Brown Moist (TILL)		24	SS	100/ 0.125				○		
282.0 41.3	END OF BOREHOLE AT 41.3m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2019.08.29	16.8	306.6

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

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

RECORD OF BOREHOLE No CN16-05

METRIC

GWP# 408-88-00
LOCATION MTM NAD 83 Zone 10: N 4 814 129.0 E 226 137.3
ORIGINATED BY BL
DIST HWY 7
BOREHOLE TYPE Hollow Stem Augers/Tricone
COMPILED BY BH
DATUM Geodetic
DATE 2019.07.04 - 2019.07.08
LATITUDE
LONGITUDE
CHECKED BY JPL

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
325.5	GROUND SURFACE					
0.0	**TOPSOIL:**(125mm)					
0.1	Silty **SAND**, some clay, trace gravel Loose to Compact Brown Moist (FILL)	1	SS	16	325	
		2	SS	13	324	
		3	SS	7		3 54 31 12
	Very Dense	4	SS	53	323	
322.0		5	SS	50		Switch to tricone
3.5	**ORGANICS**, occasional roots and rootlets Black Moist				322	
321.4 / 4.1	**SAND**, trace silt, trace clay, trace gravel Very Dense Brown Moist				321	
		6	SS	34	320	
		7	SS	100/ 0.275	319	
		8	SS	100/ 0.250	318	0 85 15 (SI+CL)
316.0	Wet	9	SS	92	317 / 316	
9.5	Silty **CLAY**, sandy, trace gravel Hard Grey					

Plot headings: 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; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-05

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 129.0 E 226 137.3 | ORIGINATED BY BL

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.07.04 - 2019.07.08 | LATITUDE ___ | LONGITUDE ___ | CHECKED BY JPL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY**, sandy, trace gravel Hard Grey Moist (TILL)				315		
		10	SS	45		o	
					314		
		11	SS	58	313	wP–wL	3 27 47 23
					312		
		12	SS	64		o	
					311		
310.7 / 14.8	Sandy **GRAVEL**, trace silt and clay, occasional cobbles Very Dense Grey Moist						Tricone grinding
		13	SS	55	310	o	51 30 19 (SI+CL)
309.2 / 16.3	Silty **CLAY**, trace sand Hard Grey Moist				309		
		14	SS	35		o	
					308		
		15	SS	26	307	o	
					306		

Column headings: SOIL PROFILE; SAMPLES; 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 wP, NATURAL MOISTURE CONTENT w, LIQUID LIMIT wL; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CN16-05 METRIC

GWP# 408-88-00 LOCATION MTM NAD 83 Zone 10: N 4 814 129.0 E 226 137.3 ORIGINATED BY BL

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH

DATUM Geodetic DATE 2019.07.04 - 2019.07.08 LATITUDE LONGITUDE CHECKED BY JPL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY**, trace sand Hard Grey Moist	16	SS	43	305	
					304	
					303	
		17	SS	88	302	0 2 42 56
					301	
					300	
		18	SS	80	299	
					298	
					297	
		19	SS	93	296	

Column headings: 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/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-05

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 129.0 E 226 137.3 | ORIGINATED BY BL

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.07.04 - 2019.07.08 | LATITUDE ___ LONGITUDE ___ | CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							
	Silty **CLAY**, trace sand, trace gravel, occasional cobbles Hard Grey Moist					295		
						294		
			20	SS	80	293	o	
						292		
	0.3m thick sandy silt layer at 34.6m					291		
			21	SS	100/ 0.125	290	o	
			22	SS	100/ 0.150	289	o ├──┤	3 15 24 58
								Tricone grinding
287.9 / 37.6	Sandy **SILT**, gravelly, some clay, occasional cobbles Very Dense Grey Moist (TILL)					288		
287.3 / 38.3			23	SS	100/ 0.150		o	
	END OF BOREHOLE AT 38.3m. CAVED-IN DEPTH AND WATER LEVEL NOT AVAILABLE DUE TO USE OF MUD ROTARY DRILLING. BOREHOLE BACKFILLED WITH CEMENT AND GROUT, THEN BENTONITE HOLEPLUG TO SURFACE.							

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O 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

+ 3, × 3 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No CN16-06

METRIC

GWP# 408-88-00 LOCATION MTM NAD 83 Zone 10: N 4 814 136.3 E 226 121.6 ORIGINATED BY BL

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH

DATUM Geodetic DATE 2019.07.08 - 2019.07.08 LATITUDE LONGITUDE CHECKED BY JPL

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
325.9	GROUND SURFACE					
0.0	**TOPSOIL:** (125mm)					
0.1	Silty **SAND** to Sandy **SILT**, trace clay, trace gravel Loose to Compact Brown Moist (FILL)	1	SS	11		
		2	SS	6	325	
		3	SS	8	324	
		4	SS	21		2 60 30 8
					323	Switch to tricone
	Occasional cobbles Very Dense	5	SS	56		1 51 44 4
					322	
321.8 4.1	**SAND**, some gravel, trace silt, trace clay Very Dense Brown Moist					
		6	SS	70	321	
					320	
	Occasional cobbles	7	SS	80		10 79 11 (SI+CL)
					319	
		8	SS	100/ 0.175	318	
	some silt				317	
		9	SS	100/ 0.275	316	

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

Continued Next Page

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

RECORD OF BOREHOLE No CN16-06

METRIC

GWP# 408-88-00	LOCATION MTM NAD 83 Zone 10: N 4 814 136.3 E 226 121.6		ORIGINATED BY BL
DIST ____ HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY BH
DATUM Geodetic	DATE 2019.07.08 - 2019.07.08	LATITUDE ____ LONGITUDE ____	CHECKED BY JPL

Column headings: SOIL PROFILE (ELEV / DEPTH; DESCRIPTION; STRAT PLOT); SAMPLES (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; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
315.8 / 10.1	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL) 0.5m thick silty sand layer at 10.9m	10	SS	100/ 0.225	315				
		11	SS	65	314				
312.6 / 13.3	Silty **SAND**, some clay, trace gravel with silty clay seams Dense to Very Dense Grey Moist	12	SS	63	313, 312	6	59	20	15
		13	SS	39	311				
310.2 / 15.7									
310.0 / 15.8	Silty **CLAY**, some to trace sand, trace gravel Hard Grey Moist								

END OF BOREHOLE AT 15.8m.
CAVED-IN DEPTH AND WATER LEVEL NOT AVAILABLE DUE TO USE OF MUD ROTARY DRILLING.
BOREHOLE BACKFILLED WITH CEMENT AND GROUT, THEN BENTONITE HOLEPLUG TO SURFACE.

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-07

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 089.7 E 226 153.3 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.29 - 2019.08.29 | LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
320.8	GROUND SURFACE					
0.0 / 0.1	**TOPSOIL:** (75mm)					
	Silty **SAND**, trace clay, trace gravel, occasional organics, occasional decayed wood fragments, occasional cobbles Very Dense Brown Moist (FILL)	1	SS	27		6 58 28 8
		2	SS	80	320	
		3	SS	27	319	
		4	SS	100/ 0.250		No recovery
317.8 / 3.0	**SAND**, some silt, trace gravel Dense Brown Moist				318	Switch to tricone
		5	SS	34		
316.7 / 4.1	Silty **CLAY**, sandy, trace gravel Very Stiff to Hard Grey Moist (TILL)				317	
		6	SS	23	316	3 30 48 19
					315	
		7	SS	27	314	
		8	SS	27	313	
					312	
		9	SS	30	311	

Groundwater level symbol shown at approx. elevation 315.0.

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

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Ontario

THURBER

RECORD OF BOREHOLE No CN16-07

METRIC

GWP# 408-88-00 LOCATION MTM NAD 83 Zone 10: N 4 814 089.7 E 226 153.3 ORIGINATED BY BL

DIST ____ HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH

DATUM Geodetic DATE 2019.08.29 - 2019.08.29 LATITUDE ____ LONGITUDE ____ CHECKED BY JPL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
310.6 10.2	Silty **CLAY**, some sandy to sandy, trace gravel Hard Grey Wet					
					310	
		10	SS	31		
					309	
		11	SS	39	308	
		12	SS	31	307	
					306	
		13	SS	43		0 22 50 28
305.0 15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.				305	

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2019.08.31	5.8	315.0

Column headings: SOIL PROFILE; SAMPLES; 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/m³

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No CN16-08

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 087.3 E 226 137.0 | ORIGINATED BY BL

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.29 - 2019.08.29 | LATITUDE ____ LONGITUDE ____ | CHECKED BY JPL

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT / REMARKS	GR	SA	SI	CL
322.0	GROUND SURFACE									
0.0	**TOPSOIL:** (125mm)									
0.1	Silty **SAND**, trace gravel, occasional organics; Loose; Brown; Moist; (FILL)	1	SS	13						
		2	SS	9	321					
		3	SS	7	320					
319.8 / 2.2	**SAND**, some silt, trace clay, trace gravel; Loose to Compact; Brown; Moist	4	SS	7			4	74	22 (SI+CL)	
					319	Switch to tricone				
		5	SS	17						
317.9 / 4.1	Silty **CLAY**, some sand, trace gravel; Very Stiff to Hard; Grey; Moist; (TILL)				318					
		6	SS	16	317					
		7	SS	29	316					
					315					
		8	SS	31	314		1	16	49	34
					313					
		9	SS	40						

Legend: 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

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No CN16-08

METRIC

GWP# 408-88-00 | LOCATION MTM NAD 83 Zone 10: N 4 814 087.3 E 226 137.0 | ORIGINATED BY BL

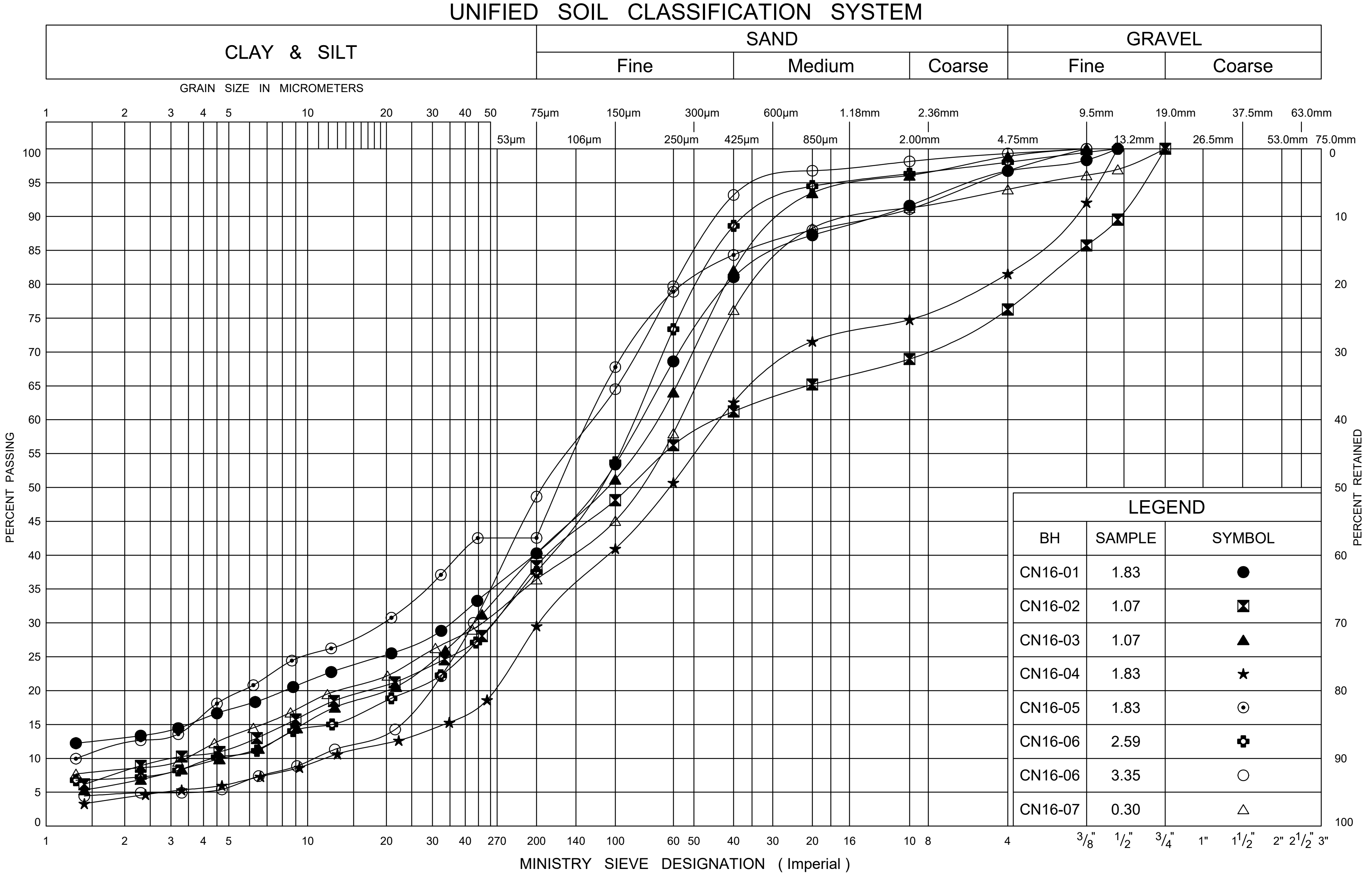
DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY BH

DATUM Geodetic | DATE 2019.08.29 - 2019.08.29 | LATITUDE ____ | LONGITUDE ____ | CHECKED BY JPL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)	10	SS	34	311		
310.3 11.7	Silty **CLAY**, trace sand Hard Grey Moist				310		
		11	SS	46			0 6 45 49
					309		
		12	SS	44	308		
					307		
		13	SS	62			
306.2 15.8	END OF BOREHOLE AT 15.8m. CAVED-IN DEPTH AND WATER LEVEL NOT AVAILABLE DUE TO USE OF MUD ROTARY DRILLING. BOREHOLE BACKFILLED WITH GROUT TO 3.0m, THEN HOLEPLUG TO SURFACE.						

Column headings: SOIL PROFILE; STRAT PLOT; 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/m³.

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
CN16-01	1.83	●
CN16-02	1.07	⧗
CN16-03	1.07	▲
CN16-04	1.83	★
CN16-05	1.83	⊙
CN16-06	2.59	✪
CN16-06	3.35	○
CN16-07	0.30	△

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GRAIN SIZE DISTRIBUTION

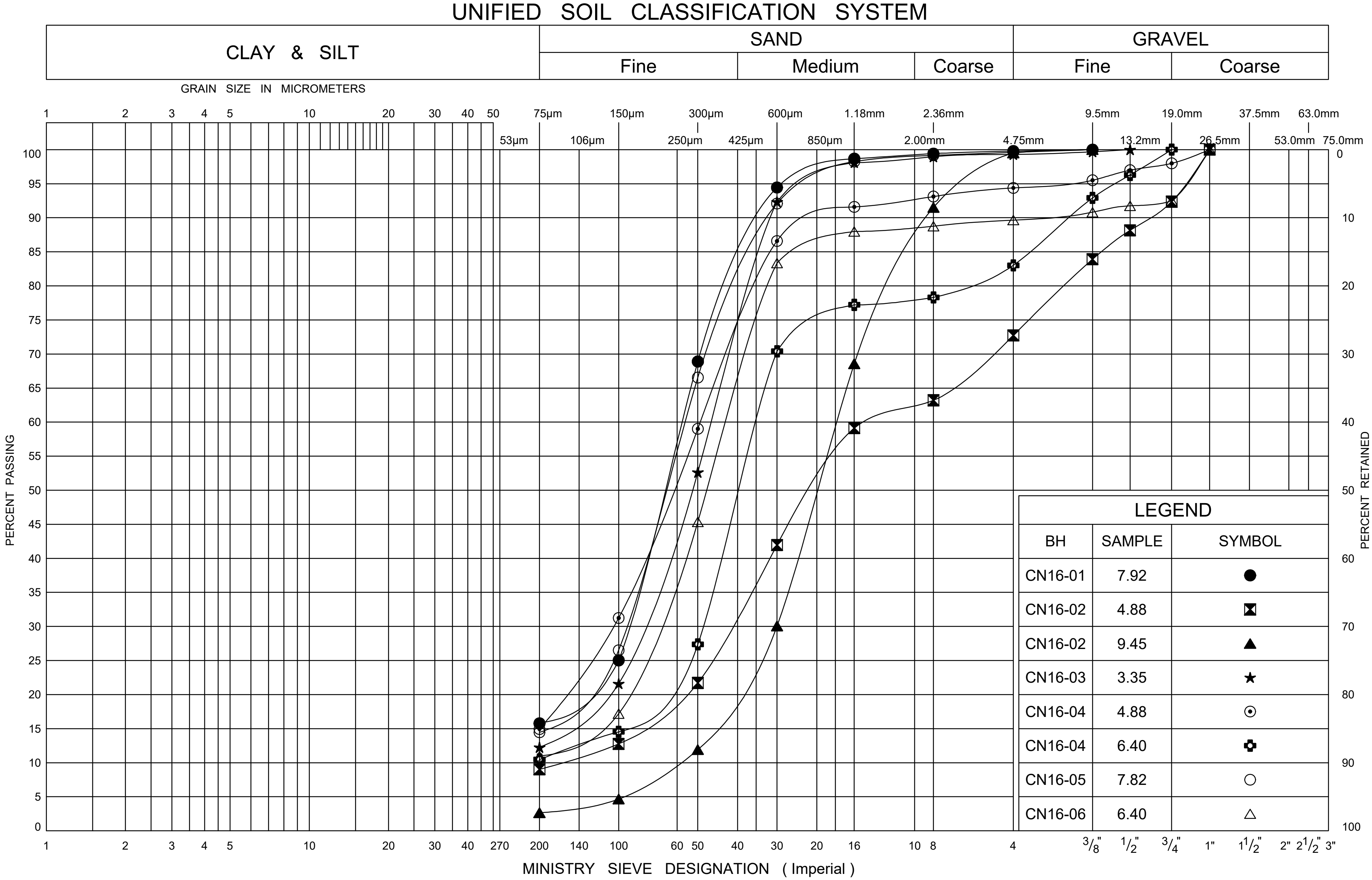
Cohesionless FILL

FIG No A1

W P 408-88-00

ONTARIO MOT GRAIN SIZE MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20

78 12 M



BH	SAMPLE	SYMBOL
CN16-01	7.92	●
CN16-02	4.88	⊠
CN16-02	9.45	▲
CN16-03	3.35	★
CN16-04	4.88	⊙
CN16-04	6.40	✿
CN16-05	7.82	○
CN16-06	6.40	△

