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FOUNDATION INVESTIGATION AND DESIGN REPORT
FREDERICK STREET UNDERPASS

HIGHWAY 7 / 85, KITCHENER, ONTARIO
Assignment No. 3020-E-0016
G.W.P. 3025-20-00
GEOCRES NO. 40P08-300

Client Name: MTO
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TABLE OF CONTENTS

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APPENDICES

APPENDIX A

Site Photographs

APPENDIX B

Previous Investigation: Record of Borehole Logs and Laboratory Test Results

APPENDIX C

Current Investigation: Record of Borehole Logs

APPENDIX D

Current Investigation: Laboratory Test Results

APPENDIX E

Foundation Comparison Table

APPENDIX F

List of OPSS Documents and NSSPs

FOUNDATION INVESTIGATION REPORT
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PART A: FACTUAL INFORMATION

1. INTRODUCTION

Thurber Engineering (Thurber) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the Frederick Street Underpass replacement over the Conestoga Parkway (Highway 7/85) in the Regional Municipality of Waterloo, Ontario. This report addresses the proposed replacement of the existing Frederick Street Underpass (MTO Structure Site No. 33X-0234/B0) and associated retaining walls at the location shown on the Key Plan in Drawing 1 to 3.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, a stratigraphic profile, cross sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

The Terms of Reference (TOR) for the foundation engineering services are outlined in MTO's Request for Proposals (RFP) for Retainer Assignment No. 2 under Agreement No. 3020-E-0016, dated September 19, 2022.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

The site is located in the City of Kitchener, approximately 350 m south of the Highway 7/85 and Victoria Street interchange. At this location, an underpass structure carries Frederick Street over the northbound and southbound lanes (NBL and SBL) of Highway 7/85 and existing ramps (E-S and S-E). The existing Frederick Street Underpass at Highway 7/85 was constructed in 1968 and is a four-span structure supported on two abutments and three piers. The original 1959 GA drawing for the structure indicates that the existing abutments and piers are supported on spread footings.

The existing grade on Frederick Street is at about Elev. 327.5 m and 325.0 m adjacent to the west and east abutments, respectively. Locally, Highway 7/85 has been constructed in a cut up to about 6.5 m deep and the existing highway grade ranges from about Elev. 321 m to 320 m, decreasing towards the east. The site is primarily surrounded by industrial and commercial lands and is relatively flat.

Photographs of the site are included in Appendix A.

3. INVESTIGATION PROCEDURES

3.1 Previous Investigations

Previous investigations have been conducted at the Frederick Street Underpass site, the titles of which are summarized below:

- Foundation Investigation Report for Frederick Street Underpass, Kitchener-Waterloo Expressway, District #4 (Hamilton), W.J. 66-F-53, W.P. 634-64, GEOCRES No. 40P8-48, prepared by DHO (Department of Highways Ontario), dated July 21, 1966.
- Foundation Investigation Report for Northeast Corner Retaining Wall – Frederick Street Underpass, Site No. 33-234, G.W.P. 3110-09-00, City of Kitchener, Ontario, GEOCRES No. 40P8-199, prepared by Peto MacCallum Ltd., dated May 31, 2012.
- Foundation Investigation and Design Report – Frederick Street Underpass, Highway 7 New – Kitchener to Guelph, GWP 408-88-00, GEOCRES No. 40P8-285, prepared by Thurber Engineering Ltd., dated February 9, 2023.

In August 2020, Thurber carried out a preliminary foundation investigation at the site, during which time two boreholes (designated as Boreholes 20-01 and 20-02) were advanced at the west abutment and east abutment of the existing underpass, respectively, as shown on Drawing 1. The results of the investigation are presented in Thurber's report titled *"Foundation Investigation Report, Frederick Street Underpass, Highway 7 – New, Kitchener to Guelph, G.W.P. 408-88-00*", dated February 9, 2021 (GEOCRES 40P8-285).

The borehole locations are provided on the borehole records in Appendix B and shown on Drawing 1. The locations are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations, and borehole depths are summarized below.

Borehole	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
20-01	4,813,653.3	226,144.0	327.5	38.3
20-02	4,813,695.8	226,245.9	325.0	38.4

Borehole records for BH 20-01 and 20-02 are included in Appendix B.

3.2 Current Investigation (2023)

The current investigation was completed in April and May 2023 and involved the completion of six boreholes designated as FS23-01 to FS23-06. These boreholes were advanced to depths ranging from 38.3 to 41.5 m. Two shallower boreholes designated as SS23-01 and SS23-02 were also advanced to depths of 8.2 m in the northwest quadrant of the site, along the area of the proposed northwest retaining wall and a sanitary sewer re-alignment. The approximate locations of the boreholes are shown on the attached Borehole Location and Soil Strata Drawings following the text of this report.

The Record of Borehole Sheets for the boreholes are included in Appendix C.

Utility clearances and Permits to Enter (PTE) were obtained prior to mobilization to the site. The ground surface elevations at the as-drilled borehole locations were obtained in the field by Thurber using a Trimble R10 survey unit. The coordinate system MTM NAD 83, Zone 10 was used for the boreholes.

During the current investigation, a truck-mounted CME 75 drill rig was used in conjunction with hollow-stem augers and tricone (mud rotary) to advance the boreholes. In the shallower boreholes, SS23-01 and SS23-02, only hollow stem augers were used. Borehole FS23-06 was hydroexcavated for the upper 6 m due to the presence of congested underground utilities at the location. In general, soil samples were obtained at selected intervals using a 50 mm diameter 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.

Results of field drilling and sampling of the current investigation are presented on the Record of Borehole sheets in Appendix C.

Groundwater conditions observed in open boreholes are not considered stabilized due to the introduction of water throughout the drilling operations. Groundwater level readings observed upon completion of drilling are shown on the Record of Borehole sheets. Piezometer installation details are provided on the borehole logs. Where piezometer was not installed in the FS-series boreholes, the borehole was grouted to 0.3 m below surface and then backfilled with sand and cold patch asphalt to surface (if advanced through pavement). Where a piezometer was not installed in SS23-02, the borehole was backfilled with holeplug.

A summary of the borehole elevations, termination depths and elevations, and piezometer tip details are in the table below.

Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth (m) / Borehole Termination Elevation (m)	Piezometer Tip Depth (m) / Elevation (m)
West Abutment	FS23-01	327.7	41.2 / 286.5	7.6 / 320.1
	FS23-02	327.3	40.4 / 286.9	-
Centre Pier	FS23-03	320.5	41.4 / 279.1	7.6 / 312.9
	FS23-04	320.8	38.3 / 282.5	-
East Abutment	FS23-05	325.3	41.5 / 283.8	-
	FS23-06	325.4	41.5 / 283.9	-
Northwest Retaining Wall/Sewer Realignment	SS23-01	324.7	8.2 / 316.5	7.6 / 317.1
	SS23-02	327.4	8.2 / 319.2	-

3.3 Laboratory Testing

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix C and are shown on figures in Appendix D.

Testing was carried out on samples of the native soils to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements of the structures. The results of the analytical testing are summarized in this report and presented in Appendix D.

4. SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

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.

4.2 Subsurface Conditions

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix C and interpreted stratigraphic profile and section are presented on the Borehole Locations and Soil Strata Drawings. A general description of the stratigraphy, based on the conditions encountered in the boreholes from the current investigation, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. Classification and descriptions of coarse- and fine-grained soils are made in general accordance with ASTM D2487, and MTO's Soil Classification Manual (as amended), respectively.

The boundaries between soil deposits on the record of boreholes have been inferred from non-continuous sampling, observation of the progress of drilling, and the results of Standard Penetration Testing. Therefore, the boundaries represent the transitions between soil deposits rather than exact planes of geological change. Variation on the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions at the site consist of a pavement structure and layers of a non-homogeneous fill overlying a silty clay to clay above a deposit of silty sand to silt. The sandy silt to silt is underlain by a lower silty clay to clay deposit, which is in turn underlain by a deposit of clayey sand to sandy silty clay till within the depths of borehole investigation.

4.3 Asphalt

Borehole FS23-01 was advanced through Frederick Street and the thickness of the asphalt was measured to be 50 mm thick. Boreholes FS23-03 and FS23-04 were advanced through Highway 7/85, near the median between the northbound and southbound express lanes of the highway. The pavement thickness was measured to be 330 mm and 300 mm thick in Boreholes FS23-03 and FS23-04, respectively. Borehole SS23-02 was advanced through the parking lot at 460 Frederick Street and the asphalt was measured to be 50 mm thick.

4.4 Topsoil

A 100 mm to 150 mm thick layer of topsoil was encountered at ground surface at Boreholes FS23-02, FS23-05 and SS23-01. The topsoil thickness may vary in other areas of the site.

4.5 Fill

An approximately 1.1 m to 5.6 m thick layer of non-homogenous fill was encountered at the ground surface in Borehole FS23-06, underlying the asphalt (Frederick Street, Highway 7/85, and parking lot of 460 Frederick Street) in Boreholes FS23-01, FS23-03, FS23-04, and SS23-02, and below the topsoil in Borehole FS23-02. The top of the fill was encountered at ground surface to a depth of 0.3 m below ground surface (between Elevations 327.7 m and 320.1 m) and extends to depths ranging from 1.4 m to 5.6 m below ground surface (between Elevations 325.5 m and 318.6 m).

In general, SPT 'N' values recorded in the non-cohesive fill generally ranged from 10 blows to 41 blows per 0.3 m penetration, indicating a compact to dense condition. However, SPT 'N' values of 0 blows (i.e. weight of hammer) and 5 blows per 0.3 m of penetration were also recorded near the bottom of the fill layer in Borehole FS23-01, indicating the fill is very loose to loose in places. Where cohesive fill was encountered in Boreholes FS23-02 to FS23-04, and SS23-02, the SPT 'N'-values ranged from 6 to 30, suggesting a generally firm to very stiff consistency. The measured moisture contents generally ranged from 2 per cent to 19 per cent.

The results of grain size analyses carried out on the fill samples are shown on the Record of Borehole sheets in Appendix C and presented in Figure D1 of Appendix D. The results are summarized as follows:

Soil Particle	Non-cohesive Fill Percentage (%)	Cohesive Fill Percentage (%)
Gravel	5 to 38	0 to 27
Sand	49 to 79	10 to 47
Silt	11 to 24	29 to 55
Clay	2 to 7	10 to 35
Silt and Clay	12 to 16	-

The results of the Atterberg Limits tests carried out on samples of the cohesive fill are shown on the Record of Borehole logs in Appendix C and presented in Figure D2 of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	17 to 27
Plastic Limit	12 to 14
Plastic Index	5 to 14

The results of the Atterberg Limits testing indicate the material is clayey silt to silty clay of low plasticity (CL-ML to CL).

4.6 Upper Sand to Silty Sand to Silt

An approximately 3.2 m to 7.1 m thick deposit, varying in composition from sand, some gravel to silty sand to silt, some sand, trace gravel, was encountered underlying the topsoil in Borehole FS23-05 and SS23-01, and underlying the fill in Boreholes FS23-01, FS23-02, and SS23-02. The top of the sand to silt deposit was encountered at depths ranging from 0.1 m to 3.7 m below ground surface (between Elevations 325.5 m and 324.0 m) and it extends to depths ranging from 3.4 m to 7.2 m below ground surface (Elevations 321.8 m to 318.1 m).

The SPT "N"-values measured within the sand to silt deposit range generally from 3 to 28 blows per 0.3 m of penetration, indicating a loose to compact relative density. One SPT "N"-value in Borehole SS23-02 measured weight of hammer (WH) in this deposit. The measured moisture contents generally ranged from 4 per cent to 23 per cent.

The results of grain size analyses carried out on samples of the sand to silt are shown on the Record of Borehole sheets in Appendix C and presented in Figure D3 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 15
Sand	54 to 83
Silt	11 to 37
Clay	1 to 9

4.7 Upper Sandy Silty Clay to Clayey Silt Till

An approximately 1.1 m to 3.5 m thick deposit, varying in composition from Sandy Silty Clay to Sandy Clayey Silt to Clayey Silt, trace to some gravel, was encountered underlying the fill in Borehole FS23-03 and FS23-06, and underlying the sand in Borehole FS23-05, SS23-01 and SS23-02. Borehole SS23-02 was terminated within this layer. The top of the cohesive till deposit was encountered at depths ranging from 1.4 m to 7.2 m below ground surface (between Elevations 321.8 m and 318.1 m) and it extends to depths ranging from 4.5 m to 10.7 m below ground surface (Elevations 320.2 m to 314.6 m).

The SPT “N”-values measured within the upper cohesive till deposit range generally from 7 to 65 blows per 0.3 m of penetration, indicating a firm to hard consistency. The measured moisture contents generally ranged from 11 per cent to 25 per cent.

The results of grain size analyses carried out on samples of the upper cohesive till are shown on the Record of Borehole sheets in Appendix C and presented in Figures D4A and D4B of Appendix D. The results for the cohesive till are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 21
Sand	4 to 32
Silt	33 to 50
Clay	11 to 46

The results of the Atterberg Limits tests carried out on samples of the upper cohesive till are shown on the Record of Borehole logs in Appendix C and presented in Figure D5A and D5B of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	17 to 26
Plastic Limit	9 to 11
Plastic Index	7 to 15

The results of the Atterberg Limits testing indicate the material is clayey silt of low plasticity to silty clay of intermediate plasticity (CL-ML to CI), shown on Figure D6A and Figure D6B, respectively.

Glacial tills inherently contain cobbles and boulders.

4.8 Silty Sand

An approximately 1.2 m thick layer of silty sand was encountered underlying the upper cohesive till in Borehole FS23-06. The top of the silty sand layer was encountered at a depth of 9.0 m below ground surface (Elevation 316.4 m) and it extends to a depth of 10.2 m below ground surface (Elevation 315.2 m).

The SPT "N"-value measured within the silty sand layer was 78 blows per 0.3 m of penetration, indicating a very dense relative density. The measured moisture content was 19 per cent.

The results of grain size analyses carried out on a sample of the silty sand is shown on the Record of Borehole sheets in Appendix C and presented in Figure D6 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	78
Silt and Clay	22

4.9 Upper Silty Clay to Clay

An approximately 4.1 m to 8.0 m thick deposit, varying in composition from silty clay to clay, trace sand, trace gravel was encountered underlying the sand to silty sand in Boreholes FS23-01, FS23-02 and FS23-06, underlying the cohesive till in Boreholes SS23-01, FS23-03 and FS23-05, and underlying the fill in Borehole FS23-04. The top of the upper silty clay to clay deposit was encountered at depths ranging from 2.2 m to 10.7 m below ground surface (between Elevations 320.9 m and 314.6 m) and it extends to depths ranging from 8.2 m to 17.8 m below ground surface (Elevations 316.5 m to 307.6 m). Borehole SS23-01 was terminated in this deposit.

The SPT "N"-values measured within the upper plastic till deposit range generally from 13 to 84 blows per 0.3 m of penetration, indicating a stiff to hard consistency. The measured moisture contents generally ranged from 10 per cent to 38 per cent.

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The results of grain size analyses carried out on samples of the upper silty clay to clay are shown on the Record of Borehole sheets in Appendix C and presented in Figure D7 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	0 to 10
Silt	29 to 56
Clay	38 to 71

The results of the Atterberg Limits tests carried out on samples of the upper silty clay to clay are shown on the Record of Borehole logs in Appendix C and presented in Figure D8 of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	33 to 57
Plastic Limit	13 to 22
Plastic Index	18 to 36

The results of the Atterberg Limits testing indicate the material is silty clay of low plasticity to a clay of high plasticity (CL to CH).

4.10 Silty Sand to Silt

An approximately 2.2 m to 5.9 m thick deposit, varying in composition from silty sand to sandy silt to silt, some sand was encountered underlying the upper silty clay to clay Boreholes FS23-01 to FS23-04 and FS23-06. The top of the silty sand to silt deposit was encountered at depths ranging from 10.2 m to 17.8 m below ground surface (between Elevations 314.0 m and 307.6 m) and it extends to depths ranging from 12.4 m to 21.6 m below ground surface (Elevations 309.5 m to 303.8 m).

The SPT "N"-values measured within the silty sand to silt deposit range generally from 40 to 134 blows per 0.3 m of penetration, indicating a dense to very dense relative density. Other SPT "N"-values measured in this deposit include 110 blows and 120 blows for 0.28 m of penetration. The measured moisture contents generally ranged from 12 per cent to 33 per cent.

The results of grain size analyses carried out on samples of the silty sand to silt are shown on the Record of Borehole sheets in Appendix C and presented in Figure D9 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	18 to 59
Silt	39 to 74
Clay	2 to 8

The results of the Atterberg Limits tests attempts carried out on samples of the silty sand to silt suggested the fines portion of the material is non-plastic.

4.11 Clayey Silt

An approximately 4.5 m thick deposit of clayey silt, some sand was encountered underlying the upper silty clay in Borehole FS23-05. The top of the silty clay deposit was encountered at a depth of 14.8 m below ground surface (Elevation 310.5 m) and it extends to a depth of 19.3 m below ground surface (Elevation 306.0 m).

The SPT "N"-values measured within the clayey silt deposit range generally from 67 to 113 blows per 0.3 m of penetration, indicating a hard consistency. The measured moisture contents generally ranged from 13 per cent to 20 per cent.

The results of grain size analyses carried out on samples of the silty clay are shown on the Record of Borehole sheets in Appendix C and presented in Figure D10 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	16
Silt	67
Clay	17

The results of the Atterberg Limits tests carried out on a sample of the silty clay are shown on the Record of Borehole logs in Appendix C and presented in Figure D11 of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	19
Plastic Limit	11
Plastic Index	8

The results of the Atterberg Limits testing indicate the material is silty clay of low plasticity (CL).

4.12 Lower Silty Clay to Clay

An approximately 9.2 m to 16.0 m thick deposit, varying in composition from silty clay to clay, trace sand was encountered underlying the silty sand to silt in Boreholes FS23-01 to FS23-04 and FS23-06, and underlying the clayey silt in Borehole FS23-05. The top of the lower silty clay to clay deposit was encountered at depths ranging from 12.4 m to 21.6 m below ground surface (between Elevations 309.5 m and 303.8 m) and it extends to depths ranging from 27.7 m to 35.4 m below ground surface (Elevations 294.6 m to 292.3 m).

The SPT "N"-values measured within the lower cohesive deposit range generally from 25 to 64 blows per 0.3 m of penetration, indicating a stiff to hard consistency. The measured moisture contents generally ranged from 17 per cent to 30 per cent.

The results of grain size analyses carried out on samples of the lower silty clay to clay are shown on the Record of Borehole sheets in Appendix C and presented in Figure D12 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 3
Silt	20 to 40
Clay	57 to 80

The results of the Atterberg Limits tests carried out on samples of the lower silty clay to clay are shown on the Record of Borehole logs in Appendix C and presented in Figure D13 of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	42 to 56
Plastic Limit	15 to 21
Plastic Index	25 to 35

The results of the Atterberg Limits testing indicate the material is silty clay of intermediate to high plasticity (CI to CH).

4.13 Lower Sand to Sandy Silt

An approximately 3.1 m thick deposit, varying in composition from sand, some silt to silty sand to sandy silt was encountered underlying the lower silty clay to clay in Boreholes FS23-03 to FS23-05. The top of the sand to sandy silt deposit was encountered at depths ranging from 27.7 m to 32.3 m below ground surface (between Elevations 293.1 m and 292.7 m) and it extends to depths ranging from 30.8 m to 35.4 m below ground surface (Elevations 290.1 m to 289.7 m).

The SPT “N”-values measured within the sand to sandy silt deposit range from 22 to 99 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The measured moisture contents generally ranged from 12 per cent to 26 per cent.

The results of grain size analyses carried out on samples of the silty sand to silt are shown on the Record of Borehole sheets in Appendix C and presented in Figure D14 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	30 to 84
Silt	62
Clay	8
Silt and Clay	16 to 20

4.14 Gravel and Sand

An approximately 1.7 m thick layer of gravel and sand, trace fines was encountered underlying the lower silt till in Borehole FS23-06. The top of the gravel and sand layer was encountered at a depth of 33.8 m below ground surface (Elevation 291.6 m) and it extends to a depth of 35.5 m below ground surface (Elevation 289.9 m).

A SPT "N"-value measured within the gravel and sand deposit was 52 blows per 0.3 m of penetration, indicating a very dense relative density. The measured moisture was 10 per cent.

The results of grain size analyses carried out on a sample of the gravel and sand are shown on the Record of Borehole sheets in Appendix C and presented in Figure D15 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	52
Sand	41
Silt and Clay	7

4.15 Lower Silt to Clayey Silt Till

A deposit at least 5.0 m to 10.6 m thick, varying in composition from sandy silt to clayey sand to sandy clayey silt to sandy silty clay, trace gravel till was encountered underlying the lower silty clay to clay deposit in Boreholes FS23-01 and FS23-02, underlying the lower sand to sandy silt in Boreholes FS23-03 to FS23-05, and underlying the gravel and sand in Borehole FS23-06. An approximately 3.0 m thick layer of silt till, trace sand was encountered underlying the lower silty clay to clay Borehole FS23-06. The top of the lower cohesive till deposit was encountered at depths ranging from 30.8 m to 35.5 m below ground surface (between Elevations 293.5 m and 289.7 m). Boreholes FS23-01 to FS23-06 were terminated in this till deposit.