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GRAIN SIZE DISTRIBUTION

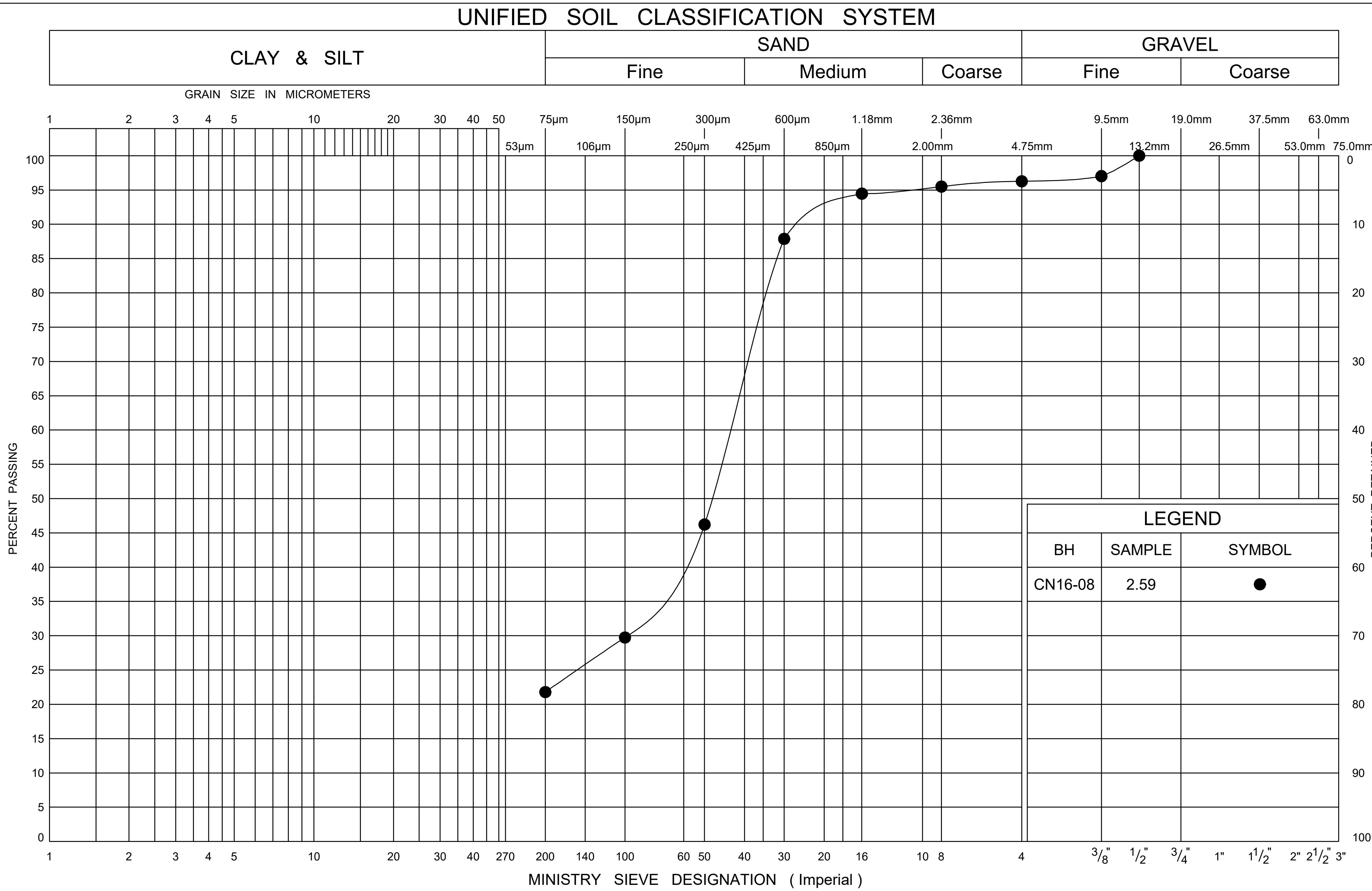
Upper SAND

FIG No A2

W P 408-88-00

ONTARIO MOT GRAIN SIZE MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20

78 12 M



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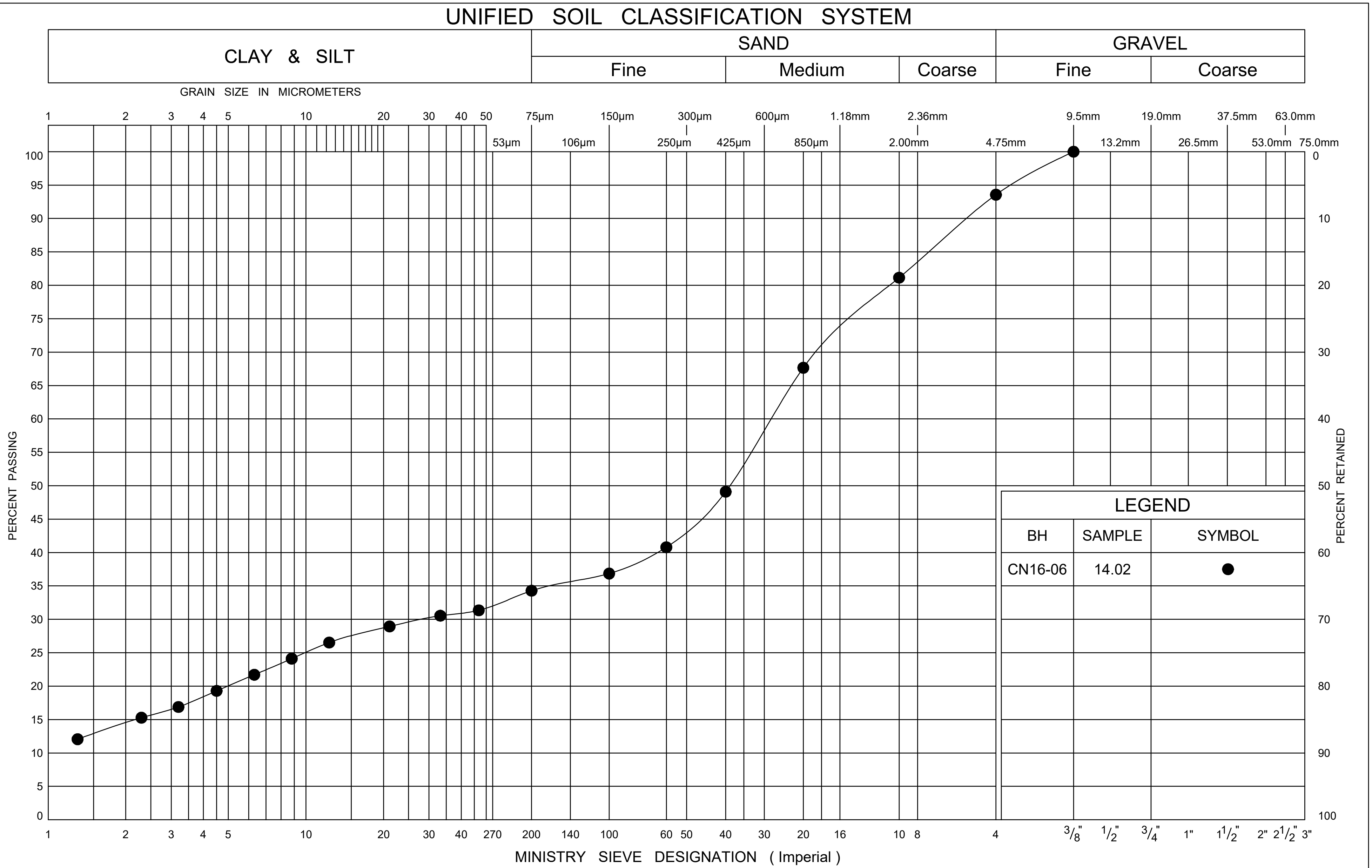
GRAIN SIZE DISTRIBUTION

Upper SAND

FIG No A3

W P 408-88-00



LEGEND		
BH	SAMPLE	SYMBOL
CN16-06	14.02	●

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GRAIN SIZE DISTRIBUTION

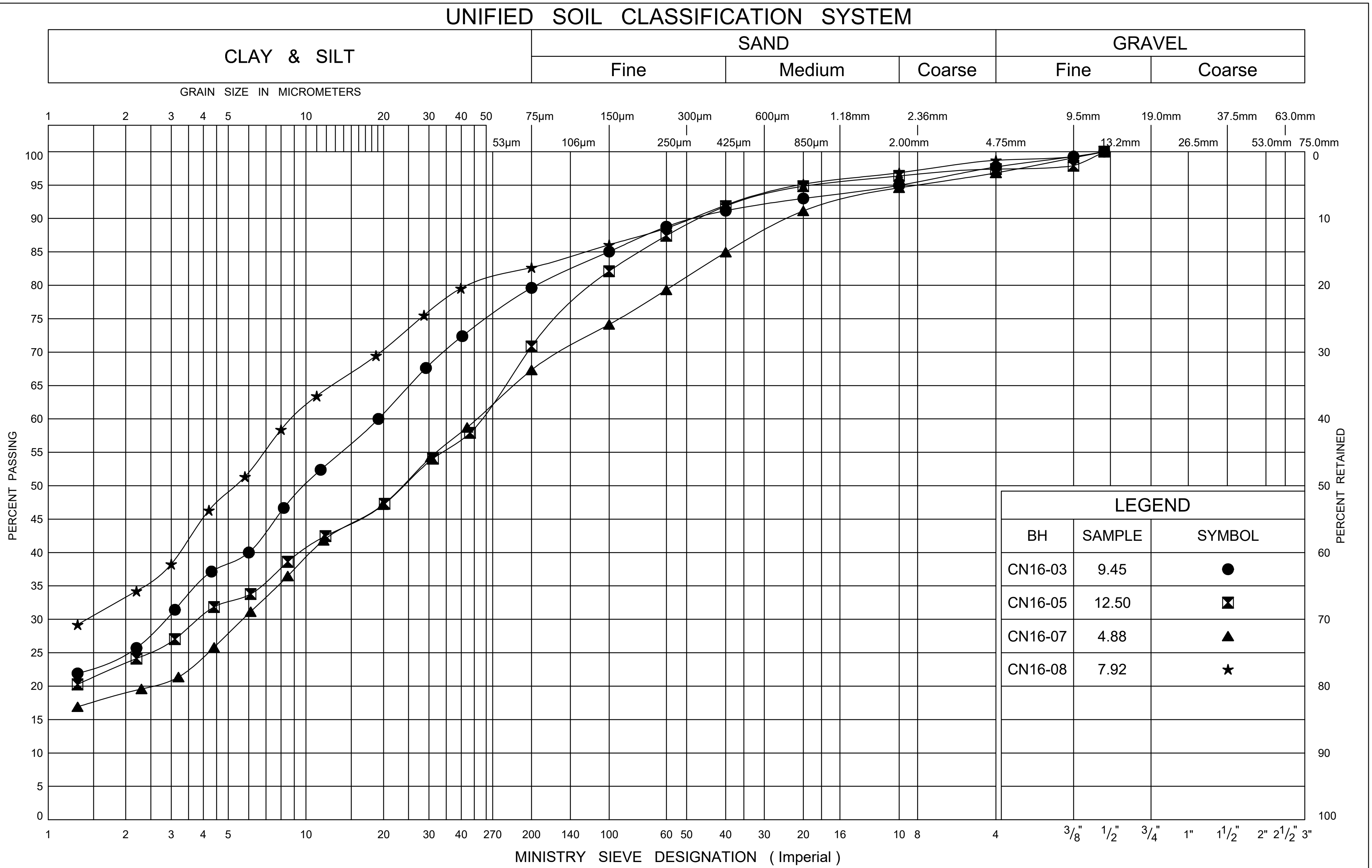
Silty SAND

FIG No A4

W P 408-88-00

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 5/14/20

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
CN16-03	9.45	●
CN16-05	12.50	⊠
CN16-07	4.88	▲
CN16-08	7.92	★

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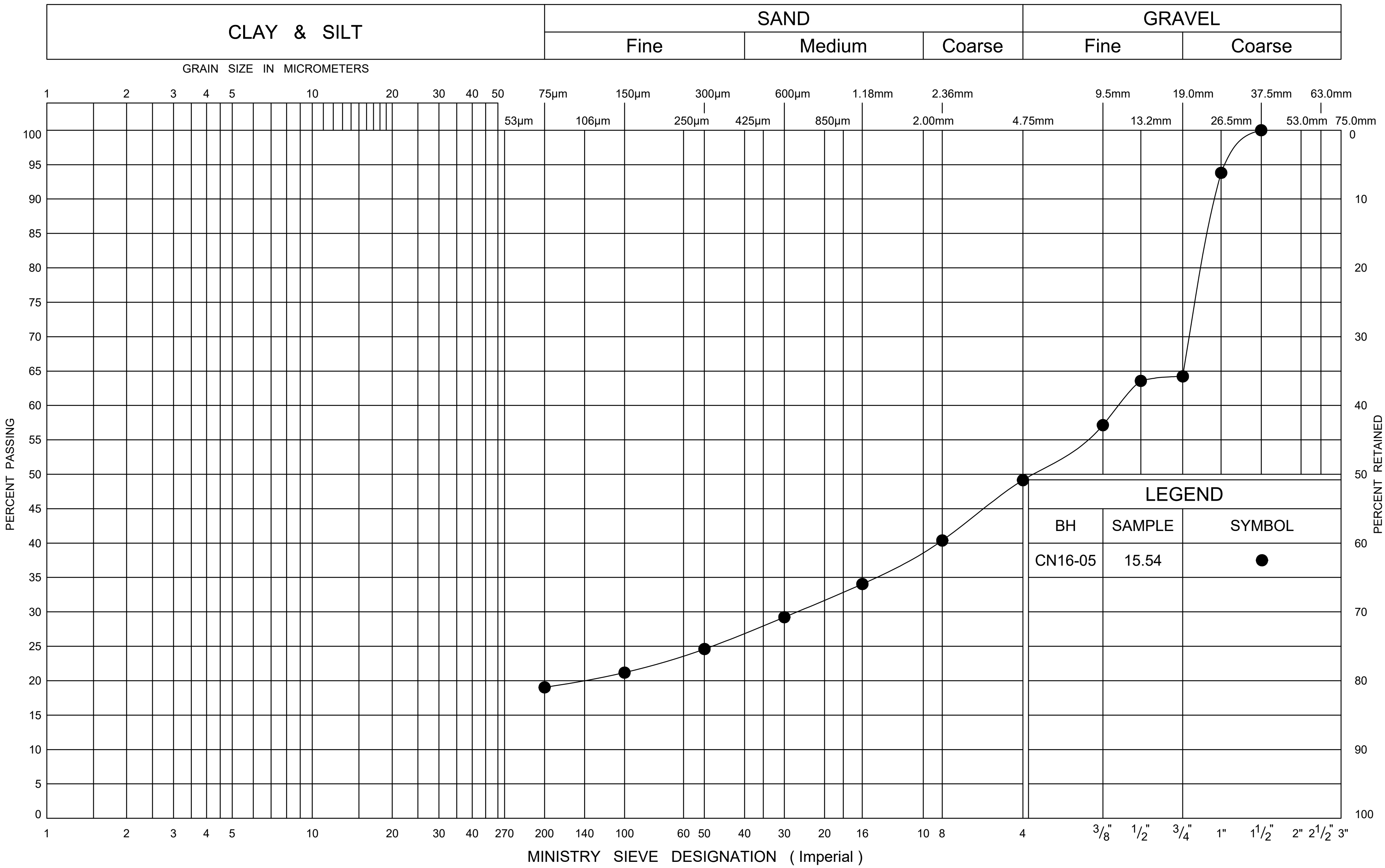
GRAIN SIZE DISTRIBUTION