The SPT "N"-values measured within the lower cohesive till deposit range generally from 102 to greater than 100 blows per 0.3 m of penetration, indicating a hard consistency. SPT "N"-values that did not achieve full penetration ranged from 100 blows for 0.08 m of penetration to 109 blows for 0.28 m of penetration. A SPT "N"-value measured within the lower non-plastic till deposit was 102 blows per 0.3 m of penetration, indicating a very dense relative density. The measured moisture contents generally ranged from 5 per cent to 28 per cent.

The results of grain size analyses carried out on samples of the lower non-plastic and plastic till deposit are shown on the Record of Borehole sheets in Appendix C and presented in Figure D16A and D16B of Appendix D. The results are summarized as follows:

Soil Particle	Plastic Till Percentage (%)	Non-Plastic Till Percentage (%)
Gravel	2 to 8	0
Sand	26 to 60	7
Silt	28 to 53	66
Clay	7 to 20	27

The results of the Atterberg Limits tests carried out on the fines portion of samples of the lower plastic till deposit are shown on the Record of Borehole logs in Appendix C and presented in Figure D17 of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	15 to 19
Plastic Limit	9 to 10
Plastic Index	5 to 10

The results of the Atterberg Limits testing indicate the material is clayey silt to silty clay of low plasticity (CL-ML to CL).

Glacial tills inherently contain cobbles and boulders.

4.16 Groundwater Conditions

Details of the water level observed in the boreholes upon completion of drilling and in piezometers are presented on the record of boreholes and summarized below.

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth[1]	Elevation	
FS23-01	June 1, 2023	5.9	321.8	In monitoring well.
	August 29, 2023	5.7	322.0	In monitoring well.
FS23-03	April 19, 2023	2.1	318.4	In monitoring well.

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth[1]	Elevation	
FS23-04	April 21, 2023	-1.6	322.4	Artesian pressure encountered when at a depth of 38.1 m below ground surface. Water level measurement in rods when tricone at a depth of 29.4 m below ground surface.[2]
SS23-01	June 1, 2023	4.9	319.8	In monitoring well.
	August 29, 2023	5.1	319.6	In monitoring well.

Notes:
1. *Positive and negative depth values are used to represent water levels that are measured either below or above the ground surface, respectively.*
2. *Water level measured in open borehole / hollow stem augers.*

The water levels measured in the borehole upon completion of drilling and piezometers are short-term observations and subject to seasonal fluctuations. In particular, the water levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

4.17 Single Well Response Test Results – Hydraulic Conductivity

The SWRT results were analyzed using the Hvorslev method. The SWRT analysis plots are included in Appendix C. The hydraulic conductivity values calculated from the in-situ SWRTs are summarized in the following table:

Monitoring Well	Screen Interval (m bgs)	Screened Geology	Hydraulic Conductivity (m/s)
SS23-01	4.5 – 7.6	Silty Clay	1.3×10^{-8}
FS23-01	4.5 – 7.6	Silty Sand / Silty Clay	6.8×10^{-8}
FS23-03	4.5 – 7.6	Clay	7.8×10^{-8}

Hydraulic conductivities from the slug tests at this site are in the range of 10^{-8} m/s, however, the silty sand that FS23-01 is screened in may have a hydraulic conductivity up to 1.6×10^{-5} m/s based on the grain size analysis.

5. ANALYTICAL LABORATORY TESTING

Three samples from select borehole locations were submitted for analytical testing for corrosivity analysis and sulphide content. The analytical test results for the soil are presented in Appendix D and are summarized below.

Borehole	FS23-02	FS23-04	FS23-05
Sample	SS7	SS5	SS12
Depth (m)	4.6 – 5.2	3.0 – 3.7	10.7 – 11.3
Elevation (m)	322.7 – 322.1	317.8 – 317.1	314.6 – 314.0
Sulphide (Na_2CO_3) %	<0.04	0.04	0.04
Chloride (µg/g)	23	98	11
Sulphate (µg/g)	17	350	260
pH	8.38	8.43	9.23
Conductivity (µS/cm)	642	430	144
Resistivity (Ohm-cm)	1560	2330	6940

6. MISCELLANEOUS

Aardvark Drilling Ltd. of Guelph, Ontario supplied and operated the drilling, sampling, and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Hayden Clarke, Mr. Jaimin Patel, Mr. Liam Scalena, EIT, and Mr. Kenneth Omenogor, EIT. The overall management of the field program was conducted by Ms. Alysha Kobylinski, P.Eng.

Geotechnical laboratory testing on soil samples was carried out in Thurber's geotechnical laboratory. Corrosivity testing on the organic silt deposit was carried out by SGS Canada Inc., a CALA accredited analytical laboratory in Guelph, Ontario.

Interpretation of the field data and preparation of this report was carried out by Ms. Alysha Kobylinski, P.Eng. The report was reviewed by Mr. Keli Shi, M.Eng., P.Eng., a Senior Geotechnical Engineer, and Dr. P.K. Chatterji, Ph.D., P.Eng., a Designated Principal Contact for MTO Foundations Projects at Thurber.

Thurber Engineering Ltd.

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Senior Geotechnical Engineer

Date: ***February 9, 2024***
File: ***35708***

P.K. Chatterji, Ph.D., P. Eng.
Designated MTO Contact

FOUNDATION DESIGN REPORT
FREDERICK STREET UNDERPASS
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 3025-20-00
GEOCRES NO. 40P08-300

PART B: ENGINEERING DESIGN RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data in the factual report and geotechnical design recommendations to assist the design team in selecting and designing a suitable foundation system for the proposed replacement structure that will carry the eastbound lanes (EBL) and westbound lanes (WBL) of Frederick Street over Highway 7/85 in the Regional Municipality of Waterloo, Ontario.

Based on the preliminary General Arrangement drawing provided by the Ministry of Transportation, Ontario (MTO), dated August 2023, the proposed structure is a 98.9 m long two-span (46.9 m-52.0 m) structure supported on caissons at both abutments and centre pier. The structure will be constructed along the same alignment as the existing bridge but is longer than the existing bridge to accommodate the proposed Bruce Street ramp and widened Edna Street-S/E-S ramp. The Frederick Street grade at the west and east abutments will be raised approximately 1 and 1.5 m to Elev. 328.7 m and 326.9 m, respectively. Retaining walls about 17 m long will be constructed at all four quadrants of the new underpass bridge.

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

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

8. FOUNDATION OPTIONS

In general, the subsurface conditions at the site consist of a pavement structure and layers of generally non-cohesive fill and upper sand to silty sand, overlying the upper silty clay to clay deposit. Highway 7/85 was constructed in a cut, and the pavement for the highway is underlain by a relatively thin layer of fill, underlain by the same upper silty clay to clay. The upper silty clay to clay is underlain by a silty sand to silt, underlain by a lower silty clay to clay layer. Soil layers varying from lower sand to sandy silt to gravel and sand were encountered below the lower silty clay to clay layer. The lower silty clay to clay is underlain by a lower silt to clayey silt till.

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

1. Spread footings on native soil
2. Drilled shafts (caissons)
3. Steel H-piles driven into the hard/very dense soils

Spread footings founded on an engineered fill pad are considered feasible at the abutments but would require relatively large and deep excavations and dewatering for engineered fill pad construction. Due to space constraints within the existing highway corridor, this option has not been developed further.

The preliminary GA drawing indicates that caissons (drilled shafts) have been suggested to support the abutments and pier. The caissons can be designed to be structurally connected to the superstructure without a pile cap and are therefore preferrable at the pier location where space is restricted between the travelled lanes. This option will require the use of temporary liners and drilling mud to support the caisson sidewalls in the cohesionless deposits below the groundwater table. This option may also require placement of concrete using tremie methods. Spread footings founded on very stiff to hard clay subgrade are also considered feasible at the pier.

Alternatively, consideration may be given to supporting the abutments and pier on driven steel H-piles. This option would require installation of a roadway protection system and excavation at the pier to permit pile cap construction. It is noted that pile driving will produce noise and vibrations which may be disruptive to residents in the area and could impact nearby structures and utilities. Vibration monitoring and a pre-condition survey of existing adjacent structures and utilities should be carried out if driven piles are selected for this site. Use of driven piles at the abutments will require retaining walls below abutment stems to support the approach embankment fill.

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

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.

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

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

10. SPREAD FOOTINGS

The highest founding levels and corresponding geotechnical resistances recommended at the pier, based on the borehole data, are presented in the following table. Footings should be founded at or below these elevations, subject to minimum requirements for frost protection. The geotechnical resistances provided are based on an assumed minimum footing width of 5 to 6 m.

Location	Depth from Road Surface to Footing Base (m)	Highest Recommended Founding Elevation (m)	Founding Soil Type	Factored ULS (kPa)	SLS (kPa) (≤ 25 mm Settlement)
West Abutment (Boreholes FS23-01, FS23-02, BH20-01)	8.8 – 9.2	318.5	Very Stiff to Hard Silty Clay	450	300
Pier (Boreholes FS23-03, FS23-04)	2.0 - 2.3 (Below Highway 7/85)	318.5	Very Stiff to Hard Silty Clay to Clayey Silt (Till)	375	250
East Abutment (Boreholes FS23-05, FS23-06, BH20-02)	7.2 – 7.6	317.5	Very Stiff to Hard Silty Clay to Clayey Silt (Till)	450	300

The use of spread footings founded below highway grade at the west abutment and east abutment is not a preferred approach due to the significant depths of excavation required to reach competent bearing stratum, and associated dewatering that would be required. Further, founding the spread footings for the abutment above the elevation of the highway (i.e. a perched abutment) is not recommended due to the proximity of the footing to the cut slope / retaining wall facing of each abutment.

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 Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The bearing resistances in the table above 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 given above are based on an estimated total settlement not exceeding 25 mm. The footing settlement is expected to be substantially complete by the end of construction.

The footing excavations at the pier are expected to extend below the groundwater level. Local groundwater control and prior dewatering, as discussed in Section 20, will be required to construct the footing in the dry and to prevent disturbance of the footing base.

Demolition of the existing footings should be done carefully to minimize disturbance to the subgrade. The bases of the foundation excavations should be inspected by a geotechnical engineer 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 mass concrete of the same strength and class as that of the footing. Where subexcavation is required to remove disturbed and unsuitable material from below the design founding level, the founding surface should be re-established using the same mass concrete.

10.1 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between cast-in-place concrete footings and the founding soils should be calculated in accordance with Section 6.10.5 of the *CHBDC* (2019). The following presents the coefficient of friction, tan δ, for the interface between the concrete footing and native soils at the proposed founding elevations, as interpreted from NAVFAC (1984):

Subgrade Material	tan δ
Very stiff to hard silty clay to clayey silt till	0.45

10.2 Key Challenges and Considerations

- Based on the groundwater level measurements, excavations for the spread footings at the pier may extend near or below the groundwater level within the silty clay deposit. Therefore, groundwater control measures such as sump and pump within shored excavation will be required to achieve and maintain a dry and stable excavation. Additional dewatering details are provided in Section 20.
- There would be a risk of disturbing the subgrade during removal of the existing pier footing with this option which could result in additional settlement of the new bridge footing.