Silty CLAY TILL

FIG No A5

W P 408-88-00

ONTARIO MOT GRAIN SIZE MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20



BH	SAMPLE	SYMBOL
CN16-05	15.54	●

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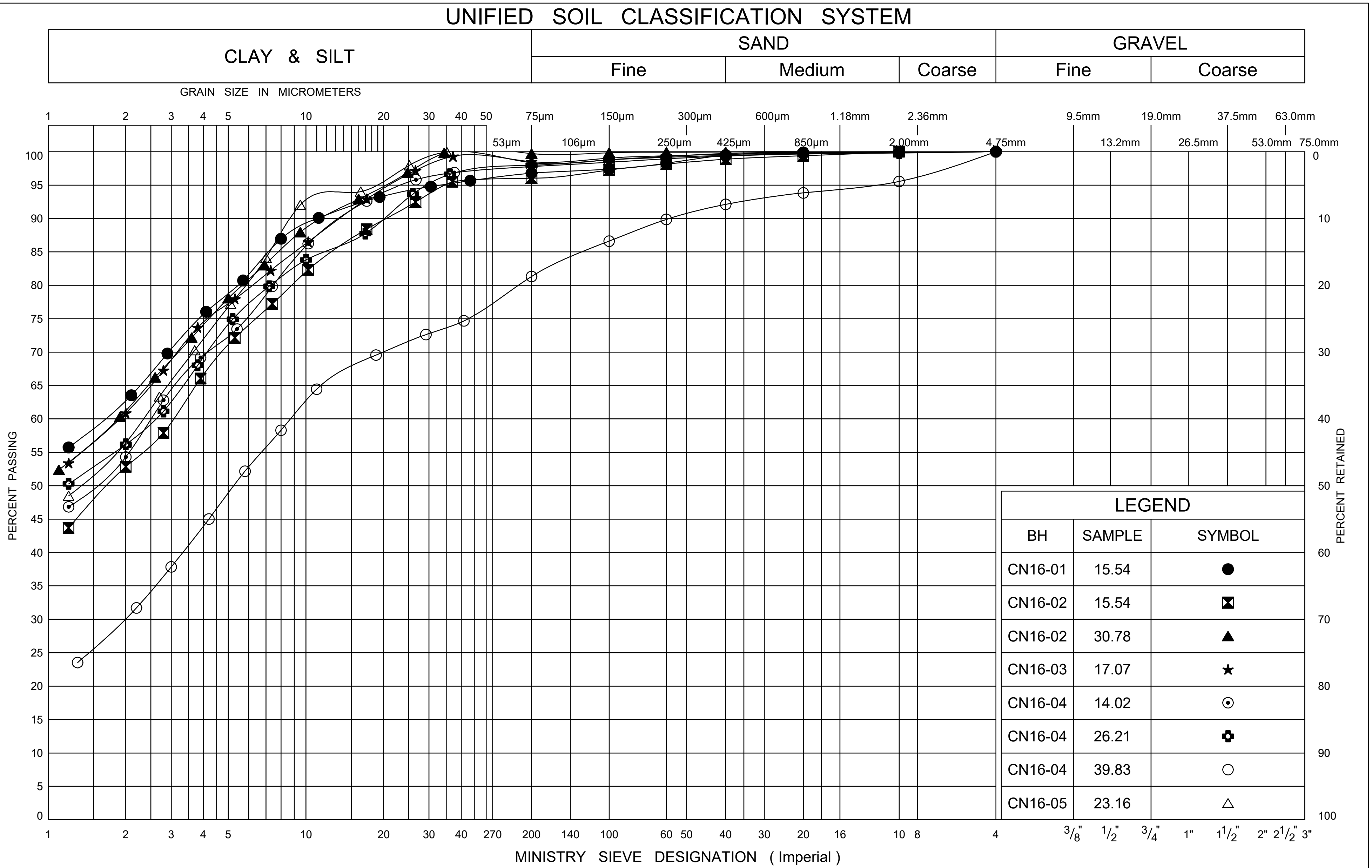
GRAIN SIZE DISTRIBUTION

Sandy GRAVEL

FIG No A6

W P 408-88-00

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
CN16-01	15.54	●
CN16-02	15.54	⧗
CN16-02	30.78	▲
CN16-03	17.07	★
CN16-04	14.02	⊙
CN16-04	26.21	✿
CN16-04	39.83	○
CN16-05	23.16	△

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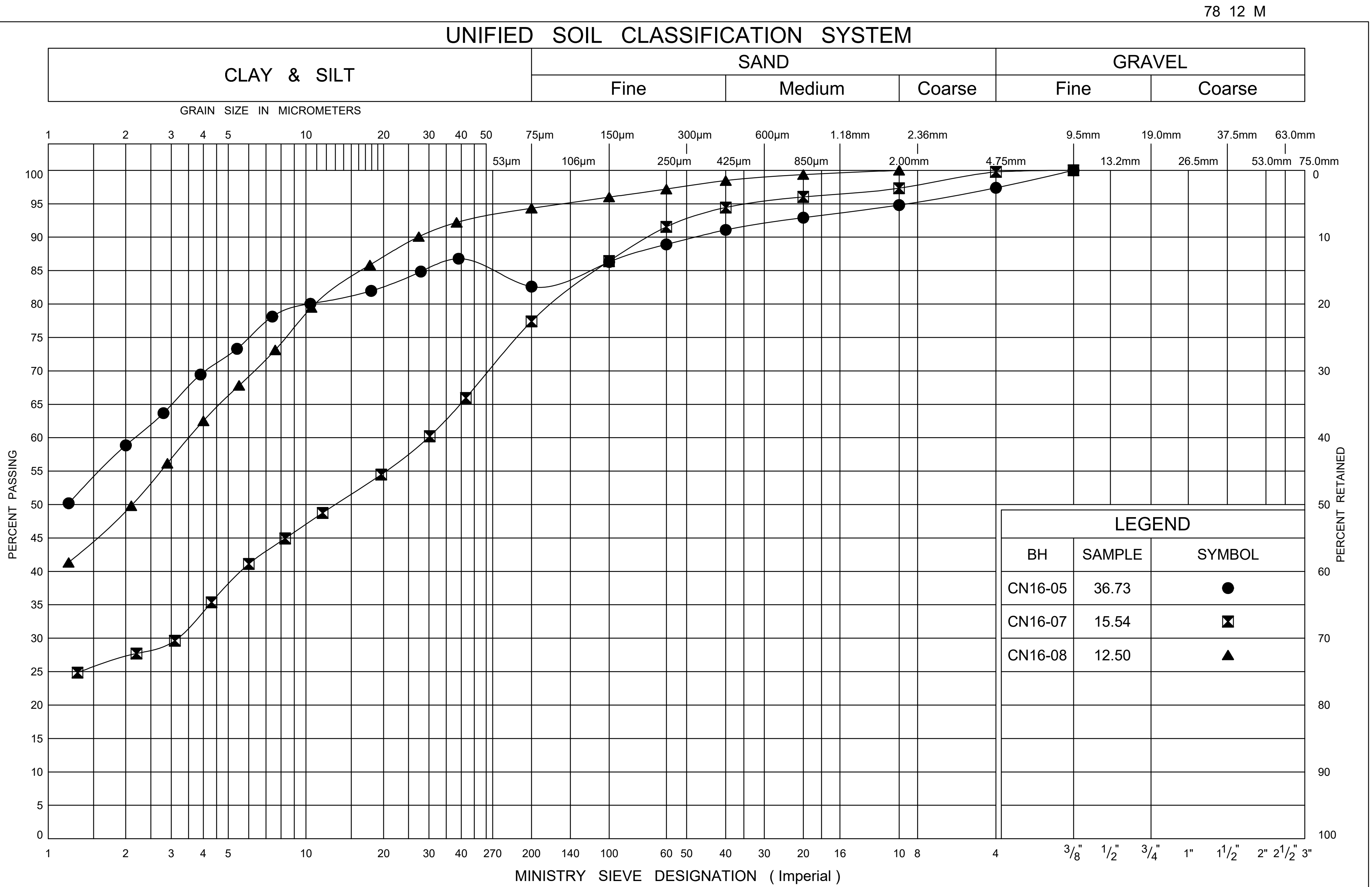
GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No A7

W P 408-88-00

ONTARIO MOT GRAIN SIZE MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20



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GRAIN SIZE DISTRIBUTION

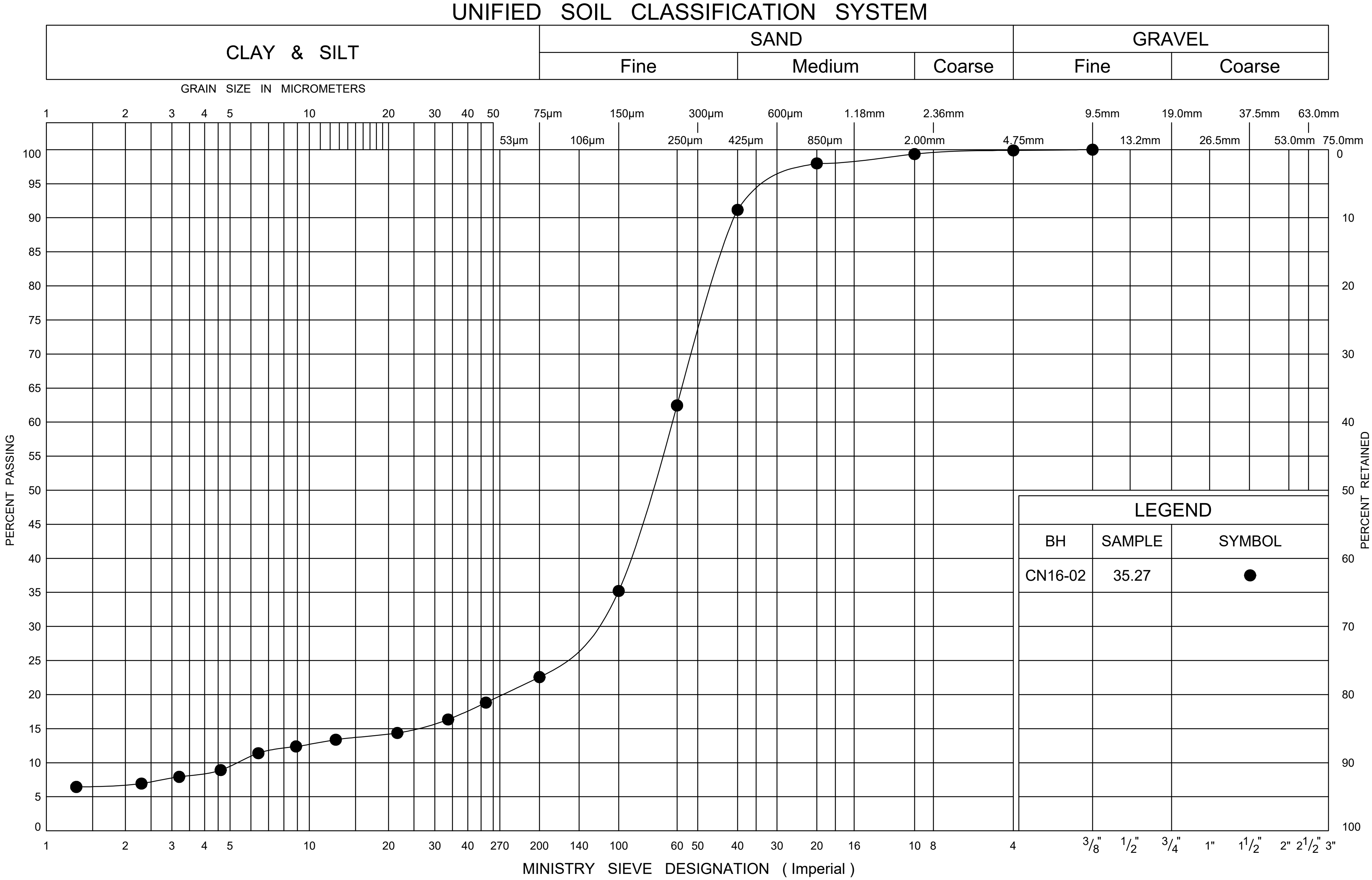
Silty CLAY

FIG No A8

W P 408-88-00

ONTARIO MOT GRAIN SIZE MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20

78 12 M



LEGEND		
BH	SAMPLE	SYMBOL
CN16-02	35.27	●

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GRAIN SIZE DISTRIBUTION

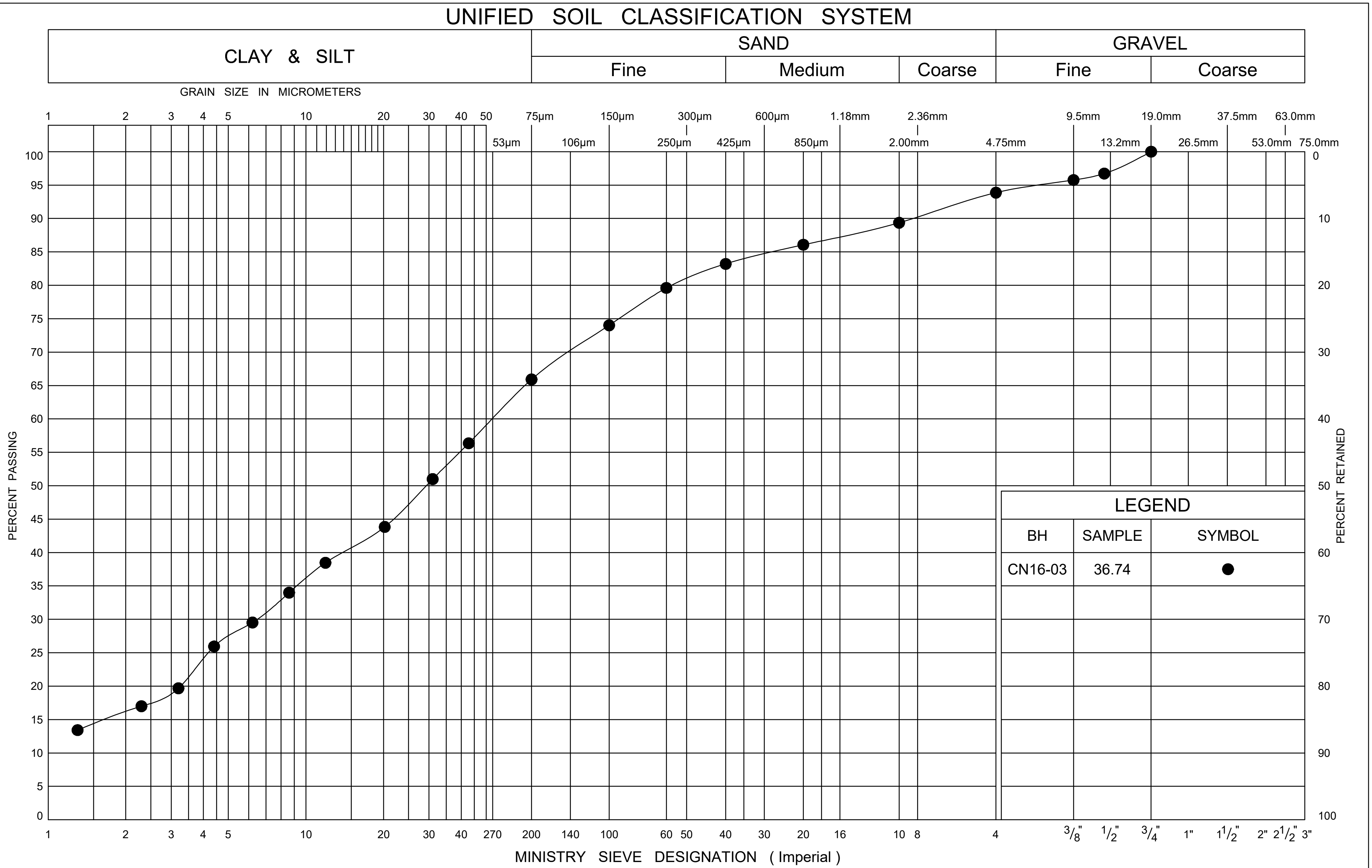
Lower SAND

FIG No A9

W P 408-88-00

ONTARIO MOT GRAIN SIZE MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
CN16-03	36.74	●

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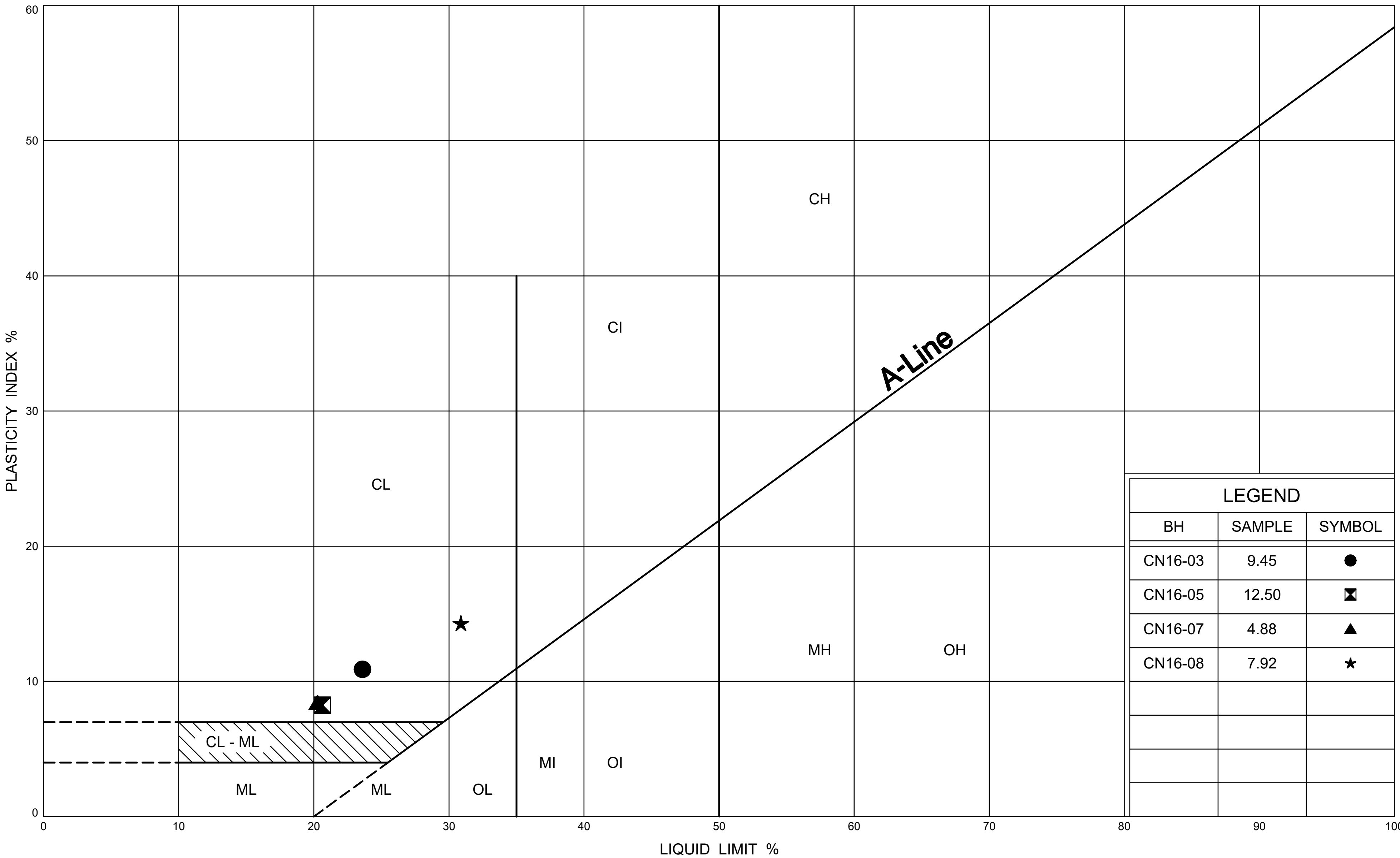
GRAIN SIZE DISTRIBUTION