11. DRILLED SHAFTS (CAISSONS)

The preliminary General Arrangement drawing provided by MTO indicates that the abutments and pier are proposed to be supported on caissons. Caissons are considered feasible at this site and may be founded within the hard silty clay till deposit.

11.1 Founding Elevations and Axial Resistance

The following drilled shaft (caisson) founding elevations (assumed to be at least two times the caisson diameter into the hard clayey silt till) and capacities for various drilled shaft (caisson) diameters may be used for design purposes.

Foundation Unit	Approx. Underside of Pile Cap Elev. (m)	Approx. Caisson Base Elev. (m) and Founding Strata	Caisson Length (m)	Caisson Diameter (m)	Factored ULS (kPa)	Factored SLS (kPa)
West Abutment (Boreholes FS23 01, FS23 02, BH20 01)	326	290 (Hard Clayey Silt to Clay Till)	36	1.2	5,750	4,800
				1.5	7,800	6,500

Foundation Unit	Approx. Underside of Pile Cap Elev. (m)	Approx. Caisson Base Elev. (m) and Founding Strata	Caisson Length (m)	Caisson Diameter (m)	Factored ULS (kPa)	Factored SLS (kPa)
Pier (Boreholes FS23 03, FS23 04)	320 (Base of pier column)	286 (Hard Clayey Silt Till)	34	2.1	13,500	11,300
East Abutment (Boreholes FS23 05, FS23 06, BH20 02)	325	287 (Hard Clayey Silt Till)	38	1.2	5,750	4,800
				1.5	7,800	6,500

The estimated factored ultimate geotechnical resistances provided above are based on shaft and tip resistances. Drilled shaft foundations should be constructed in accordance with OPSS.PROV 903 *(Deep Foundations)*, as amended by Special Provision 109F57.

Caisson construction needs to deal with artesian conditions encountered at the pier location during the field investigation (see Borehole FS23-04). Artesian conditions were encountered when advancing the borehole in the lower till deposit. The impact of the artesian conditions on the long term performance of the pier caissons (i.e. movement of water up along the shaft of the caisson) should be taken into account when selecting the preferred foundation option. Measures to minimize the long term impact of artesian conditions may be considered if caisson foundations are selected.

Temporary casings should be used to support the overburden soils during construction to minimize disturbance to the side walls. The casing should be advanced while filled with polymer slurry to minimize the potential for migration of non-cohesive soils into the drillhole, and to control base disturbance / basal heave due to groundwater pressures / seepage.

The performance of the drilled shafts in compression will depend to a large degree upon the final cleaning and verification of the condition of the base of the drilled shaft. As such, the base of each drilled shaft excavation must be cleaned to remove all loose cuttings to ensure that the concrete is in intimate contact with the undisturbed subgrade tills. A qualified geotechnical engineer should be retained during construction to inspect the drilled shafts to check that the conditions encountered are consistent with the information obtained from the boreholes and to confirm the base elevation of the drilled shaft and cleanliness. Further to the above discussion regarding the requirement for temporary casings to control the ground loss and groundwater, such casings are also required to allow for visual remote inspection of the base of the drilled shafts, which can be accomplished by means of a shaft quantitative inspection device (SQUID). Should the inspection indicate that loosened material is present at the base of the drilled shafts, the base would need to be re-cleaned and re-inspected.

Integrity testing should be considered where space allows for testing of the caissons, such as Cross-hole Sonic Logging (CSL), Pile Integrity Testing (PIT), and Thermal Integrity Profiling (TIP).

A minimum centre-to-centre drilled shaft spacing of 4B should be maintained during drilled shaft installation to limit interaction between adjacent drilled shafts until the new concrete has achieved a minimum structural strength specified by the structural designer.

Suggested wording for a Drilled Shafts NSSP has been developed to address the requirements for the use of temporary casings and slurry for the installation of drilled shafts, the placement of concrete by tremie methods, and cleaning and inspection of the base of the drilled shafts, and should be included in the Contract Documents.

12. DRIVEN STEEL H-PILES

Consideration may be given to supporting the bridge abutments and pier on steel H-piles driven into the hard silty clay till deposit and into the lower silty clay to clay deposit at the pier location.

12.1 Axial Resistance

The axial resistances of HP 310 × 110 and HP 360 × 132 steel piles driven into the hard silty clay till deposit at all foundation elements are provided in the table below. The option for shorter piles at the pier location is also provided in the table below.

Foundation Unit	Approx. Pile Tip Elev. (m) and Founding Strata	Minimum Pile Length Assumed (m)	Pile Section HP 310 × 110		Pile Section HP 360 × 132	
			Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
West Abutment (Boreholes FS23 01, FS23 02, BH20 01)	291 (Hard Clayey Silt Till)	35	1,600	1,400	1,800	1,600
(Boreholes FS23 01, FS23 02, BH20 01)	288 (Hard Clayey Silt Till)	32	1,600	1,400	1,800	1,600
Pier (Boreholes FS23 03, FS23 04)	288 (Hard Clayey Silt Till)	37	1,600	1,400	1,800	1,600

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.

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

12.2 Downdrag

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

12.3 Lateral Resistance

For pile lateral resistance design, soil-pile interaction analyses may be carried out using the coefficient of horizontal subgrade reaction values provided in Table 10.3.

The methodology outlined in Section 14 may be used to estimate the lateral geotechnical resistance of the pile by substituting the caisson diameter, D with the pile width, B.

12.4 Pile Installation

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

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 in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. 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”. “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 on at least 2 piles per foundation element in conjunction with the Hiley tests at this site, to establish set criteria, ensure the integrity of the pile and verify pile ultimate geotechnical resistance.

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

Hard driving conditions through the hard/very dense soils should be expected. Cobbles and boulders should also be anticipated within the silty clay till deposit which may affect pile installation. In order to minimize pile damage while driving the piles hard/dense zones, cobbles, and boulders, to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point). The Contract Documents must contain a NSSP alerting the Bidders to the presence of hard/dense zones, cobbles, and boulders, and the use of PDA Testing. Suggested texts for the NSSP's are included in Appendix E. The NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

Vibrations produced during pile driving may disrupt nearby residents and damage nearby structures and utilities. A preconstruction condition survey of existing structures and utilities should be carried out prior to commencement of pile installation. Vibration monitoring should also be carried out during pile driving to limit potential impacts on existing facilities, and conditions carefully monitored for signs of disturbance.

It is understood that the City of Kitchener does not provide limits on vibration levels. Therefore, it is recommended that the vibration levels stipulated in the City of Toronto By-law 514-2008 be adopted for this project. The limits are provided in the table below.

Vibration Frequency (Hz)	Vibration Peak Particle Velocity (mm/s)
Less than 4	8
4 to 10	15
More than 10	25

13. FROST PROTECTION

All footings should be provided with a minimum 1.4 m of soil cover for frost protection as per OPSD 3090.101 *(Frost Penetration Depths for Southern Ontario),* as measured vertically and perpendicular from the face of the abutment slope to the edge of the underside of the footings and/or pile caps. If adequate soil cover cannot be provided for the footings / pile caps, rigid Styrofoam insulation could be installed to compensate for the lack of soil cover and provide protection from frost penetration.

14. LATERAL RESISTANCE IN SOIL

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

Clayey Silt, Silty Clay, Silty Clay Till (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 caisson, kPa

C_u = undrained shear strength of cohesive soils, kPa

γ = unit weight of soil, kN/m^3

B = diameter of caisson, m

Sand, Sandy Silt to Silty Sand (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 caisson, m

B = diameter of caisson, m

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

γ' = Buoyant unit weight of soil, kN/m3

K_p = passive earth pressure coefficient

The above equations and parameters provided in the table below may be used to analyze the interaction between a caisson and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance.

Location	Approx. Elevation (m)		Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m³)	K_p	n_h (kN/m³)	Soil Conditions
	Top	Bottom					
West Abutment	Top of Pile	323.4	-	9	3.0	2,500	Existing Fill
	323.4	318.5	90	10	-	-	Silty Clay - Stiff to Hard
	318.5	314.5	150	11	-	-	Upper Silty Clay - V. Stiff to Hard
	314.5	308		12	4.2	10,900	Sandy Silt - V. Dense
	308	293.2	175	11	-	-	Lower Silty Clay - Stiff to Hard
	293.2	286.5	250	11.5	-	-	Sandy Silty Clay Till - Hard
Pier	Top of Pile	310.3	100	10	-	-	Upper Clayey Silt - Stiff to Hard
	310.3	305.7	-	12	3.6	6,800	Silty Sand to Sandy Silt - Dense to V. Dense
	305.7	292.7	175	11	-	-	Lower Silty Clay - Hard
	292.7	289.7	-	12	4.2	10,900	Sand to Silty Sand – Compact to V. Dense
	289.9	279.1	250	11.5	-	-	Sandy Clayey Silt Till - Hard
East Abutment	Top of Pile	318	-	9	3.0	2,500	Sand – V. Loose to Compact
	318	307.6	150	11	-	-	Upper Silty Clay - Stiff to Hard
	307.6	303.8	-	12	4.0	9,000	Silty Sand - V. Dense
	303.8	292.5	175	11	-	-	Lower Silty Clay - Hard
	292.7	289.9	-	12	3.8	8,000	Sandy Silt to Silt Till to Sand and Gravel - V. Dense
	290.1	283.9	250	11.5	-	-	Sandy Clayey Silt Till - Hard

* Buoyant unit weight below water table

The spring constant, Ks, for analysis may be obtained by the expression, $K_s = k_s L D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the caisson diameter (m) and L is the length (m) of the caisson segment or element used in the analysis. The ultimate lateral resistance, P_{ult}, can be obtained from the expression, $P_{ult} = p_{ult} L D$. This represents the ultimate load at which the supporting soil fails and will not support any additional load at greater displacements.

The coefficient of horizontal subgrade reaction and ultimate lateral resistance should be reduced based on the caisson/pile spacing to account for group effect. The group efficiency factors provided in CHBDC (2019) Commentary Section C6.11.3.4 may be used for a caisson/pile group oriented perpendicular or parallel to the direction of loading. 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).

15. DEMOLITION OF EXISTING STRUCTURE

It is understood that the existing bridge will be closed for the project duration and that staged construction will not be required to maintain the live lanes of Frederick Street. The demolition of the existing abutment and pier footings must be carried out using procedures that minimize the potential for disturbance of the footing subgrade or undermining of the Highway 7/85 travelled lanes.