SILT TILL

FIG No A10

W P 408-88-00

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
CN16-03	9.45	●
CN16-05	12.50	⧗
CN16-07	4.88	▲
CN16-08	7.92	★

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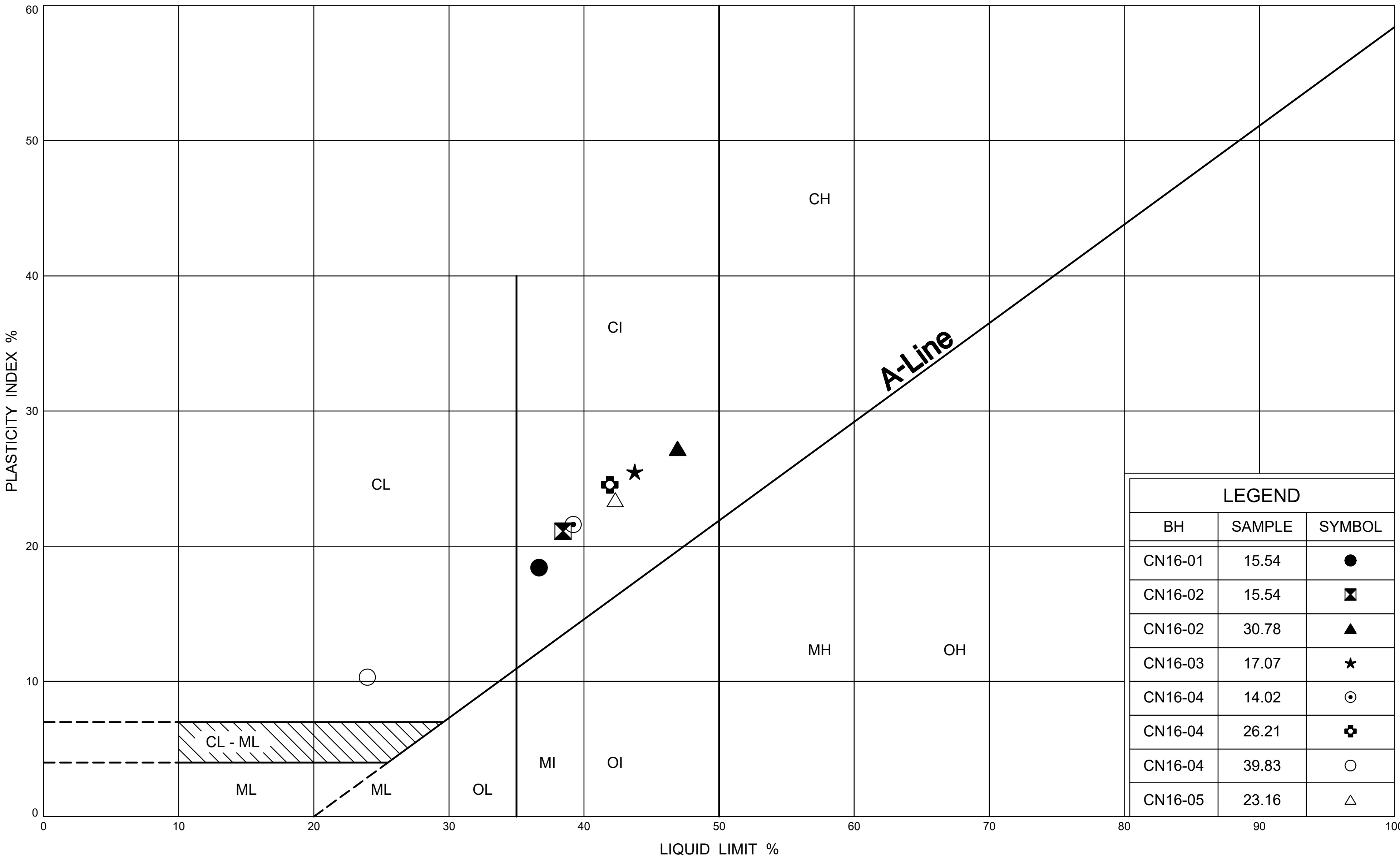
PLASTICITY CHART
Silty CLAY TILL

FIG No A11

W P 408-88-00



LEGEND

BH	SAMPLE	SYMBOL
CN16-01	15.54	●
CN16-02	15.54	⧗
CN16-02	30.78	▲
CN16-03	17.07	★
CN16-04	14.02	⊙
CN16-04	26.21	✿
CN16-04	39.83	○
CN16-05	23.16	△

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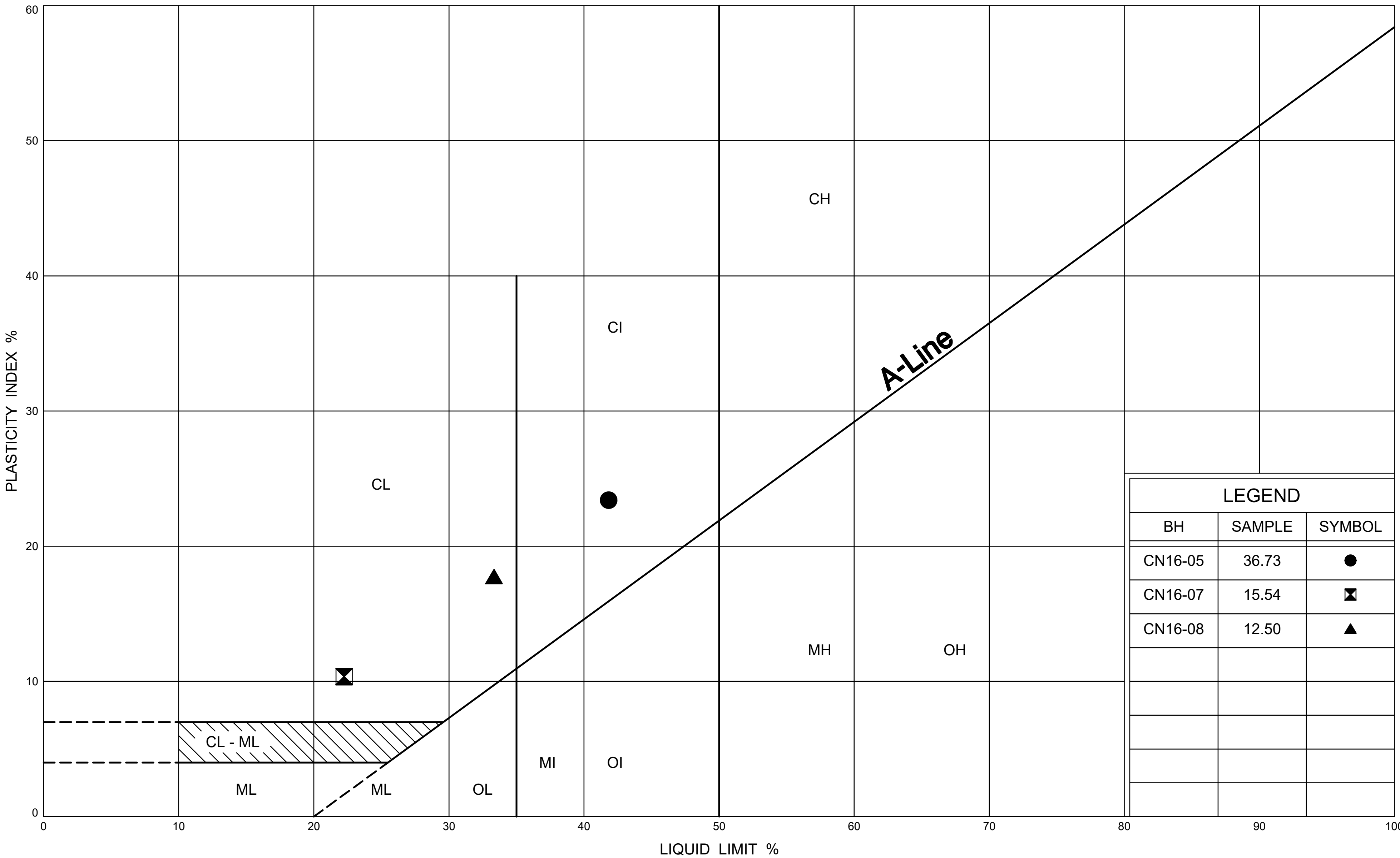
PLASTICITY CHART

Silty CLAY

FIG No A12

W P 408-88-00

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
CN16-05	36.73	●
CN16-07	15.54	⧗
CN16-08	12.50	▲

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PLASTICITY CHART
Silty CLAY

FIG No A13
W P 408-88-00

ONTARIO MOT PLASTICITY CHART MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 1/16/20

THURBER

Appendix B

Record of Borehole Sheets and Laboratory 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** (MPa)	(psi)	**Field Estimation of Hardness***
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

THURBER

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-041

METRIC

G.W.P.	408-88-00	LOCATION	N 4 814 110.33 E 226 090.75	ORIGINATED BY	SLL
HWY	7	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	FK
DATUM	Geodetic	DATE	2008.08.11 - 2008.08.13	CHECKED BY	RPR

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
326.3	
0.0 / 0.1	**TOPSOIL:** (40mm), occasional rootlets and roots
	SAND, some gravel Brown Moist (FILL)
325.7 / 0.6	Clayey **SILT**, some sand to sandy, trace gravel Very Stiff Brown (FILL)
324.9 / 1.4	**SAND**, trace to some silt, trace gravel Compact to Dense Brown Moist occasional topsoil, black Very Dense Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	26	o	
2	SS	36	o	
3	SS	32	o	
4	SS	28	o	2 86 12 (SI+CL)
5	SS	13	o	
6	SS	100/ .225	o	
7	SS	100/ .200	o	2 89 10 (SI+CL)
8	SS	76	o	

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (326, 325, 324, 323, 322, 321, 320, 319, 318, 317); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O 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.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 6417R.GPJ 10/31/08

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-041

METRIC

G.W.P. 408-88-00	LOCATION N 4 814 110.33 E 226 090.75		ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY FK
DATUM Geodetic	DATE 2008.08.11 - 2008.08.13		CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, trace to some silt, trace gravel Very Dense Grey Moist				316	
		9	SS	63		2 86 12 (SI+CL)
					315	
314.5 11.8	Silty **CLAY**, some sand to sandy, trace gravel Hard Grey (TILL)				314	
		10	SS	54		
					313	
		11	SS	33		1 16 48 35
					312	
					311	
	silty sand seams					
		12	SS	31		
					310	
		13	SS	33		
					309	
					308	
		14	SS	31		
					307	
306.3						

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; 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/m³

Continued Next Page

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

ONTMT4S 6417R.GPJ 10/24/08

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-041

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 110.33 E 226 090.75 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY FK

DATUM Geodetic DATE 2008.08.11 - 2008.08.13 CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
20.0	Silty **CLAY**, trace to some sand Hard Grey	15	SS	23		0	6	30	64
					306				
					305				
					304				
		16	SS	73					
					303				
					302				
		17	SS	108		0	6	41	53
					301				
		18	SS	101/ .275					
					300				
					299				
		19	SS	58					
					298				
		20	SS	76		0	2	32	66
					297				

Column headings: 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/m³; STRAT PLOT

Continued Next Page

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 08-041

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 110.33 E 226 090.75 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY FK

DATUM Geodetic DATE 2008.08.11 - 2008.08.13 CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY** Hard Grey				296		
		21	SS	55		o	
					295		
	silt seams	22	SS	74	294	o	
					293		
		23	SS	100/ .150		o	
291.9 34.4	**SILT**, some sand, trace clay Very Dense Grey Moist (TILL)				292		
		24	SS	100/ .175	291		
					290		
		25	SS	100/ .150		o	0 19 75 6
289.1 37.2	END OF BOREHOLE AT 37.2m BOREHOLE BACK FILLED WITH GROUT TO 0.61m HOLEPLUG TO SURFACE						

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O 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

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-042

METRIC

G.W.P. 408-88-00 | LOCATION N 4 814 134.35 E 226 152.53 | ORIGINATED BY SA

HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MFA

DATUM Geodetic | DATE 2008.08.14 - 2008.08.14 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.8						
0.0	**TOPSOIL:** (300mm), occasional roots Dark Brown Moist					
322.5 / 0.3	Silty **SAND**, trace gravel, occasional topsoil Compact to Dense Brown to Dark Brown Moist (FILL)	1	SS	32		
		2	SS	25	322	
321.3 / 1.5	**SAND**, trace to some silt Compact to Very Dense Brown Moist	3	SS	17	321	0 86 14 (SI+CL)
		4	SS	52	320	
		5	SS	100	319	0 92 8 (SI+CL)
318.5 / 4.3	Silty **CLAY**, some sand, trace gravel, occasional silty sand seams Very Stiff to Hard Grey (TILL)	6	SS	21	318	
		7	SS	36	317, 316	
		8	SS	82	315 (water level)	
	Occasional sand seams				314	
		9	SS	42		
312.8					313	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O 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

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-042

METRIC

G.W.P.	408-88-00	LOCATION	N 4 814 134.35 E 226 152.53	ORIGINATED BY	SA
HWY	7	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2008.08.14 - 2008.08.14	CHECKED BY	RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	Silty **CLAY**, trace gravel, trace sand Hard Grey					
		10	SS	39	312	
		11	SS	36	311	0 1 36 63
		12	SS	61	310 / 309	
	sandy	13	SS	100/ .225	308 / 307	1 36 38 25
		14	SS	100/ .150	306	1 27 57 16
		15	SS	118/ .100	305 / 304	0 1 41 58
					303	

Continued Next Page

+ 3, × 3 Numbers refer to Sensitivity

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

ONTMT4S 6417R.GPJ 10/28/08

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-042

METRIC

G.W.P. 408-88-00	LOCATION N 4 814 134.35 E 226 152.53	ORIGINATED BY SA
HWY 7	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY MFA
DATUM Geodetic	DATE 2008.08.14 - 2008.08.14	CHECKED BY RPR

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
302.7			16	SS	100/ .150						
20.1	END OF BOREHOLE AT 20.1m. WATER LEVEL OBSERVED AT 4.5m 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) 2008.08.20 7.9 314.9						302				