16. LATERAL EARTH PRESSURES

Structural backfill material for the design of the bridge abutments, wingwalls, and associated retaining walls should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 specifications and SP110S06. The backfill must be in accordance with OPSS 902 and placed to the extents shown on OPSD 3101.150. The backfill should be compacted and compaction equipment to be used adjacent to the wall must be restricted in accordance with OPSS.PROV 501. Subdrains should be incorporated by the RSS proprietary designer.

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

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

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

where: p_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see Table below)

γ = unit weight of retained soil (see Table below) h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa).

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

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

Wall Condition	**Earth Pressure Coefficient (K)**					
	OPSS Granular A or OPSS 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**		**Existing Granular Fill ϕ = 30°, γ = 20 kN/m^3**	
	Horizontal Surface Behind Wall	**Sloping Backfill (2H:1V)**	**Horizontal Surface Behind Wall**	**Sloping Backfill (2H:1V)**	**Horizontal Surface Behind Wall**	**Sloping Backfill (2H:1V)**
Active, K_A (Yielding / Unrestrained Wall)	0.27	0.39	0.31	0.47	0.33	0.54
At Rest, K_O (Non-Yielding / Restrained Wall)	0.43	0.62	0.47	0.68	0.5	0.72
Passive, K_p (movement toward soil)	3.7	-	3.2	-	3.0	-

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

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

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) is preferred as it results in lower earth pressures acting on the wall.

The factors in the previous table are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.27 in the Commentary to the CHBDC 2019.

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

17. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. From the boreholes and subsurface information collected at this site, the subsurface conditions 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 2020).

Retaining structures (i.e. bridge abutment walls, wing walls, and retaining walls) 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 the table below may be used:

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**	**Existing Granular Fill** ϕ **= 30°,** γ **= 20 kN/m^3**
Active (K_{AE})*	0.29	0.33	0.36
Passive (K_{PE})	3.6	3.2	2.9
At Rest (K_{OE})**	0.50	0.55	0.58

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

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

18. BRIDGE APPROACHES

Based on the preliminary general arrangement drawing, the grade at the west and east abutments of the replacement underpass structure will be raised by approximately 1 and 1.5 m to Elev. 328.7 m and 326.9 m, respectively.

Where retaining walls are not used, slope inclinations not steeper than 2 horizontal to 1 vertical (2H:1V) may be used for grade raise provided the embankments are constructed with granular or clean earth fill which does not contain medium or high plastic clay. All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements.

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

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 should be provided as necessary to maintain slope stability.

The foundation settlement under the approximately 1 to 1.5 m grade raise is expected to be negligible. Embankment settlement due to fill compression is expected to be negligible.

19. TEMPORARY EXCAVATION AND ROADWAY PROTECTION

The existing retaining walls and abutments beneath the bridge deck will be excavated to permit construction of the proposed S-E ramp (Bruce Street ramp) to the east and widening of the existing E-S ramp to the west. The cuts will extend to depths ranging from about 6 to 6.5 m from Frederick Street grade primarily through sand to silty sand fill and the upper sand to silty sand to silt native soils.

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

For the purposes of the OHSA, the existing fills and native soils within the proposed excavation depth may be classified as Type 3 and Type 4 above and below the water table, respectively.

Temporary excavations for pile caps at the abutments will extend through the approach fills to be at least 1.4 m below the existing grade on Frederick Street. Temporary excavations for spread footing or pile cap construction at the pier will extend to at least 2.2 m below the existing highway grade. The excavations will extend to or below the measured groundwater level at the pier.

Installation of roadway protection systems will be required to permit footing or pile cap construction at the pier location given the proximity of the pier to the travelled lanes of Highway 7/85. Given the grade difference between the highway and Frederick Street, as well as the property limitations and existing utilities at Frederick Street grade, the use of shoring systems is preferred.

The temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Construction Specification for Temporary Protection Systems) and designed for Performance Level 2 or higher if the temporary protection systems will be integrated into the permanent structure at a later construction stage. Design of such systems must adequately consider both the temporary loading conditions as a shoring system and the permanent loading conditions as part of the permanent structure. Temporary shoring should be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces.

The following soil parameters may apply for design of the temporary protection systems or walls with horizontal backfill:

Stratigraphic Unit	Unit Weight of Material, γ' (kN/m^3)	Angle of Internal Friction, φ (kN/m^3)	Coefficient of Static Lateral Earth Pressure	
			Active, K_a	Passive, K_p
Existing Embankment Fill	20	30	0.33	3.00
Upper Sand to Silty Sand to Silt	20	33	0.29	3.39
Upper Sandy Silty Clay to Clayey Silt Till	20	34	0.28	3.54
Silty Sand	20	33	0.29	3.39
Upper Silty Clay to Clay	19	28	0.36	2.77
Silty Sand to Silt	20	35	0.27	3.69
Silty Clay and Lower Silty Clay to Clay	19	30	0.33	3.00
Lower Sand to Sandy Silt	20	35	0.27	3.69
Gravel and Sand	21	36	0.26	3.85

Stratigraphic Unit	Unit Weight of Material, γ' (kN/m^3)	Angle of Internal Friction, φ (kN/m^3)	Coefficient of Static Lateral Earth Pressure	
			Active, K_a	Passive, K_p
Lower Silt to Clayey Silt Till	21	32	0.31	3.25

Notes:

1. The lateral earth pressure coefficients presented above are based on static loading conditions and level backfill/ground surface behind the protection system. Where there is sloping ground behind the protection system, the coefficient of lateral earth pressure must be adjusted to account for the slope.
2. The total passive resistance below the base of excavation, if required, may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the Canadian Highway Bridge Design Code (CHBDC, 2019).

In accordance with OPSS.PROV 539, should the temporary protection systems be left in place after completion of construction, the top shall be removed to at least 1.2 m below the finished grade or ground level.

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.

The selection of the method of excavation and the design of the shoring system that will not be integrated into the permanent structure is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Provision must be made for the handling of pavement materials and potential obstructions in the fill.

20. GROUNDWATER AND SURFACE WATER CONTROL

Dewatering of all excavations should be carried out / managed in accordance with OPSS. PROV 902 as amended by Special Provision FOUN0003. It is recommended that a Professional Engineer with greater than 5 years of experience in designing dewatering systems be retained by the Contractor.

The design of the dewatering system is the responsibility of the Contractor, and the Contract Documents must alert him to this responsibility. Seasonal fluctuations of the groundwater level are to be expected.

Water takings in excess of 50,000 L/day are regulated by the Ministry of the Environment, Conservation and Parks (MECP). Certain takings of groundwater and stormwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MECP Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a PTTW for water taking and a Section 53 approval for discharge of water to the environment. A “Water Taking Plan” and a “Discharge Plan” are required by the MECP if water is taken in accordance with an EASR. In all cases, discharge under the EASR must be in accordance with a Discharge Plan (to be developed by a qualified professional). The contractor will be responsible for obtaining any required discharge approvals. A Category 3 PTTW would be required for water takings in excess of 400,000 L/day.

Recommendations specific to the proposed foundations elements are in the following sections.

20.1 Drilled Shafts (Caissons) at Abutments

The groundwater levels measured in the piezometers and open boreholes ranged from 4.9 m to 5.9 m below the ground surface at Frederick Street grade (Elev. 322.0 m to 319.6 m). The excavations for proposed pile caps at the abutments may extend to Elevation 325 m and 326 m at the east and west abutments, respectively, or approximately 4 m above the anticipated groundwater level.

Excavations for pile caps at the abutments will likely be above the observed groundwater level. Seepage or perched water from the granular layers is to be expected. 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.

If drilled shaft foundations are adopted, temporary casings with a balancing head of bentonite/polymer slurry will be required to support the overburden soils and equalize groundwater pressures during construction. In addition, placement of concrete by tremie methods would be required.

20.2 Footings / Shallow Foundations at Pier

The measured water level in the monitoring well installed at Highway grade was at a depth of 2.1 m below ground surface (Elev. 318.4 m), and artesian conditions were observed at a depth of 38.1 m in the adjacent borehole advanced at Highway grade (1.6 m above ground surface, at Elev. 322.4 m).

In general, from the perspective of installation of proposed shallow foundations for the pier or excavations for proposed pile caps at the pier, the groundwater level beneath the bridge is expected to be located slightly below the highway grade (i.e. at or below Elev. 320 m). 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 in the silty clay within sheeted excavation. 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.

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 must be done in the dry. Dewatering must remain operational and effective until the foundations are constructed and backfilled.

21. BACKFILL TO ABUTMENTS

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

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

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

22. CORROSION POTENTIAL

Based on results of corrosivity testing on samples of the native silty sand and silty clay, the following statements can be made in reference to the MTO Gravity Pipe Design Guideline. However, it should be noted that effects of road de-icing salts/chemicals should be considered when selecting pipe material and/or corrosion mitigation measures.

Sample (Location) / Soil	Resistivity (ohm-cm) / Corrosion Potential[1]	Sulphate Concentration (µg/g) / Degree of Sulphate Attack on Concrete[2]	pH level / Impact on Durability of Concrete[3]
FS23-02 SS7 (West Abutment) / Silty Sand	1560 / Severe (2,000 ohm-cm > R)	17 / Negligible	8.38 / Not detrimental

Sample (Location) / Soil	Resistivity (ohm-cm) / Corrosion Potential[1]	Sulphate Concentration (µg/g) / Degree of Sulphate Attack on Concrete[2]	pH level / Impact on Durability of Concrete[3]
FS23-04 SS5 (Pier) / Silty Clay	2330 / Moderate (4,500 ohm-cm > R > 2,000 ohm-cm)	350 / Negligible	8.43 / Not detrimental
FS23-05 SS12 (East Abutment) / Silty Clay	6940 / Very Low (10,000 ohm-cm > R > 6,000 ohm-cm)	260 / Negligible	9.23 / Detrimental

Notes: 1. According to Table 3.2 of the MTO Gravity Pipe Design Guideline.
2. According to Table 7.2 of the MTO Gravity Pipe Design Guideline
3. According to Section 7.1.1 of the MTO Gravity Pipe Design Guideline

23. CONSTRUCTION CONCERNS

During construction, qualified geotechnical personnel should be retained to observe activities related to the bridge replacement and advise the Contract Administrator on construction concerns related to performance of the embankment and instability of slopes.

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

- Driven piles may achieve refusal within the hard/dense zones at varying elevations.
- Artesian conditions encountered within / below the lower till zone at this site.
- Although not encountered in the boreholes drilled, glacial deposits inherently contain cobbles and boulders, which may affect installation of piles/caissons. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles/caissons to competent foundation level.
- Demolition of existing footings has potential to disturb the subgrade. Consideration could be given to leaving the footings in place provided they do not interfere with the abutment construction and new foundation elements (i.e. Retaining walls and pier).
- Caisson installation will extend through cohesionless soils below the groundwater table. Therefore, temporary steel liners and stabilization using a synthetic slurry will be required to support the caisson sidewalls and to provide seepage cut-off where required. If accumulated water in the caisson hole cannot be removed, consideration should then be given to using the tremie technique to place concrete inside the caisson hole.
- Vibration monitoring should be carried out during pile driving (if piles selected) and during existing structure demolition to limit potential impacts on existing facilities and residents,

and conditions carefully monitored for signs of disturbance. A preconstruction condition survey of existing structures and utilities should be carried out prior to commencement of pile installation and structure demolition to confirm that the vibration levels are within tolerable limits.

24. CLOSURE

Engineering analysis and preparation of this report was carried out by Ms. Alysha Kobylinski, P.Eng. The report was reviewed by Mr. Keli Shi, M.Eng., P.Eng., a Senior Geotechnical Engineer, and Dr. P.K. Chatterji, Ph.D., P.Eng., a Designated Principal Contact for MTO Foundations Projects at Thurber.

Thurber Engineering Ltd.

Alysha Kobylinski, P. Eng.
Geotechnical Engineer

Keli Shi, M.Eng., P. Eng.
Senior Geotechnical Engineer

Date: ***February 9, 2024***
File: ***35708***

P.K. Chatterji, Ph.D., P. Eng.
Designated MTO Contact

THURBER

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1. STANDARD OF CARE

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

2. COMPLETE REPORT

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

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

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a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

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METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

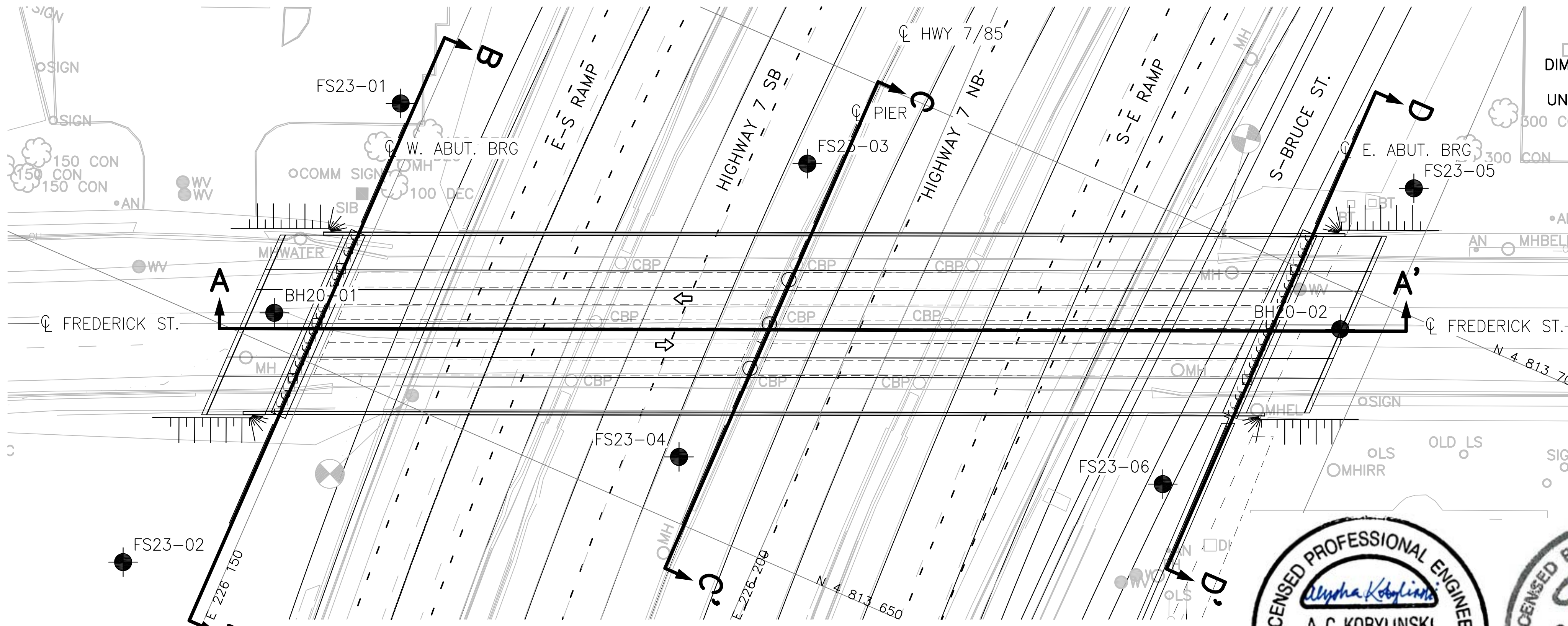
CONT No
WP No

SHEET

HIGHWAY 7/85
FREDERICK STREET BRIDGE UNDERPASS REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.



PLAN

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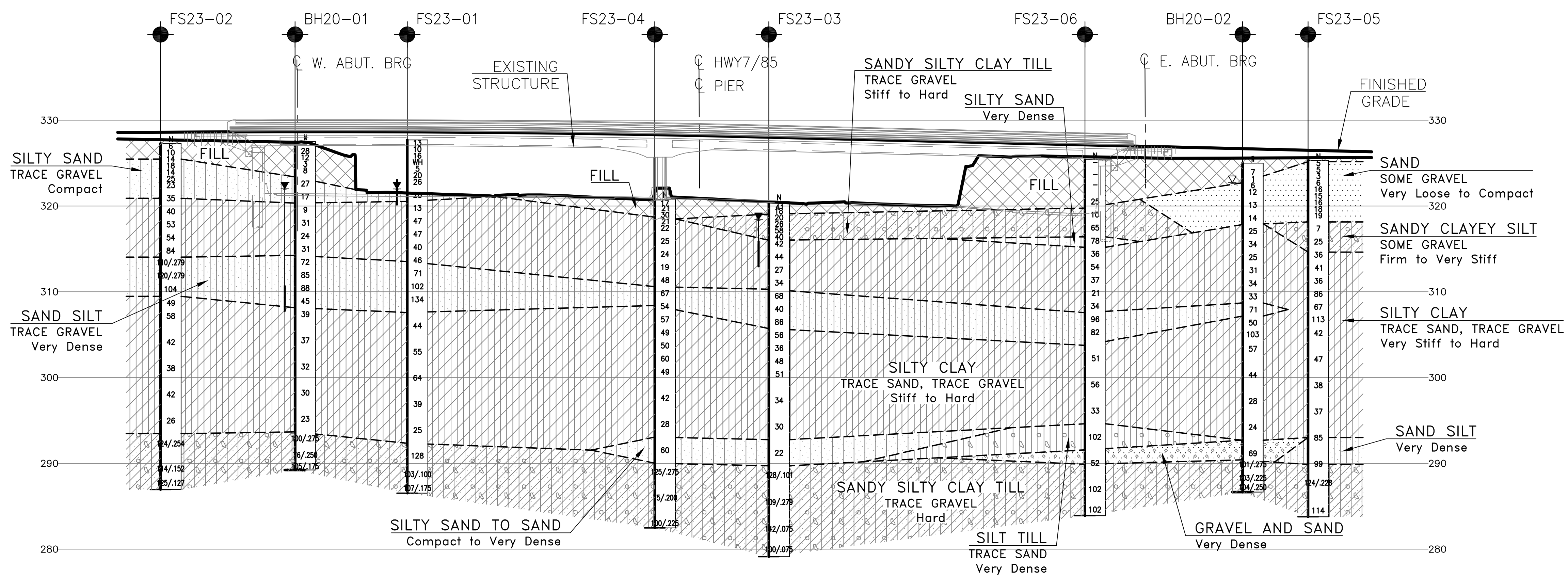

PROFILE ALONG ℄ FREDERICK ST. (A-A')

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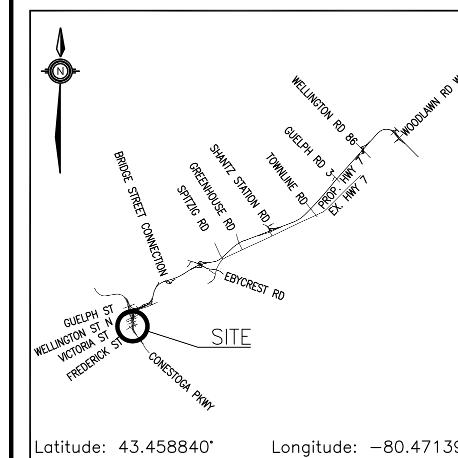

KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
┃	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH20-01	327.5	4 813 653.3	226 144.0
BH20-02	325.0	4 813 695.8	226 245.9
FS23-01	327.7	4 813 678.4	226 147.3
FS23-02	327.3	4 813 623.3	226 139.9
FS23-03	320.5	4 813 689.5	226 188.4
FS23-04	320.8	4 813 656.3	226 188.4
FS23-05	325.3	4 813 712.3	226 247.1
FS23-06	325.4	4 813 673.8	226 235.5

-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. 40P08-300

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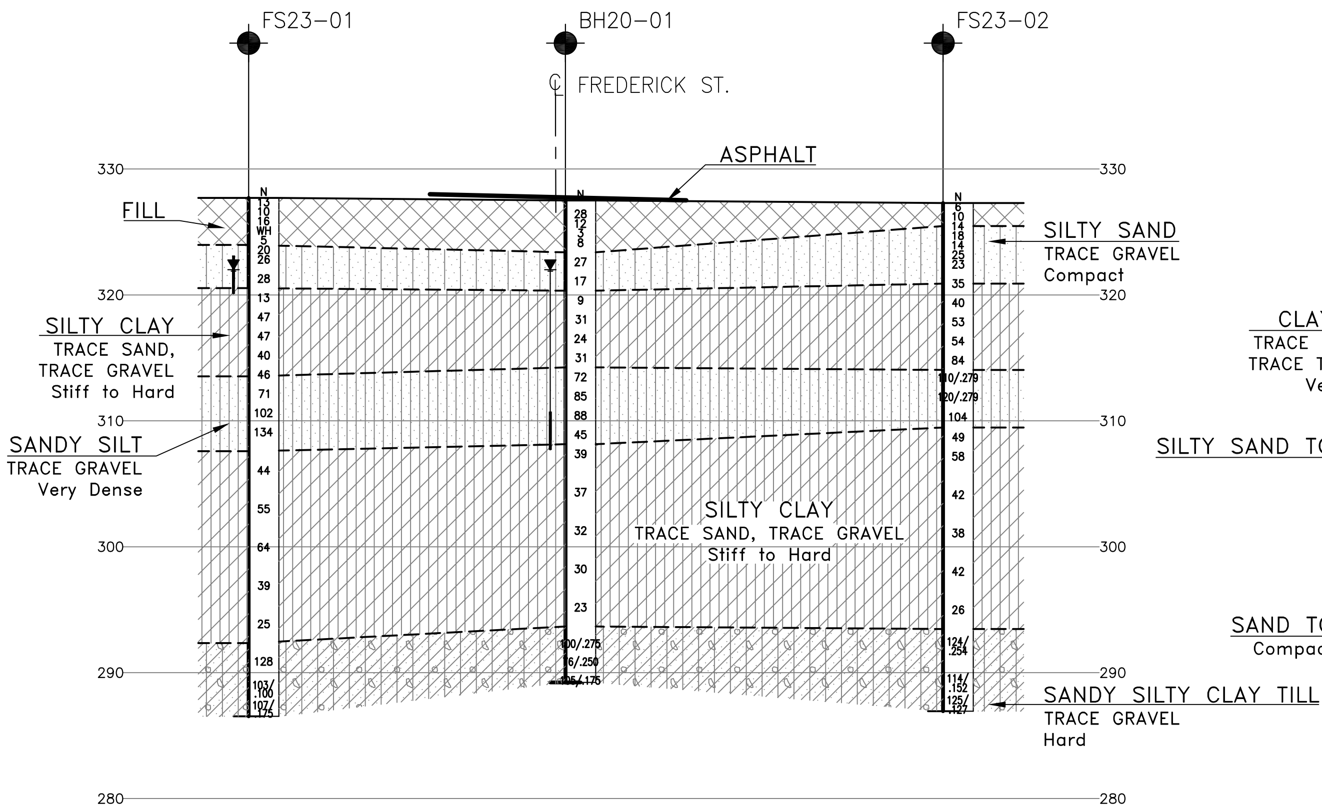