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

15-○-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

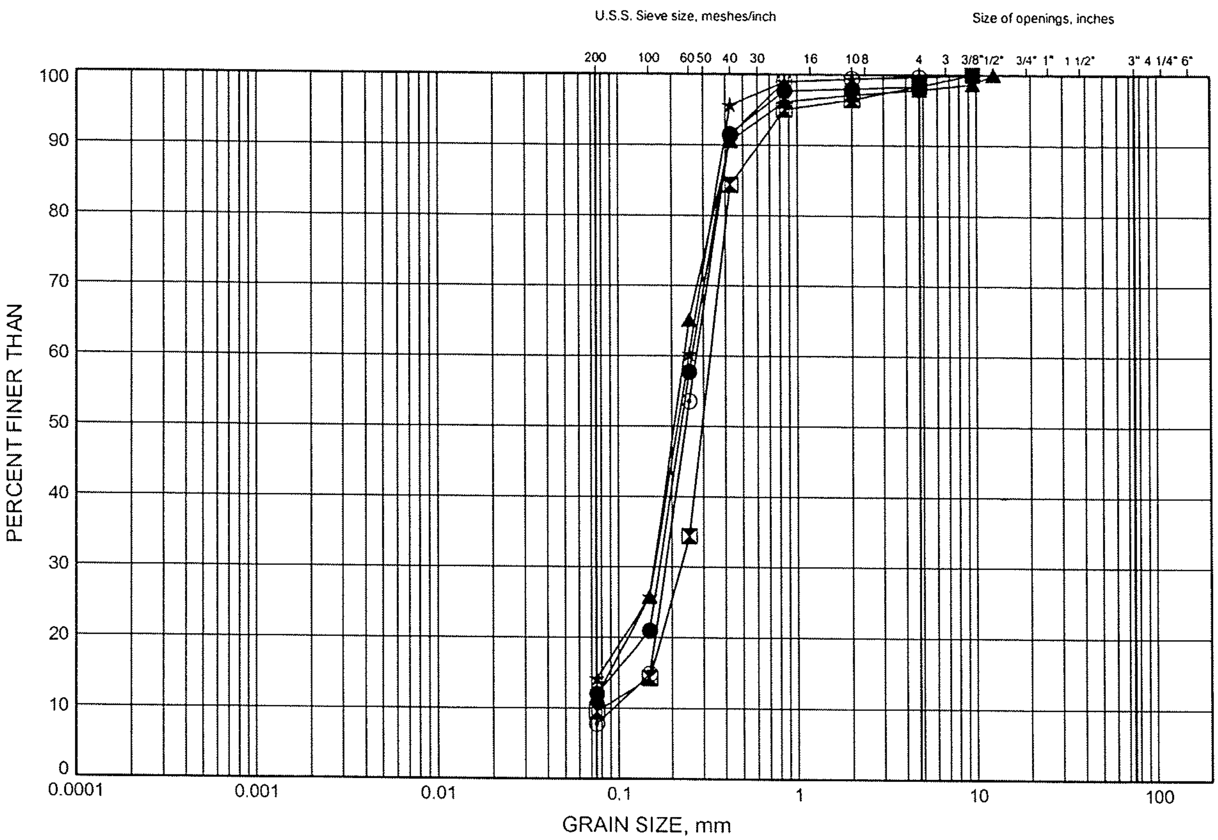
THURBER

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-041	3.35	322.95
⊠	08-041	7.80	318.50
▲	08-041	10.96	315.34
☆	08-042	1.83	320.95
⊙	08-042	3.35	319.43

W.P.# 408-88-00

Prepared By AN

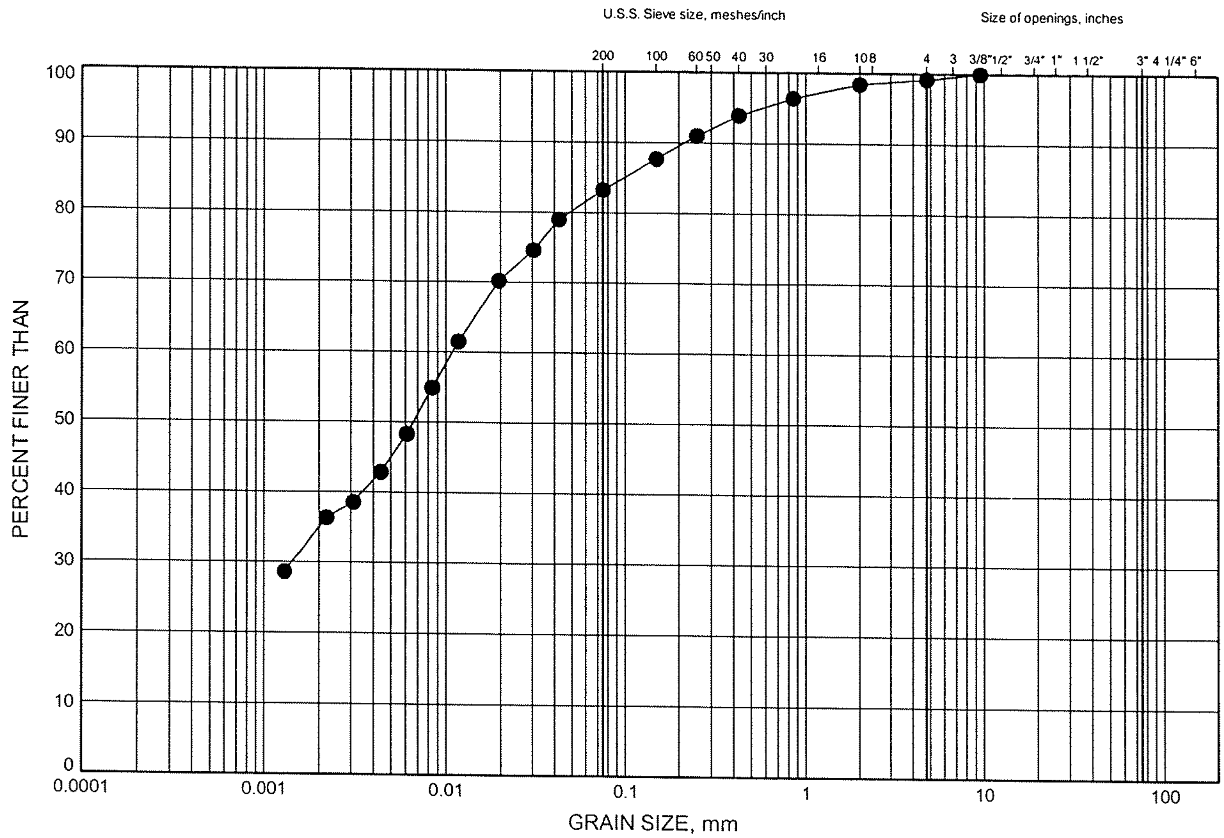
Checked By RPR

THURBER

Highway 7 - New
GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-041	14.02	312.28

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

THURBER

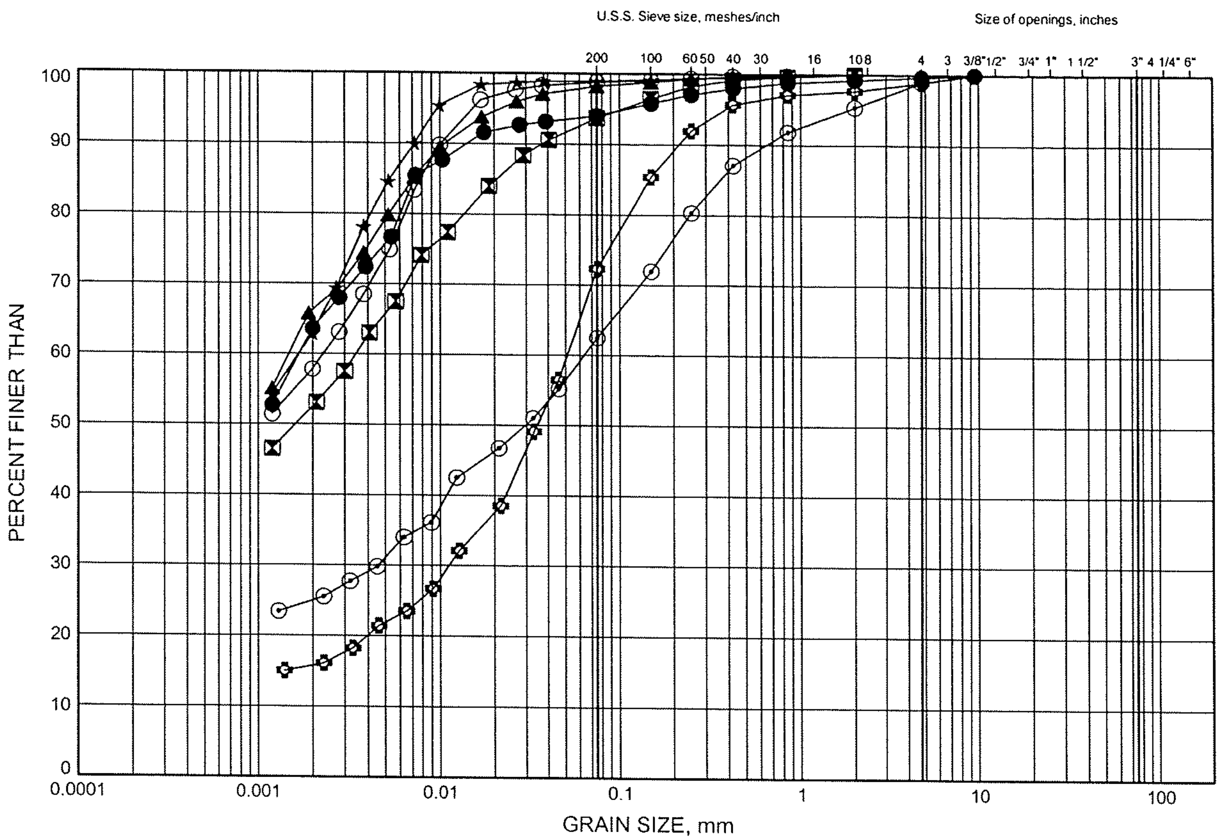
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 10/28/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-041	20.12	306.18
⊠	08-041	24.46	301.84
▲	08-041	29.26	297.04
☆	08-042	12.50	310.29
⊙	08-042	15.29	307.49
✿	08-042	16.92	305.87

W.P.# 408-88-00

Prepared By AN

Checked By RPR

THURBER

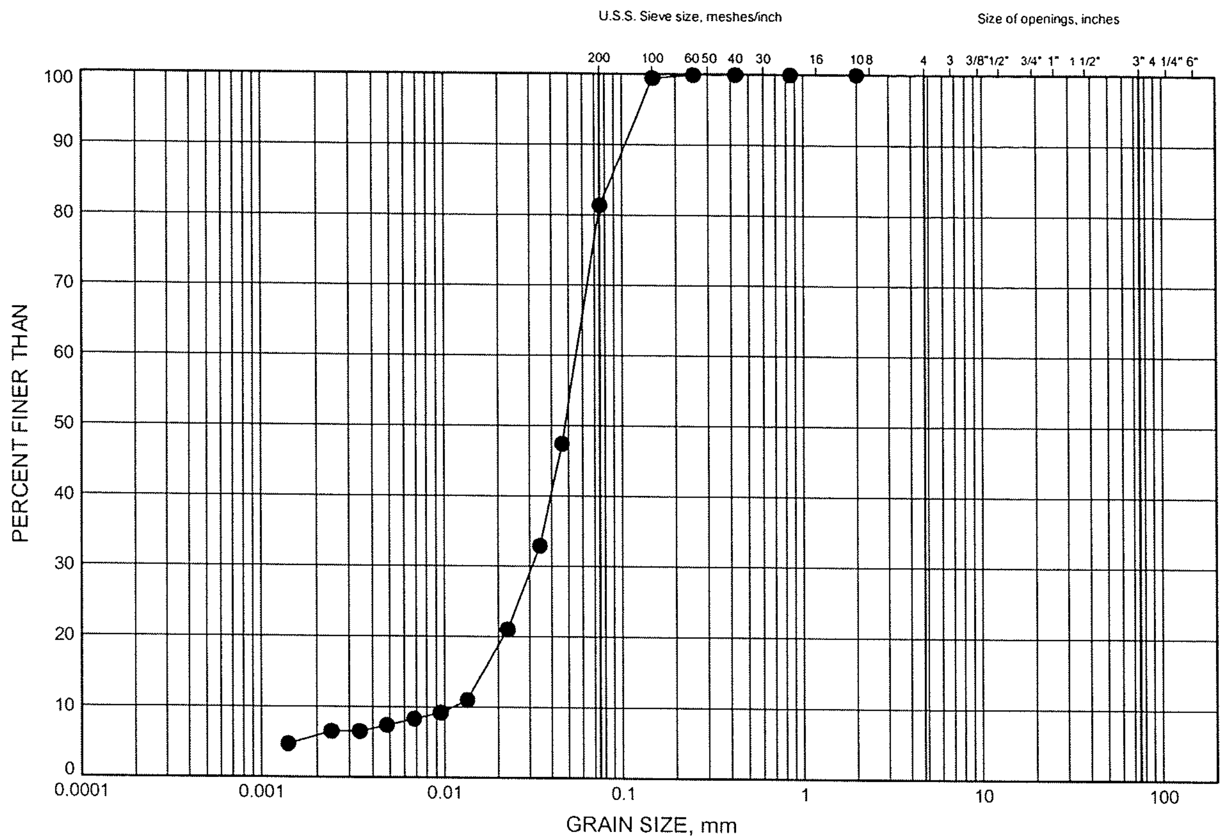
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 10/28/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-041	36.73	289.57

W.P.# 408-88-00

Prepared By AN

Checked By RPR

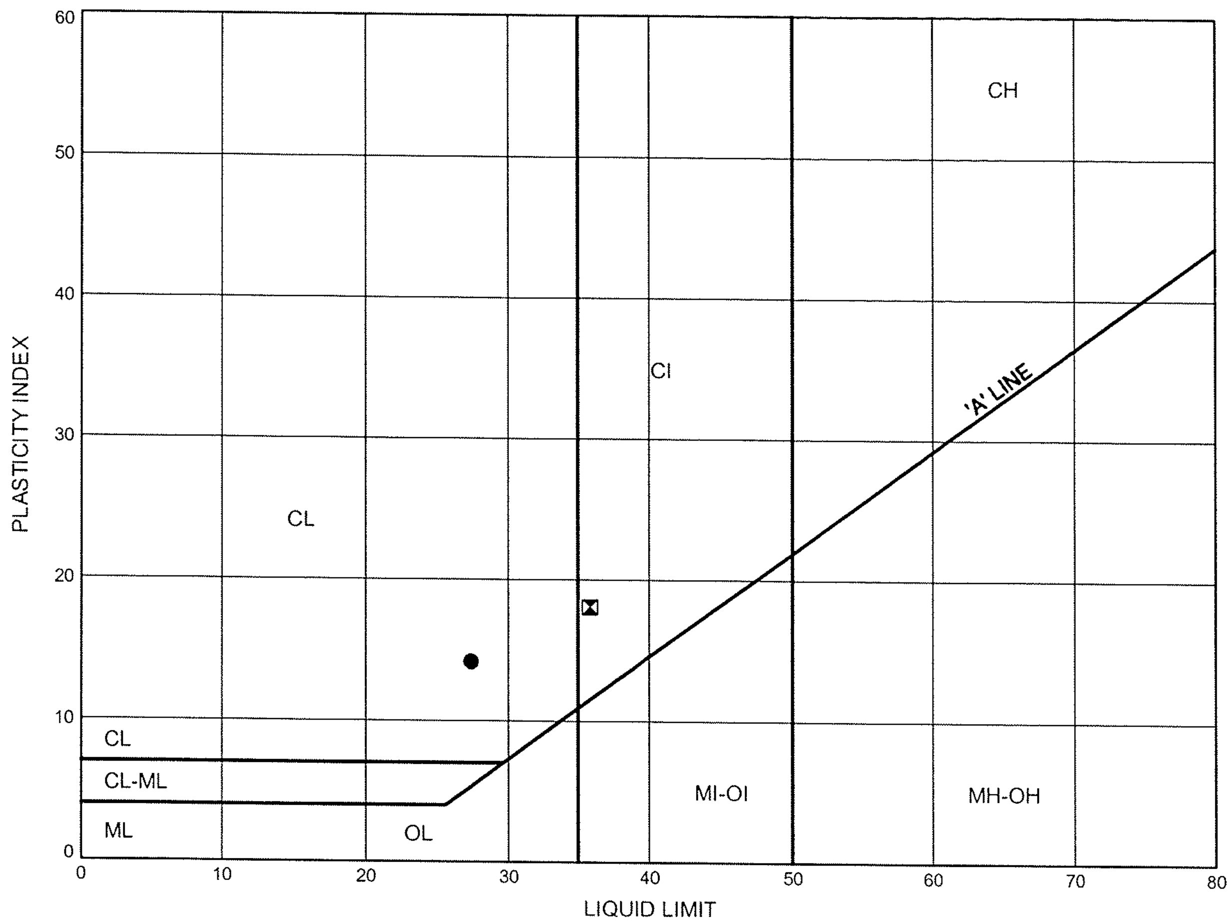
THURBER

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-041	14.02	312.28
⊠	08-042	9.45	313.33

THURBALT 6417R.GPJ 10/28/08

Date October 2008

Project 408-88-00

THURBER

Prep'd AN

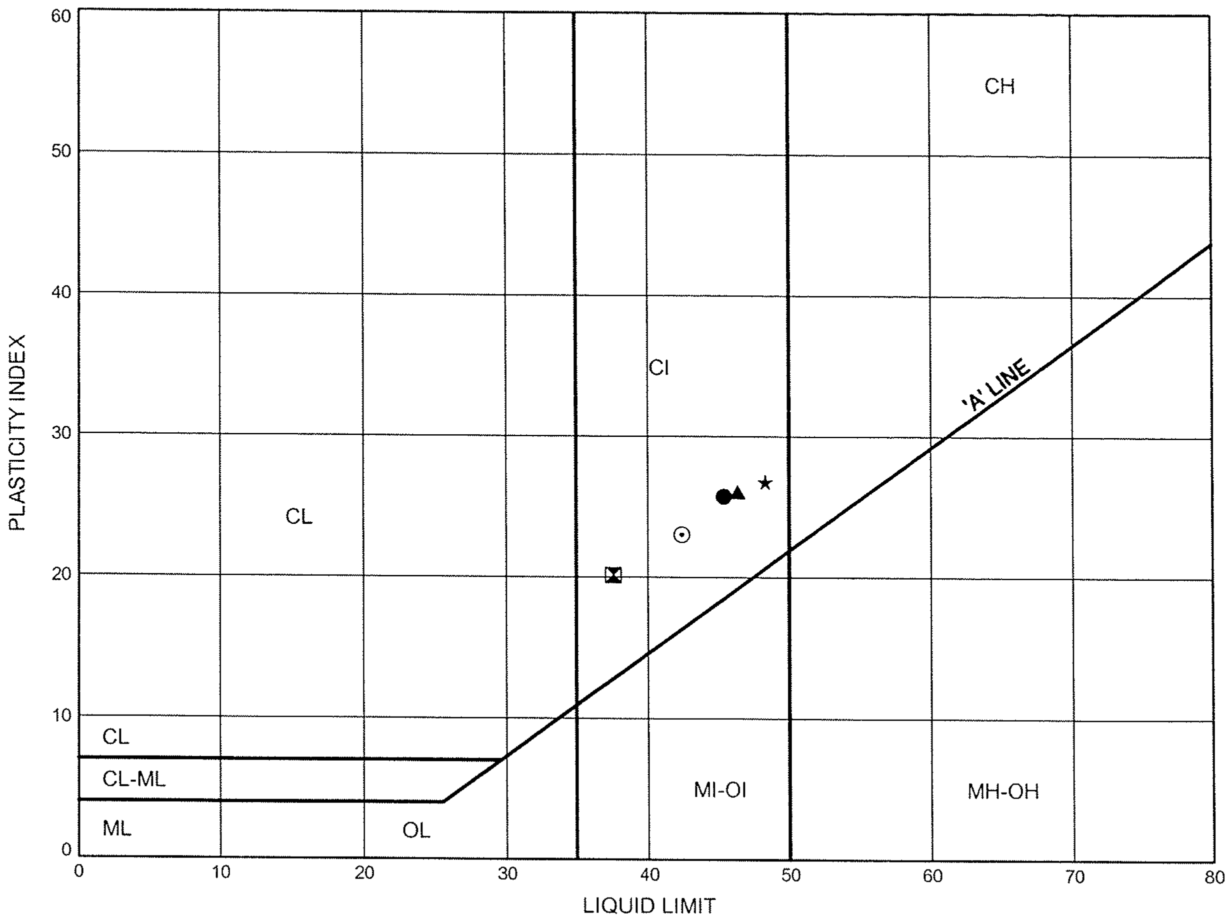
Chkd. RPR

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-041	20.12	306.18
⊠	08-041	24.61	301.69
▲	08-041	29.26	297.04
★	08-042	12.50	310.29
⊙	08-042	18.59	304.19

Date October 2008

Project 408-88-00

THURBER

Prep'd AN

Chkd. RPR

THURBALT 6417R.GPJ 10/28/08

THURBER

Appendix C

Analytical Laboratory Test Results (Present Investigation)

SGS

FINAL REPORT

CA14437-AUG19 R1

11375 Hwy 7 New, Kitchener

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Rob Irwin B.Sc., C.Chem
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Nancy Berg	Telephone	705-652-2361
Telephone	905-829-8666 x 228	Facsimile	705-652-6365
Facsimile		Email	rob.irwin@sgs.com
Email	nberg@thurber.ca	SGS Reference	CA14437-AUG19
Project	11375 Hwy 7 New, Kitchener	Received	08/13/2019
Order Number		Approved	08/19/2019
Samples	Soil (5)	Report Number	CA14437-AUG19 R1
		Date Reported	08/19/2019

COMMENTS

Temperature of Sample upon Receipt: 4 degrees C

Cooling Agent Present: yes

Custody Seal Present: no

Chain of Custody Number: 009972

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

Rob Irwin B.Sc., C.Chem

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.

Project: 11375 Hwy 7 New, Kitchener

Project Manager: Nancy Berg

Samplers: Nancy Berg

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

			Sample Number	5	6	7	8	9
			Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index								
Corrosivity Index	none	1		4	1	5	11	14
Soil Redox Potential	mV	-		306	312	255	263	227
Sulphide	%	0.02		< 0.02	< 0.02	0.02	< 0.02	< 0.02
pH	pH Units	0.05		8.56	8.29	7.88	8.18	8.66
Resistivity (calculated)	ohms.cm	-9999		5100	3200	2500	780	1400

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

			Sample Number	5	6	7	8	9
			Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
General Chemistry								
Conductivity	uS/cm	2		195	317	400	1280	736

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

			Sample Number	5	6	7	8	9
			Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics								
Moisture Content	%	0.1		20.1	6.1	24.6	13.1	6.5
Sulphate	µg/g	0.4		25	12	100	31	13

Client: Thurber Engineering Ltd.

Project: 11375 Hwy 7 New, Kitchener

Project Manager: Nancy Berg

Samplers: Nancy Berg

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

			Sample Number	5	6	7	8	9
			Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Other (ORP)								
Chloride	µg/g	0.4		25	7.8	60	760	430

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 (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Chloride	DIO0262-AUG19	µg/g	0.4	<0.4	9	20	93	80	120	98	75	125
Sulphate	DIO0262-AUG19	µg/g	0.4	<0.4	13	20	94	80	120	96	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 (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Sulphide	ECS0029-AUG19	%	0.02	<0.02	ND	20	110	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 (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Conductivity	EWL0246-AUG19	uS/cm	2	< 0.002	0	10	100	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I 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	EWL0246-AUG19	pH Units	0.05	NA	0		100			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.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety - 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

Request for Laboratory Services and CHAIN OF CUSTODY

No: 009972

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Oleg Mozhin
Received By (signature): [signature]
Received Date (mm/dd/yyyy): 8/13/19 (mm\dd\yy)
Custody Seal Present: ☐ No
Cooling Agent Present: ☑ ice
Received Time: 11:05
Custody Seal Intact: ☐ no
Temperature Upon Receipt (°C): 9°, 9°, 9°
LAB LIMS #: CA14437-Aug19

REPORT INFORMATION

Company: Thurber Engineering Ltd
Contact: Nancy Berg
Address: 103 - 2010 Winston Park Dr, Oakville On L6H 5J7
Phone: 647-633-8417
Email: nberg@thurber.ca
Email:

INVOICE INFORMATION

☐ (same as Report Information)
Company:
Contact:
Address:
Phone:
Email:

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 11375
Site Location/ID: Hwy 7 New, Kitchener

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 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ R/P/I ☐ I/C/C ☐ A/O
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	CN16-10 SS5	July 19/19		1	soil											✓					
2	CN 16-04 SS4	July 23/19		1	soil											✓					
3	CN16-15 SS4	July 18/19		1	soil											✓					
4	RW24-02 SS4	Aug 6/19		1	soil											✓					
5	NE16-09 SS4	Aug 7/19		1	soil											✓					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

Observations/Comments/Special Instructions

Sampled By (NAME): Nancy Berg — Signature: [signature] — Date: 08/12/19 (mm/dd/yy) — Pink Copy - Client

Relinquished by (NAME): Nancy Berg — Signature: [signature] — Date: 08/13/19 (mm/dd/yy) — Yellow & White Copy - SGS

THURBER

Appendix D

Borehole Locations and Soil Strata Drawing

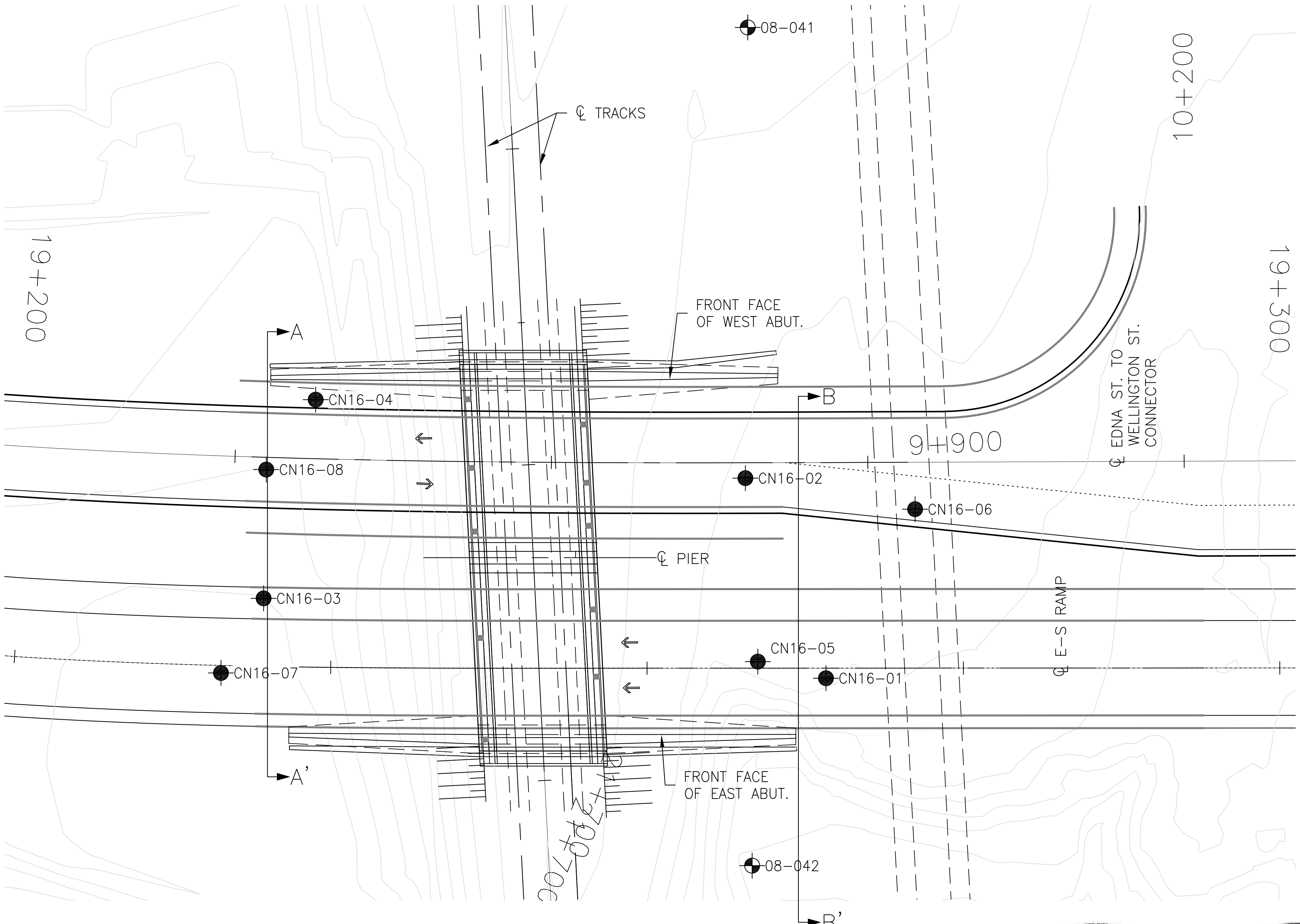
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408–88–00

METROLINX RAILWAY BRIDGE FROM WELLINGTON ST N TO EDNA ST CONNECTION AND E–S RAMP
BOREHOLE LOCATIONS PLAN

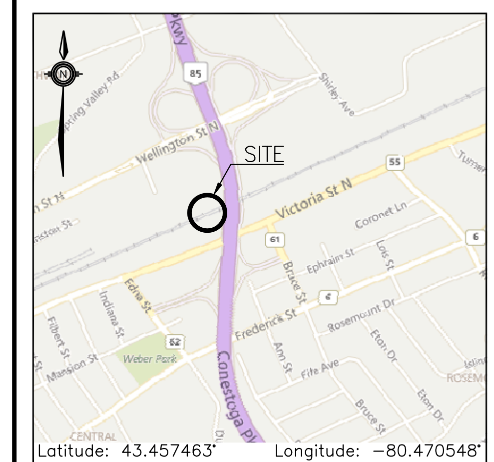
SHEET

THURBER ENGINEERING LTD.



PLAN

8 0 8 16m
SCALE 1:400



KEYPLAN

LEGEND

	Borehole (Current Investigation)
	Borehole (Previous Investigation By Thurber)
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
08–041	326.3	4 814 110.3	226 090.8
08–042	322.8	4 814 134.4	226 152.5
CN16–01	325.5	4 814 134.5	226 136.6
CN16–02	326.1	4 814 122.9	226 124.1
CN16–03	321.3	4 814 090.7	226 146.6
CN16–04	323.3	4 814 089.0	226 130.4
CN16–05	325.5	4 814 129.0	226 137.3
CN16–06	325.9	4 814 136.3	226 121.6
CN16–07	320.8	4 814 089.7	226 153.3
CN16–08	322.0	4 814 087.3	226 137.0

-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. 40P8-278

LICENSED PROFESSIONAL ENGINEER J.P.K. LEE 100086735 06/17/2020 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI 06/17/2020 PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION

DESIGN NB	CHK PKC	CODE	LOAD	DATE JUN 2020
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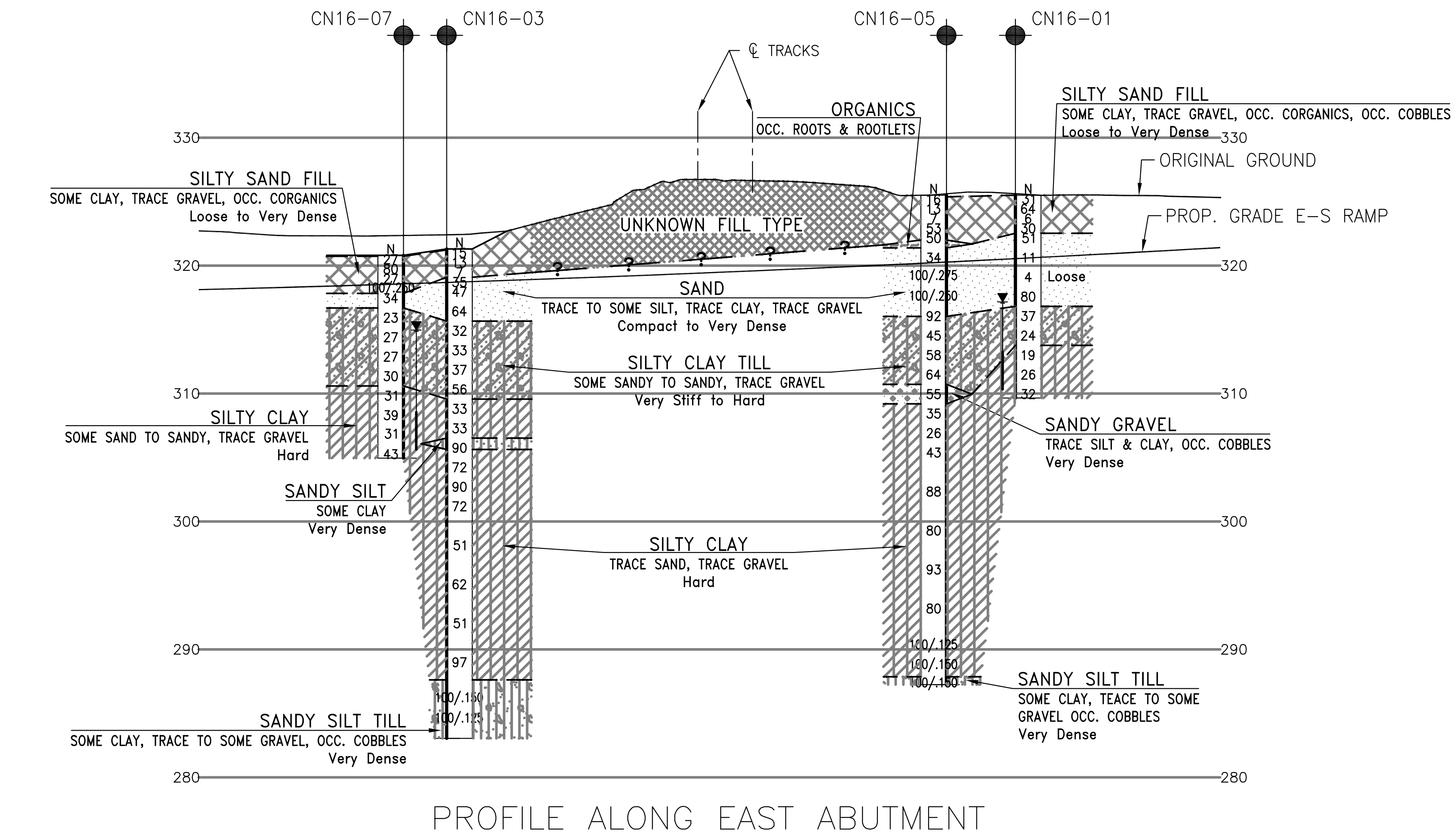
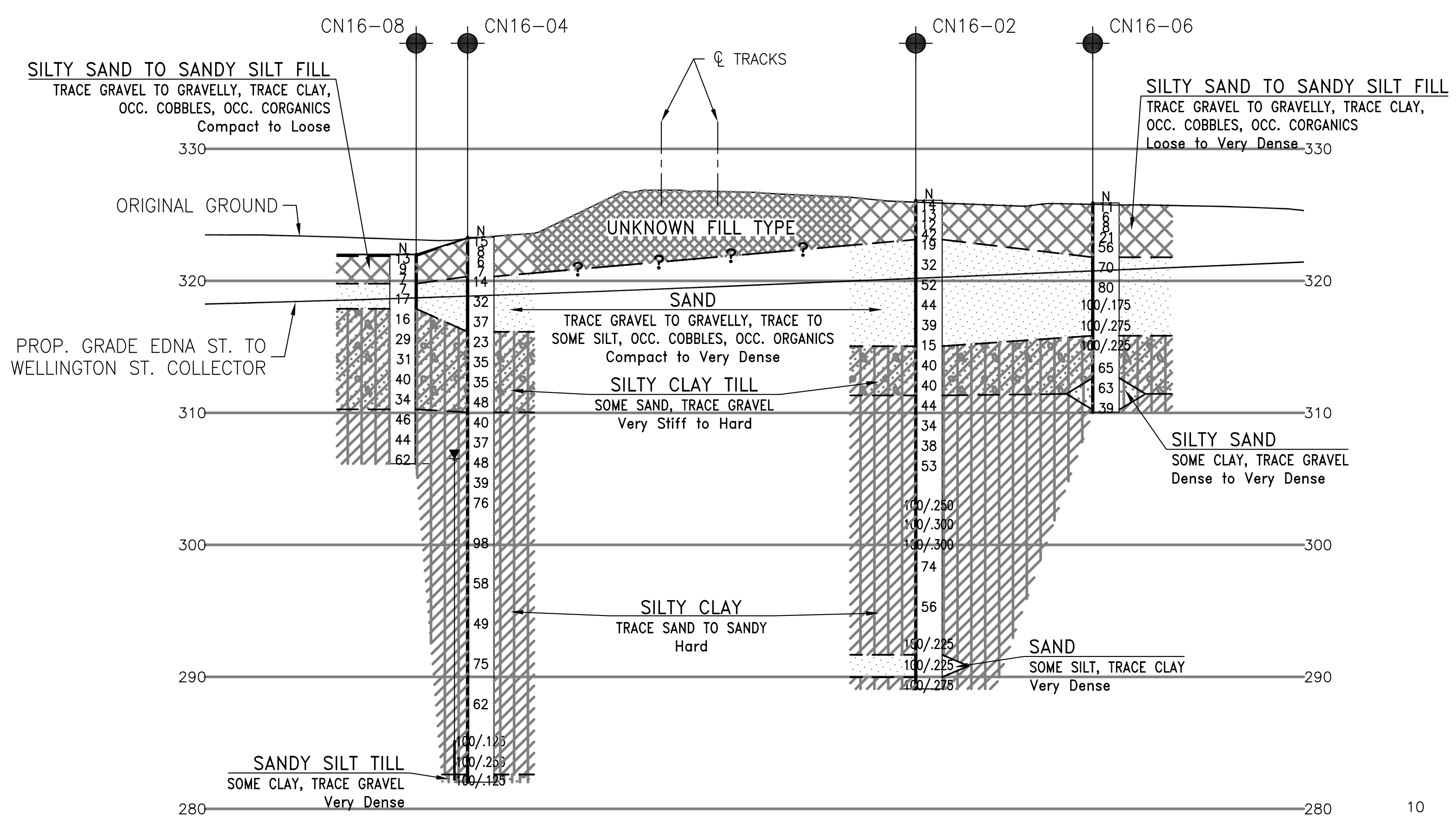