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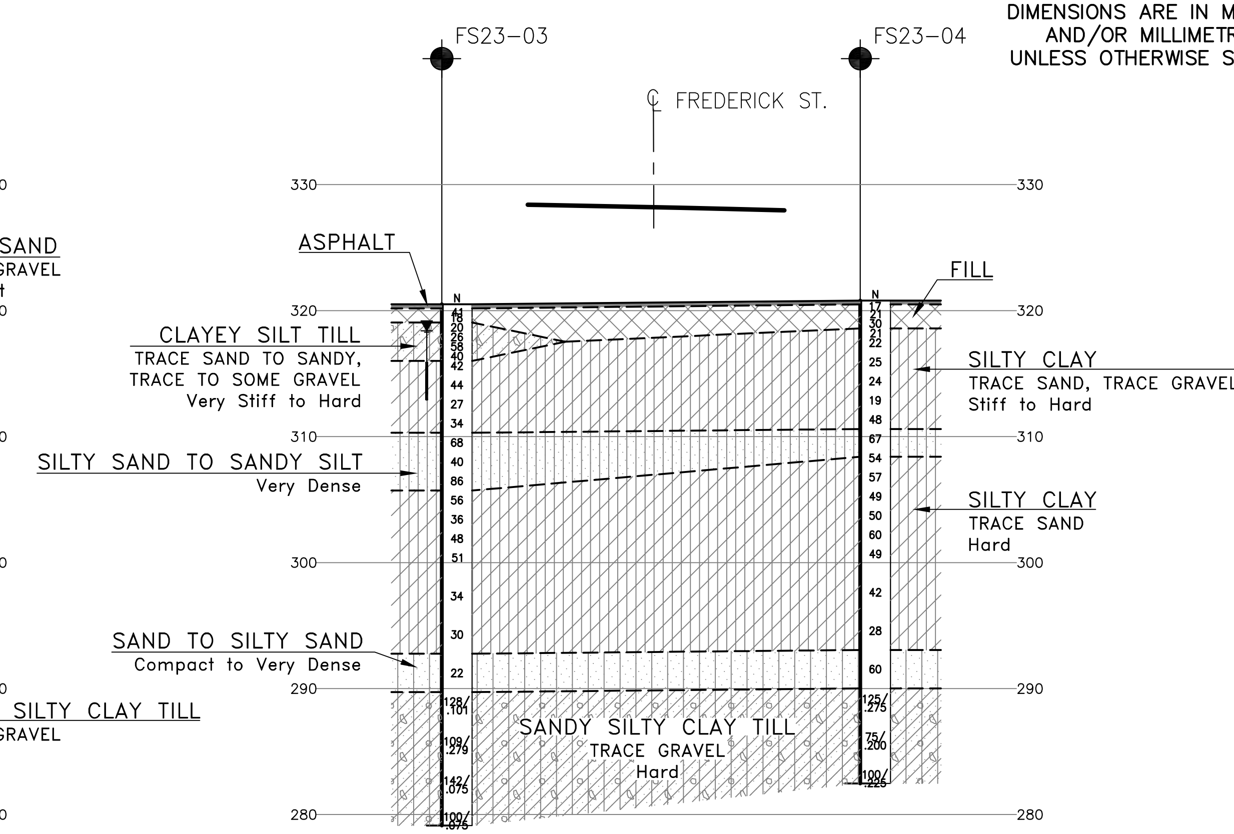

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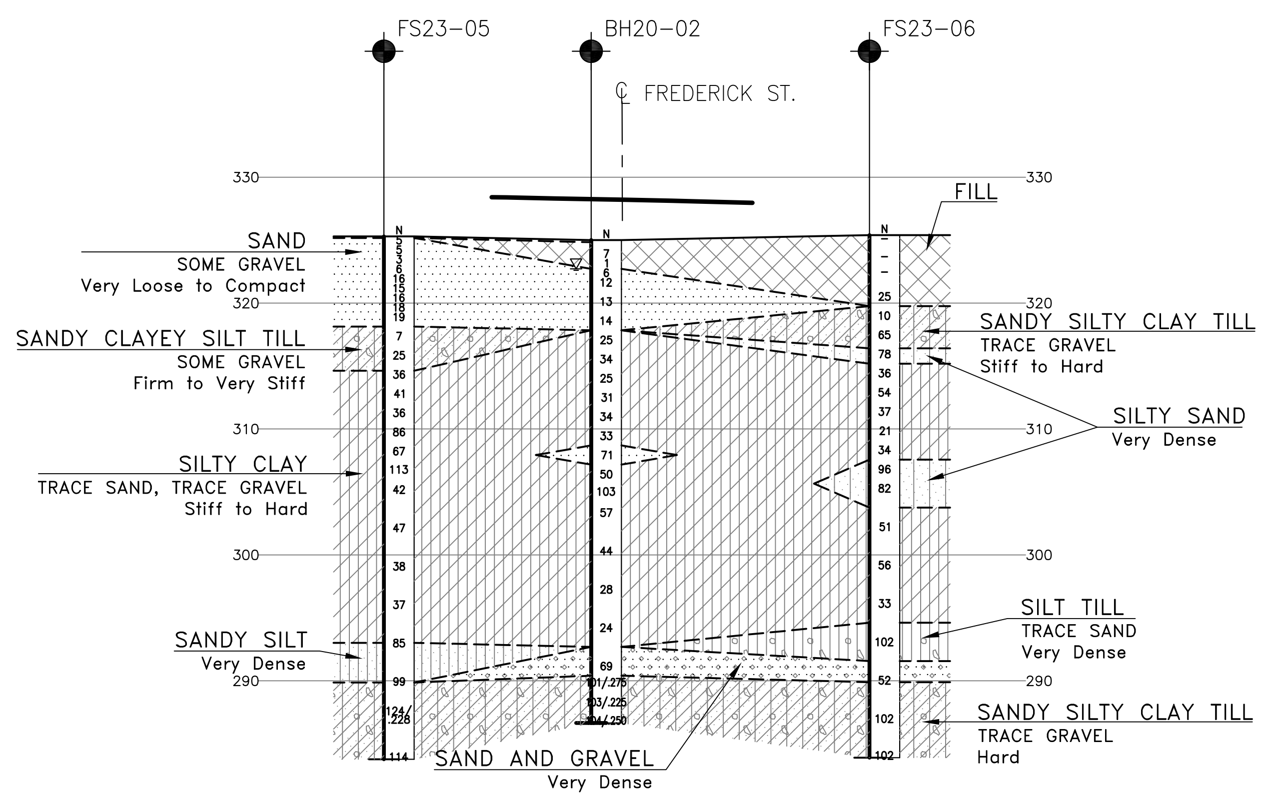

SECTION ALONG E. ABUT. BRG (D–D')

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SCALE 1:600

CONT No

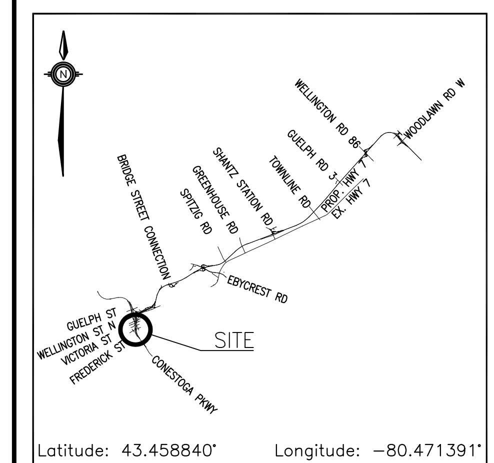
WP No

HIGHWAY 7/85
FREDERICK STREET BRIDGE UNDERPASS REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⌖	Borehole
⌖	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
⊻	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
┃	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH20-01	327.5	4 813 653.3	226 144.0
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GEOCRES No. 40P08-300

REVISIONS	DATE	BY	DESCRIPTION

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APPENDIX A

Site Photographs

Photograph #1 – Frederick Street near west abutment, facing east. (Google Earth)

Photograph #2 – Frederick Street near east abutment, facing west. (Google Earth)

Photograph #3 – Highway 7/85, south of the Frederick Street bridge, facing north. (Google Earth)

Photograph #4 – Highway 7/85, north of the Frederick Street bridge, facing south. (Google Earth)

Photograph #5 – Borehole advancement at FS23-05, facing north. (May 2023)

Photograph #6 – Hydroexcavation at Borehole FS23-06, facing north. (May 2023)

Photograph #7 – Pieces of concrete and debris (metal cooking pot) encountered in Fill at FS23-06 hydroexcavated interval. (May 2023)

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APPENDIX B

Previous Investigation: Record of Borehole Logs and Laboratory Test Results

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND 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			

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BH20-01

METRIC

GWP# 408-88-00	LOCATION , MTM NAD 83 Zone 10: N 4 813 653.3 E 226 144.0		ORIGINATED BY MC
DIST ____ HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY AN
DATUM Geodetic	DATE 2020.08.17 - 2020.08.19	LATITUDE 43.458660 LONGITUDE -80.471975	CHECKED BY GRL

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)

ELEV / DEPTH	DESCRIPTION
327.5	GROUND SURFACE
0.0	**ASPHALT:** (200mm)
0.2	**SAND** and **GRAVEL** Brown Dry (FILL)
326.7 / 0.8	**SAND**, some silt, some gravel Compact Brown Dry (FILL)
325.3 / 2.2	**SAND**, trace silt Very Loose to Loose Brown Dry (FILL)
323.4 / 4.1	**SAND**, trace silt Compact Brown Wet
320.3 / 7.2	Clayey **SILT**, trace sand, trace gravel Stiff Brown Wet
318.8 / 8.7	Silty **CLAY**, trace sand Very Stiff to Hard Grey Wet

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	28				
2	SS	12				
3	SS	3				
4	SS	8	0	89	11 (SI+CL)	
5	SS	27				
6	SS	17				
7	SS	9	1	7	78	14
8	SS	31				

Elevation scale: 327, 326, 325, 324, 323, 322, 321, 320, 319, 318

Groundwater level symbol (▼) shown at approx. elevation 322.