PROFILE ALONG EAST ABUTMENT



PROFILE ALONG WEST ABUTMENT

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

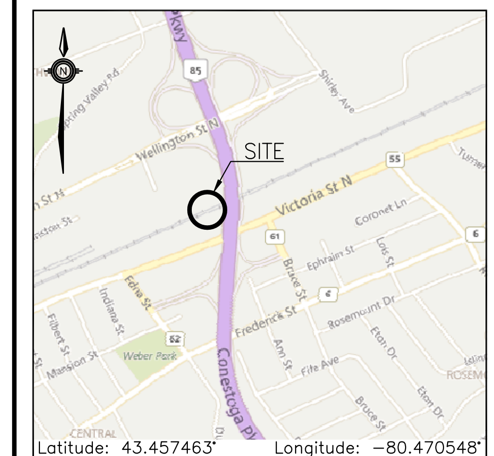
CONT No
GWP No 408-88-00

METROLINX RAILWAY BRIDGE FROM WELLINGTON ST N TO EDNA ST CONNECTION AND E-S RAMP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⌖	Borehole (Current Investigation)
⌖	Borehole (Previous Investigation By Thurber)
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
08-041	326.3	4 814 110.3	226 090.8
08-042	322.8	4 814 134.4	226 152.5
CN16-01	325.5	4 814 134.5	226 136.6
CN16-02	326.1	4 814 122.9	226 124.1
CN16-03	321.3	4 814 090.7	226 146.6
CN16-04	323.3	4 814 089.0	226 130.4
CN16-05	325.5	4 814 129.0	226 137.3
CN16-06	325.9	4 814 136.3	226 121.6
CN16-07	320.8	4 814 089.7	226 153.3
CN16-08	322.0	4 814 087.3	226 137.0

-NOTES-

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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. 40P8-278

LICENSED PROFESSIONAL ENGINEER
J. P. K. LEE
100086735
06/17/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
06/17/2020
PROVINCE OF ONTARIO

10 0 10 20m
SCALE 1:500

REVISIONS

DATE	BY	DESCRIPTION			
DESIGN NB	CHK PKC	CODE	LOAD	DATE	JUN 2020
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METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

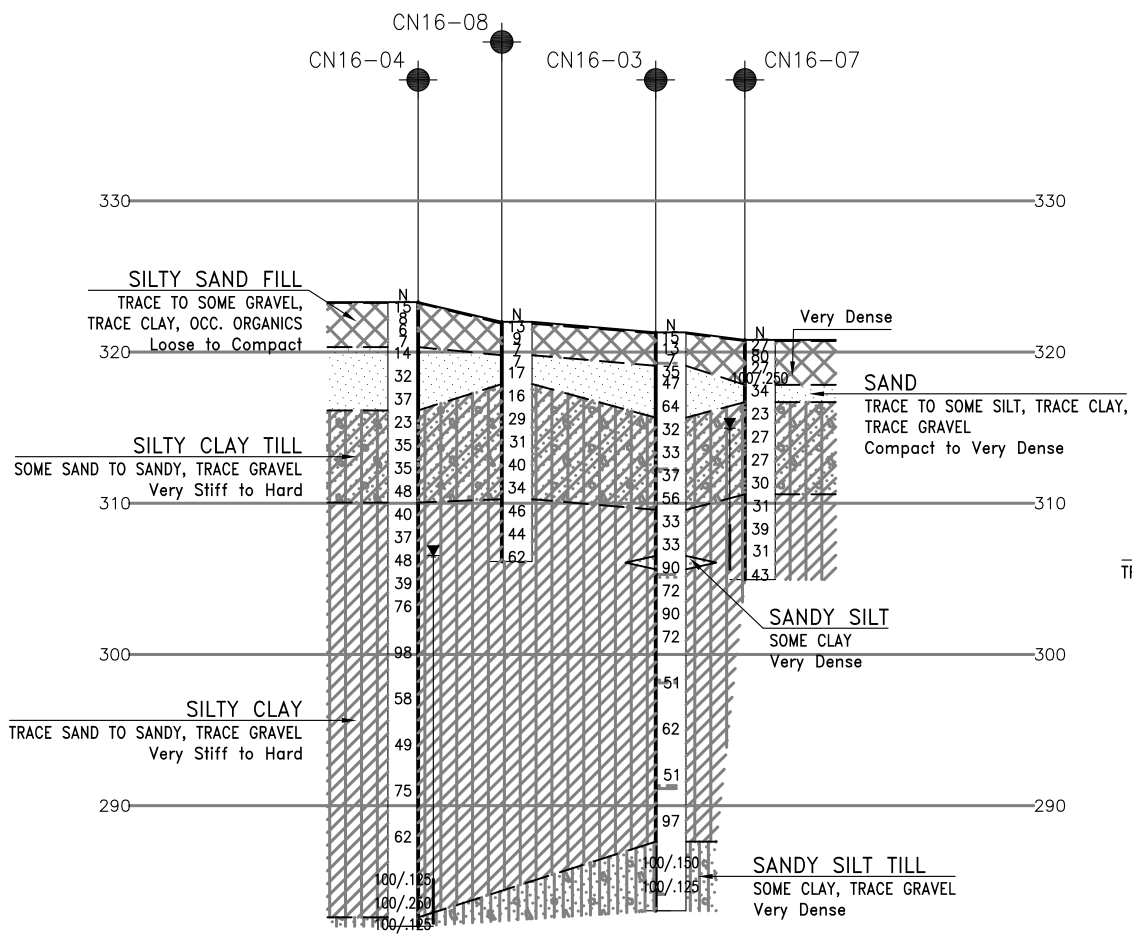
CONT No
GWP No 408-88-00

METROLINX RAILWAY BRIDGE FROM WELLINGTON ST N TO EDNA ST CONNECTION AND E-S RAMP
BOREHOLE LOCATIONS AND SOIL STRATA

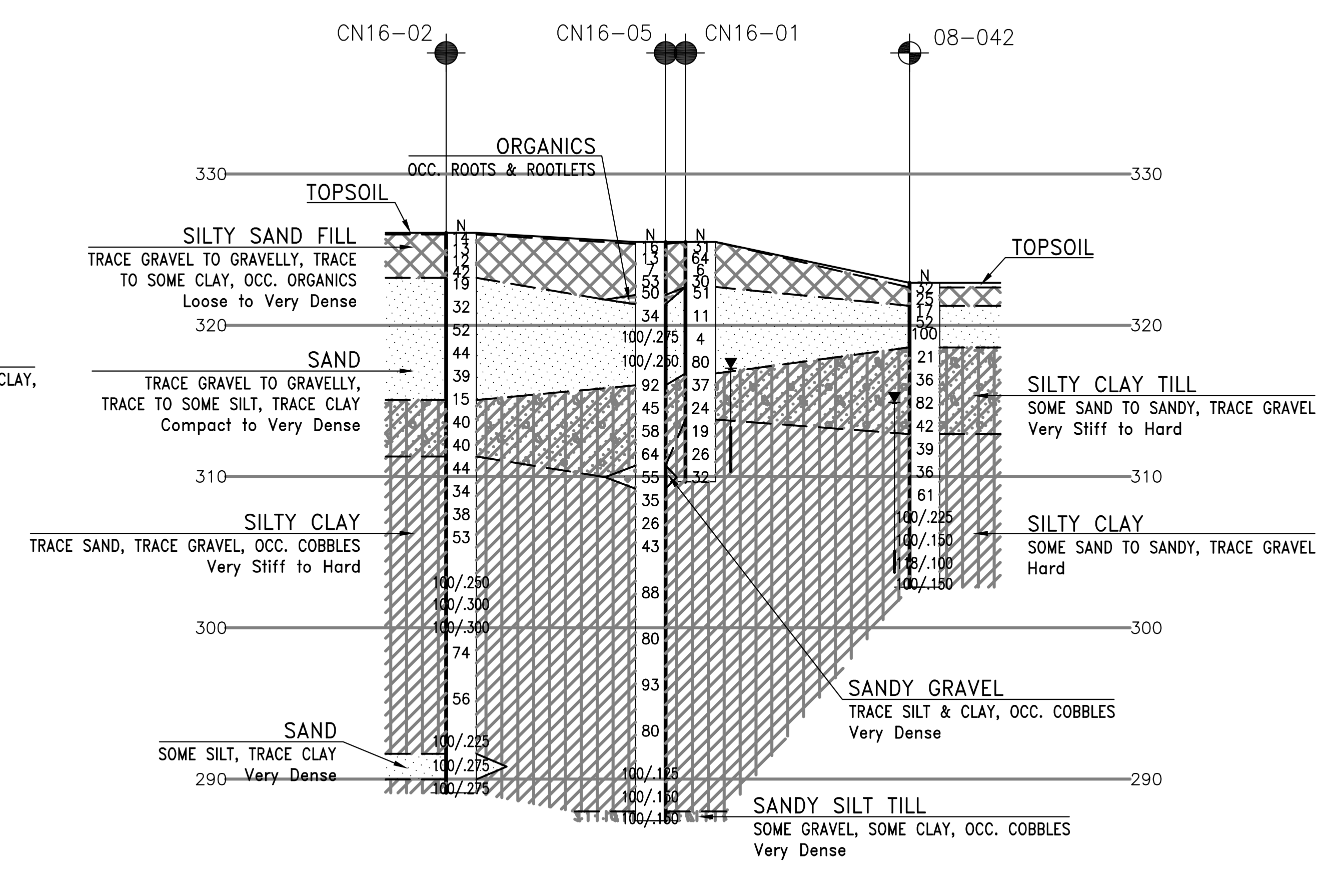
SHEET

WSP

THURBER ENGINEERING LTD.



SECTION ALONG A–A'



SECTION ALONG B–B'

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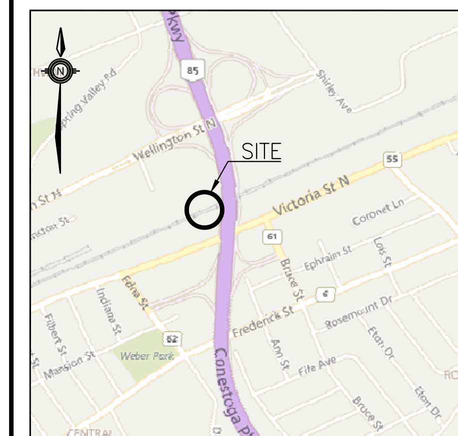

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KEYPLAN

LEGEND

⌖	Borehole (Current Investigation)
⌖	Borehole (Previous Investigation By Thurber)
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
08–041	326.3	4 814 110.3	226 090.8
08–042	322.8	4 814 134.4	226 152.5
CN16–01	325.5	4 814 134.5	226 136.6
CN16–02	326.1	4 814 122.9	226 124.1
CN16–03	321.3	4 814 090.7	226 146.6
CN16–04	323.3	4 814 089.0	226 130.4
CN16–05	325.5	4 814 129.0	226 137.3
CN16–06	325.9	4 814 136.3	226 121.6
CN16–07	320.8	4 814 089.7	226 153.3
CN16–08	322.0	4 814 087.3	226 137.0

-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. 40P8-278

LICENSED PROFESSIONAL ENGINEER
J. P. K. LEE
100086735
06/17/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
06/17/2020
PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN NB	CHK PKC	CODE	LOAD	DATE JUN 2020	
DRAWN AN	CHK NB	SITE	STRUCT	DWG 3	

FILENAME: H:\Drafting\11000\11375\TED-11375-BHPP-ES-Ramp.dwg
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Appendix E

Site Photographs

Figure 1: Borehole CN16-02, looking South at existing Metrolinx tracks

Figure 2: Borehole CN16-03, looking North at existing Metrolinx fence line

Figure 3: Borehole CN16-04, looking North at existing Metrolinx fence line

Figure 4: Borehole CN16-05, looking Southeast towards existing Metrolinx tracks

Figure 5: Borehole CN16-06, looking South towards existing Metrolinx tracks

Figure 6: Borehole CN16-07, looking Northeast at existing Metrolinx fence line and KWE

Figure 7: Borehole CN16-08, looking Northeast towards existing Metrolinx fence line and KWE

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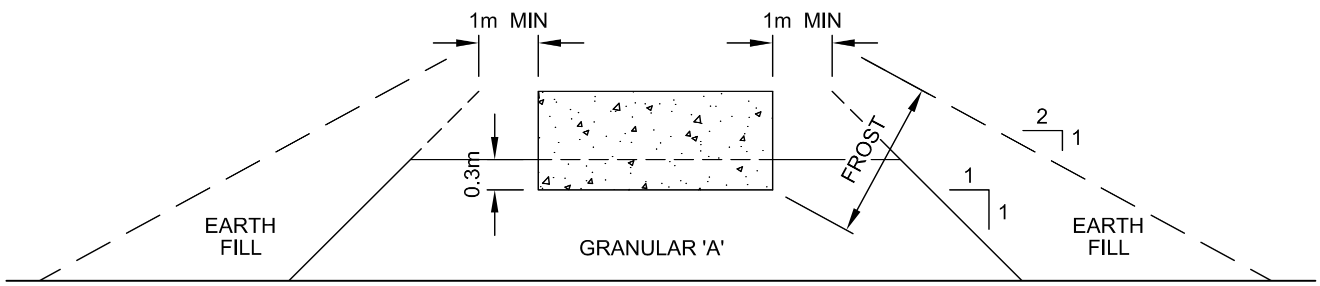
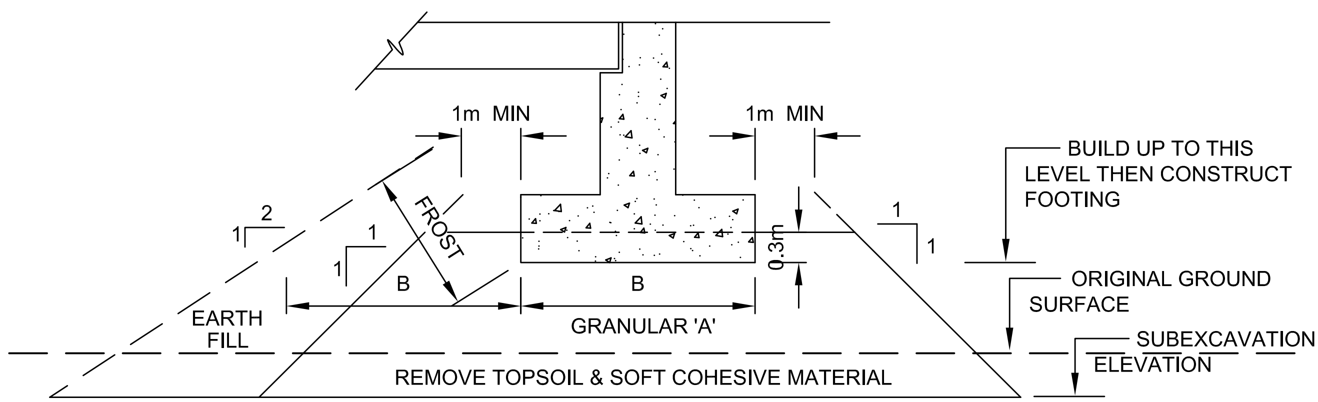
Appendix F

Figure
For
Engineered Fill Pad



CROSS-SECTION



LONGITUDINAL SECTION

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
-	MFA	-
DATE : SEPTEMBER 2016	SCALE : N.T.S.	DRAWING No. FIGURE 1

THURBER

Appendix G

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

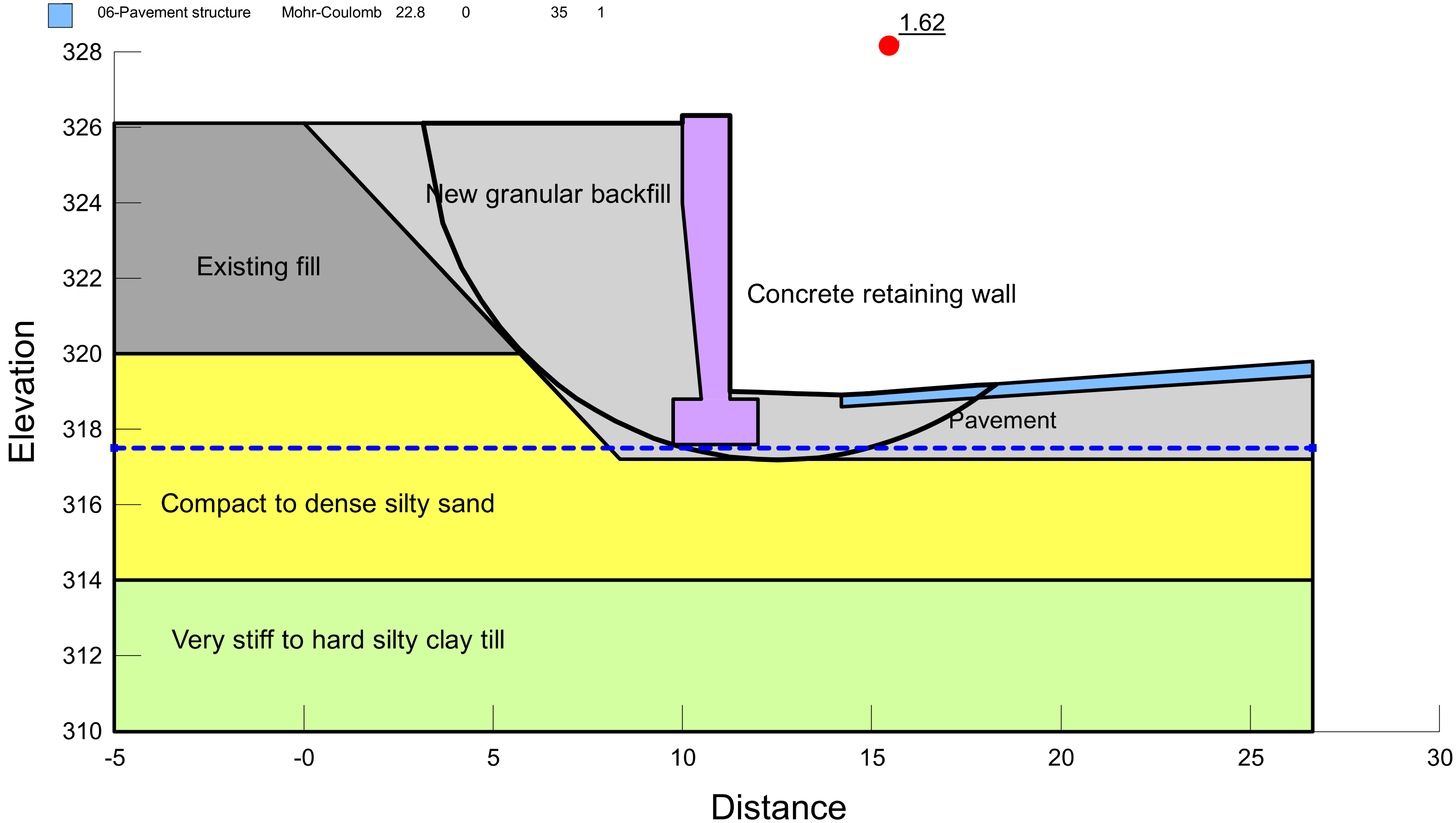
Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caisson
Abutments	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Dewatering may be required, depending on depth of excavation. ii. Sub excavation will be required to penetrate fill. **RECOMMENDED (for non-integral abutments)**	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. iii. Founding level can be adjusted. ***Disadvantages:*** i. Excavation of existing fill will be required to place the engineered fill on competent native soils. ii. Dewatering may be required, depending on depth of excavation. **FEASIBLE**	***Advantages:*** i. High geotechnical resistance may be developed by driving the piles into very dense till. ii. Comparatively short abutment stem possible iii. Permits integral abutment design. iv. Readily installed. v. Installation of piles could continue in freezing conditions. vi. Driven plies require less volume of excavation than footings. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles. iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving. **RECOMMENDED (for integral abutments)**	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense till. iii. Sub excavation of fill and variable material not required. ***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. iv. Installation of deep caissons will be required. **NOT RECOMMENDED**

THURBER

Appendix H

Slope Stability Output

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	01-Existing gravelly sand/silty sand fill	Mohr-Coulomb	19	0	30	1
	02-New granular fill	Mohr-Coulomb	22	0	32	1
	03-Compact to silty sand	Mohr-Coulomb	20	0	32	1
	04- Very stiff to hard silty clay	Mohr-Coulomb	19	0	29	1
	05-Concrete retaining wall	Mohr-Coulomb	24	30,000	0	1
	06-Pavement structure	Mohr-Coulomb	22.8	0	35	1



Project
11375 - Hwy 7-New ES Ramp Under CNR

Analysis
Concrete Retaining Wall- Drained Analysis

Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2020-05-19,06:06:17 PM	1:185

Additional Details

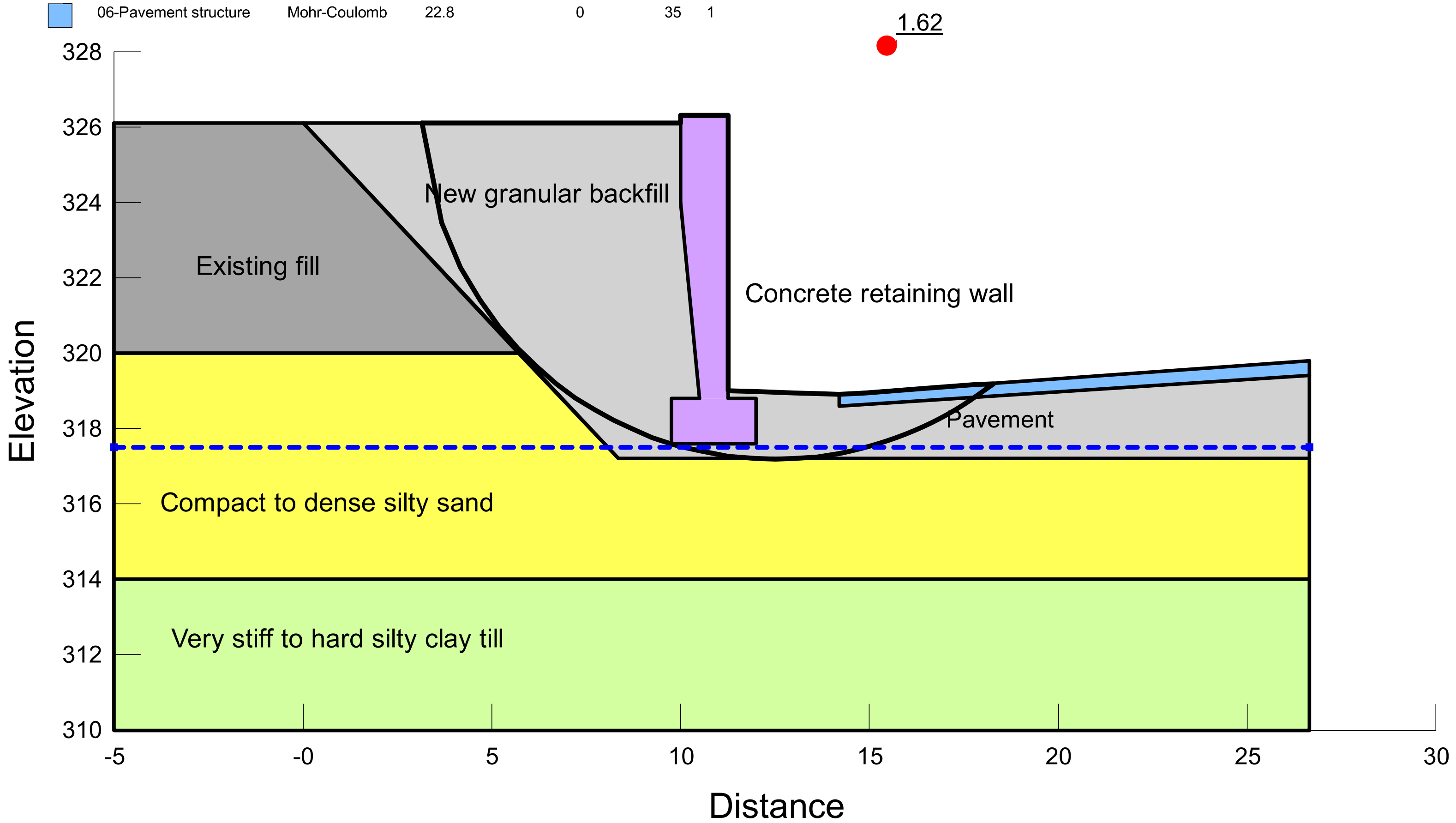
THURBER

Figure H1

H:\10000+\11375 Hwy 7 New PD and DD Foundations\Reports & Memos\Rail Bridges\ES\Analysis\Slope stability\11375-CN ES Ramp- Ret Wall- drained-G1.gsz

Tool Version: 10.2.1.19666

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	01-Existing gravelly sand/silty sand fill	Mohr-Coulomb	19		0	30	1
	02-New granular fill	Mohr-Coulomb	22		0	32	1
	03-Compact to silty sand	Mohr-Coulomb	20		0	32	1
	04- Very stiff to hard silty clay till	Undrained (Phi=0)	19	100			1
	05-Concrete retaining wall	Mohr-Coulomb	24		30,000	0	1
	06-Pavement structure	Mohr-Coulomb	22.8		0	35	1



Project	Analysis	Seismic Coefficient	Last Run	Scale	Additional Details
11375 - Hwy 7-New ES Ramp Under CNR	Concrete Retaining Wall- Undrained Analysis	H: 0g, V: 0g	2020-05-19,06:10:11 PM	1:185	

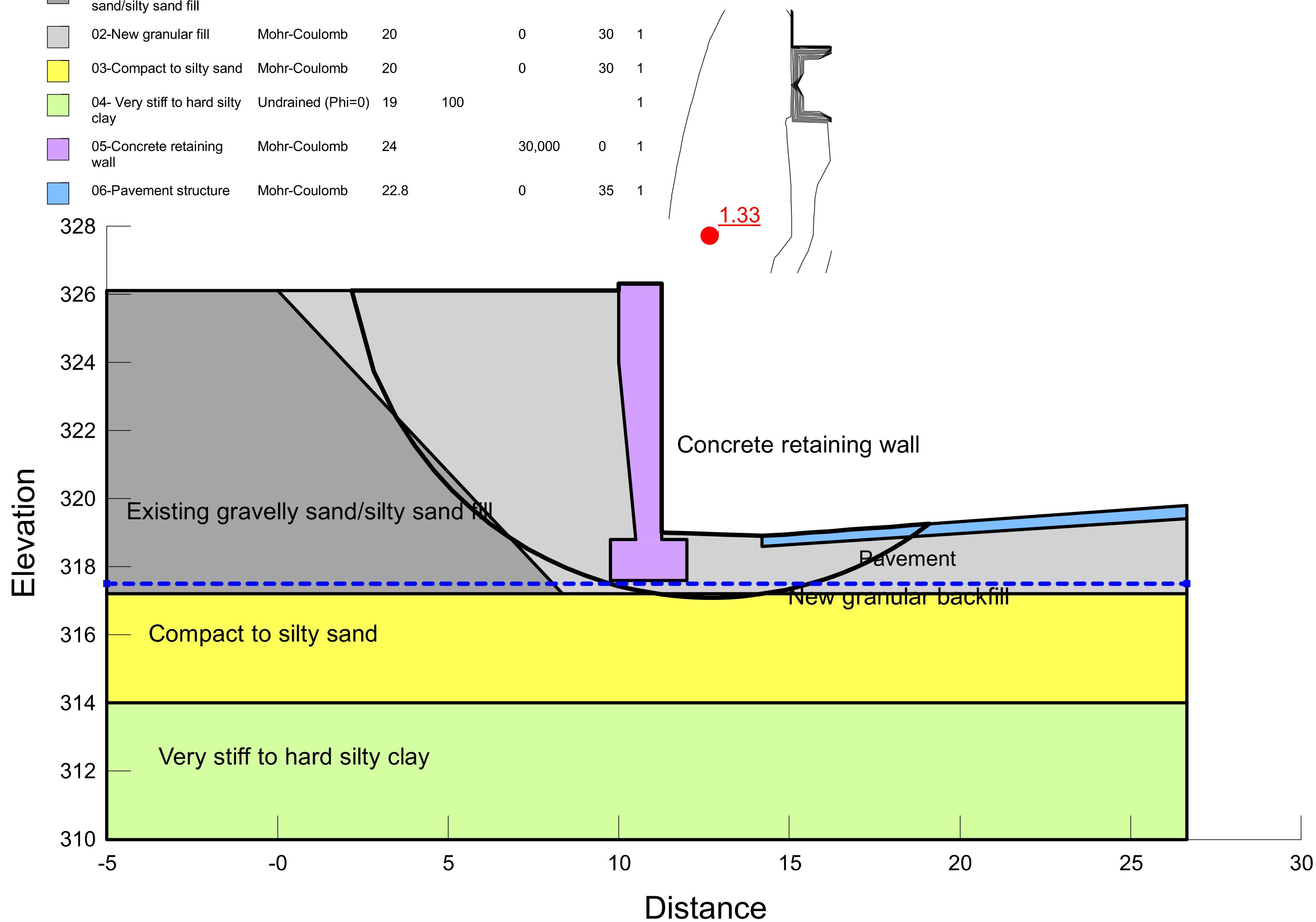
THURBER

Figure H2

H:\10000+\11375 Hwy 7 New PD and DD Foundations\Reports & Memos\Rail Bridges\ES\Analysis\Slope stability\11375-CN ES Ramp- Ret Wall- undrained-H2.gsz

Tool Version: 10.2.1.19666

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	01-Existing gravelly sand/silty sand fill	Mohr-Coulomb	19		0	28	1
	02-New granular fill	Mohr-Coulomb	20		0	30	1
	03-Compact to silty sand	Mohr-Coulomb	20		0	30	1
	04- Very stiff to hard silty clay	Undrained (Phi=0)	19	100			1
	05-Concrete retaining wall	Mohr-Coulomb	24		30,000	0	1
	06-Pavement structure	Mohr-Coulomb	22.8		0	35	1



THURBER

Project
11375 - Hwy 7-New ES Ramp Under CNR

Analysis
Concrete Retaining Wall- Drained Analysis

Seismic Coefficient	Last Run	Scale
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Additional Details

Figure G1

H:\10000+\11375 Hwy 7 New PD and DD Foundations\Reports & Memos\Rail Bridges\ES\Analysis\Slope stability\11375-CN ES Ramp- Ret Wall- seismic-G3.gsz

Tool Version: 10.2.1.19666

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Appendix I

List of OPSS Documents and NSSP Wording

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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
-	SP FOUN0003	Amendment to OPSS.PROV 902
-	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
-	SP 109S12	Amendment to OPSS 902
-	OPSS PROV 903	Construction specification for deep foundations
-	SP 109F57	Amendment to OPSS 903
-	OPSS PROV 1010	Material specification for aggregates - base, subbase, select subgrade, and backfill material
-	OPSD 3102.100	Wall abutments, backfill drain
-	OPSD 3101.150	Wall abutment, backfill minimum granular requirement

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2. Suggested text for a NSSP on Pile Installation

The presence of 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 cobbles and boulders may impede the driving of the piles resulting in more arduous driving in the very dense soils.
- Some piles may meet refusal on boulders that are large enough not to be dislodged or broken by the pile driving.
- As a result of the presence of boulders, piles may meet refusal at varying depths.
- Pile driving must be controlled according to the criteria specified for the site.

3. 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. For bridge foundation construction, appropriate dewatering systems must be installed and made operational prior to excavating below the groundwater level. The dewatering scheme must be effective to lower the groundwater level at least 0.5 m below the footing/pile cap grade level to avoid base boiling in the native soils. It is also important to minimize disturbance of the exposed silty sand surfaces by limiting construction traffic.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV.517. A preconstruction survey is required, thus Designer Fill-In ** in SP FOUN0003 and SP517F01 should be “Yes”.

It is recommended that a Professional Engineer with greater than 5 years of experience in designing dewatering systems be retained.

4. Suggested Text for NSSP on “Impact on Adjacent Structure”

It is critical that Contractor’s excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of the rail tracks, any adjacent structures or underground utilities:

- The lanes of the Kitchener-Waterloo Express way and Metrolinx tracks will be open during excavation and foundation construction of the Metrolinx bridge over the planned E-S Ramp and Wellington Street to Edna Street Connection
- Protection of structure foundations and utilities (if present at this site) during excavation and pile driving.
- Protection of existing approach fills.

5. Suggested Text for NSSP on Embankment Construction

No medium to high plastic clays can be used for embankment construction.