Continued Next Page

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

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 2/9/21

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BH20-01

METRIC

GWP# 408-88-00	LOCATION , MTM NAD 83 Zone 10: N 4 813 653.3 E 226 144.0		ORIGINATED BY MC
DIST HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY AN
DATUM Geodetic	DATE 2020.08.17 - 2020.08.19	LATITUDE 43.458660 LONGITUDE -80.471975	CHECKED BY GRL

Continued From Previous Page

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
314.2 / 13.3	Silty **SAND** to Sandy **SILT**, trace clay Very Dense to Dense Grey Wet
308.1 / 19.4	Silty **CLAY**, trace sand Hard Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
9	SS	24	0	0	30	70
10	SS	31				
11	SS	72				
12	SS	85				
13	SS	88	0	28	66	6
14	SS	45				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (317, 316, 315, 314, 313, 312, 311, 310, 309, 308); 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

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BH20-01

METRIC

GWP# 408-88-00 | LOCATION , MTM NAD 83 Zone 10: N 4 813 653.3 E 226 144.0 | ORIGINATED BY MC

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

DATUM Geodetic | DATE 2020.08.17 - 2020.08.19 | LATITUDE 43.458660 | LONGITUDE -80.471975 | CHECKED BY GRL

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

Number	Type	"N" Values	Elevation Scale	GR	SA	SI	CL
15	SS	39					
			307				
			306				
			305				
16	SS	37					
			304				
			303				
			302				
17	SS	32					
			301				
			300				
			299				
18	SS	30		0	4	36	60
			298				

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No BH20-01

METRIC

GWP# 408-88-00 | LOCATION , MTM NAD 83 Zone 10: N 4 813 653.3 E 226 144.0 | ORIGINATED BY MC

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

DATUM Geodetic | DATE 2020.08.17 - 2020.08.19 | LATITUDE 43.458660 | LONGITUDE -80.471975 | CHECKED BY GRL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
					297		
					296		
	Very Stiff	19	SS	23	295	~20	
					294		
293.7 / 33.8	Silty **CLAY**, sandy, trace gravel Hard Grey Wet (TILL)				293		
		20	SS	100/ 0.275	292		
					291		
		21	SS	76/ 0.250		~10	3 31 51 15
					290		
289.2 / 38.3		22	SS	105/ 0.175		~10	

END OF BOREHOLE AT 38.3m.
Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2020.08.24	5.5	322.0

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/m³

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BH20-02

METRIC

GWP# 408-88-00 LOCATION , MTM NAD 83 Zone 10: N 4 813 695.8 E 226 245.9 ORIGINATED BY MC

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

DATUM Geodetic DATE 2020.08.20 - 2020.08.21 LATITUDE 43.459054 LONGITUDE -80.470721 CHECKED BY GRL

ELEV / DEPTH (m)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
325.0	GROUND SURFACE					
0.0	**ASPHALT:** (163mm)					
0.2	**SAND** and **GRAVEL**, Brown, Dry (FILL)					
324.3 / 0.7	**SAND**, gravelly to some gravel, Loose to Very Loose, Brown, Dry (FILL)	1	SS	7		324
		2	SS	1		323
322.7 / 2.3	**SAND**, trace silt, Loose to Compact, Brown, Dry	3	SS	6	∇	
		4	SS	12		322
						321
	Wet	5	SS	13		320
		6	SS	14		319
317.8 / 7.2	Silty **CLAY**, trace sand, Very Stiff to Hard, Grey, Wet					318
		7	SS	25		317
		8	SS	34		316
						315

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

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

RECORD OF BOREHOLE No BH20-02

METRIC

GWP# 408-88-00 | LOCATION , MTM NAD 83 Zone 10: N 4 813 695.8 E 226 245.9 | ORIGINATED BY MC

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

DATUM Geodetic | DATE 2020.08.20 - 2020.08.21 | LATITUDE 43.459054 | LONGITUDE -80.470721 | CHECKED BY GRL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		9	SS	25	314	w ≈ 21	
		10	SS	31	313	wP ≈ 20, w ≈ 29, wL ≈ 50	0 0 34 66
310.9 / 14.1	**SAND** Dense Brown Wet	11	SS	34	312, 311	w ≈ 30; w ≈ 18	
310.2 / 14.8		12	SS	33	310	w ≈ 28	
308.7 / 16.3	**SAND** Very Dense Brown Wet	13	SS	71	309, 308	w ≈ 17	
307.2 / 17.8	Silty **CLAY**, trace sand Hard Grey Wet	14	SS	50	307, 306, 305	wP ≈ 19, w ≈ 21, wL ≈ 42	0 1 43 56

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No BH20-02

METRIC

GWP# 408-88-00	LOCATION , MTM NAD 83 Zone 10: N 4 813 695.8 E 226 245.9				ORIGINATED BY MC
DIST	HWY 7	BOREHOLE TYPE Hollow Stem Augers/Tricone			COMPILED BY AN
DATUM Geodetic	DATE 2020.08.20 - 2020.08.21	LATITUDE 43.459054	LONGITUDE -80.470721		CHECKED BY GRL

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 γ kN/m³	GR	SA	SI	CL
			15	SS	103									
							304							
			16	SS	57				o					
							303							
							302							
							301							
			17	SS	44				├o──┤		0	2	37	61
							300							
							299							
							298							
	Very Stiff		18	SS	28				o					
							297							
							296							
							295							

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; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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 BH20-02 METRIC

GWP# 408-88-00 | LOCATION , MTM NAD 83 Zone 10: N 4 813 695.8 E 226 245.9 | ORIGINATED BY MC

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

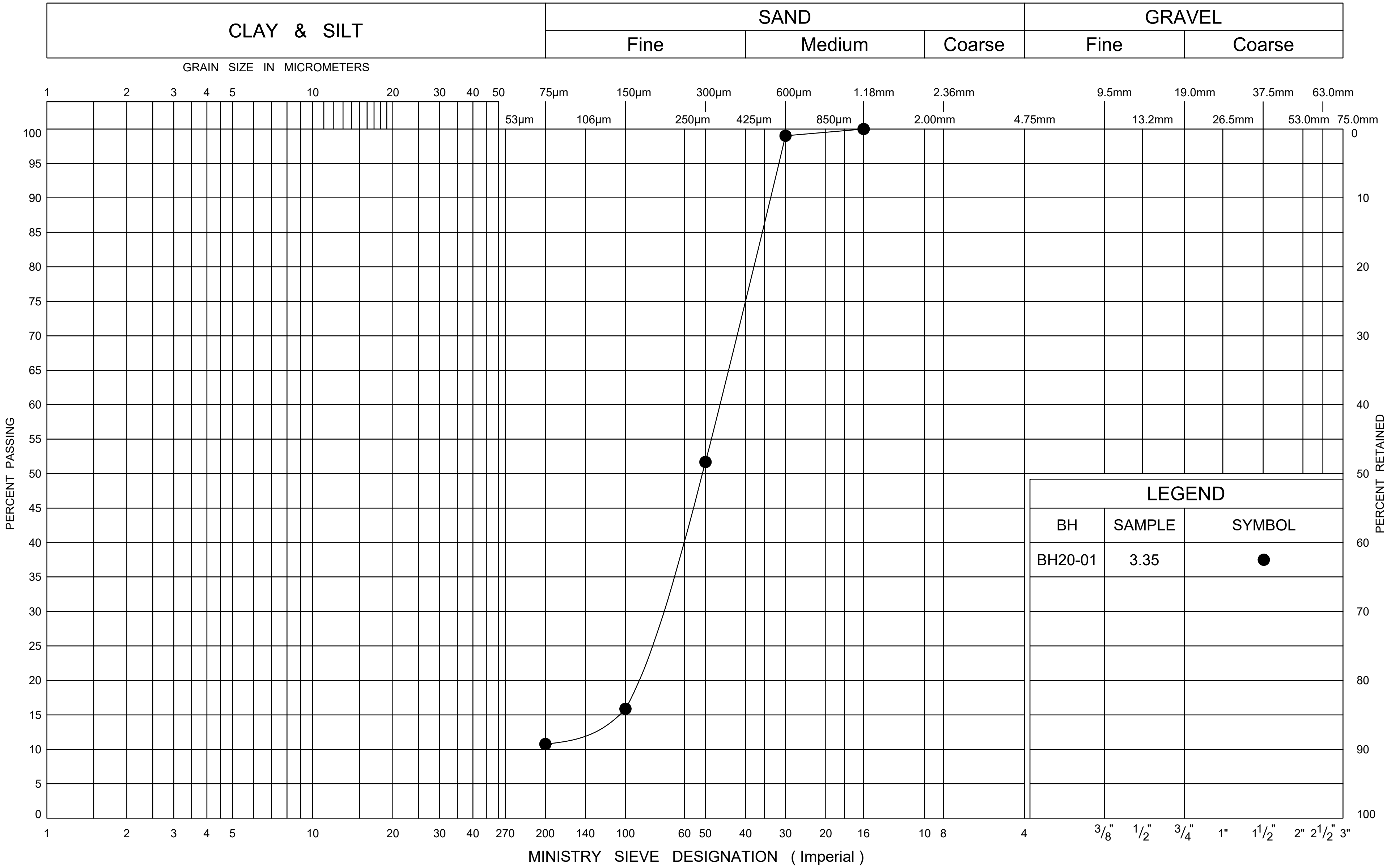
DATUM Geodetic | DATE 2020.08.20 - 2020.08.21 | LATITUDE 43.459054 | LONGITUDE -80.470721 | CHECKED BY GRL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		19	SS	24	294	o	
					293		
292.7 / 32.3	**SAND**, with gravel, trace silt Very Dense Grey Wet				292		
		20	SS	69	291	o	
290.4 / 34.6	Silty **CLAY**, with sand, gravelly Hard Grey Wet (TILL)				290		
		21	SS	101/ 0.275		o	21 36 28 15
					289		
		22	SS	103/0.225	288	o	
					287		
		23	SS	104/ 0.250		o	
286.6 / 38.4	END OF BOREHOLE AT 38.35m. WATER LEVEL AT 2.3m. BOREHOLE BACKFILLED WITH BENTONITE CUTTINGS AND ASPHALT COLD PATCH TO SURFACE.						

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

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



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Ontario

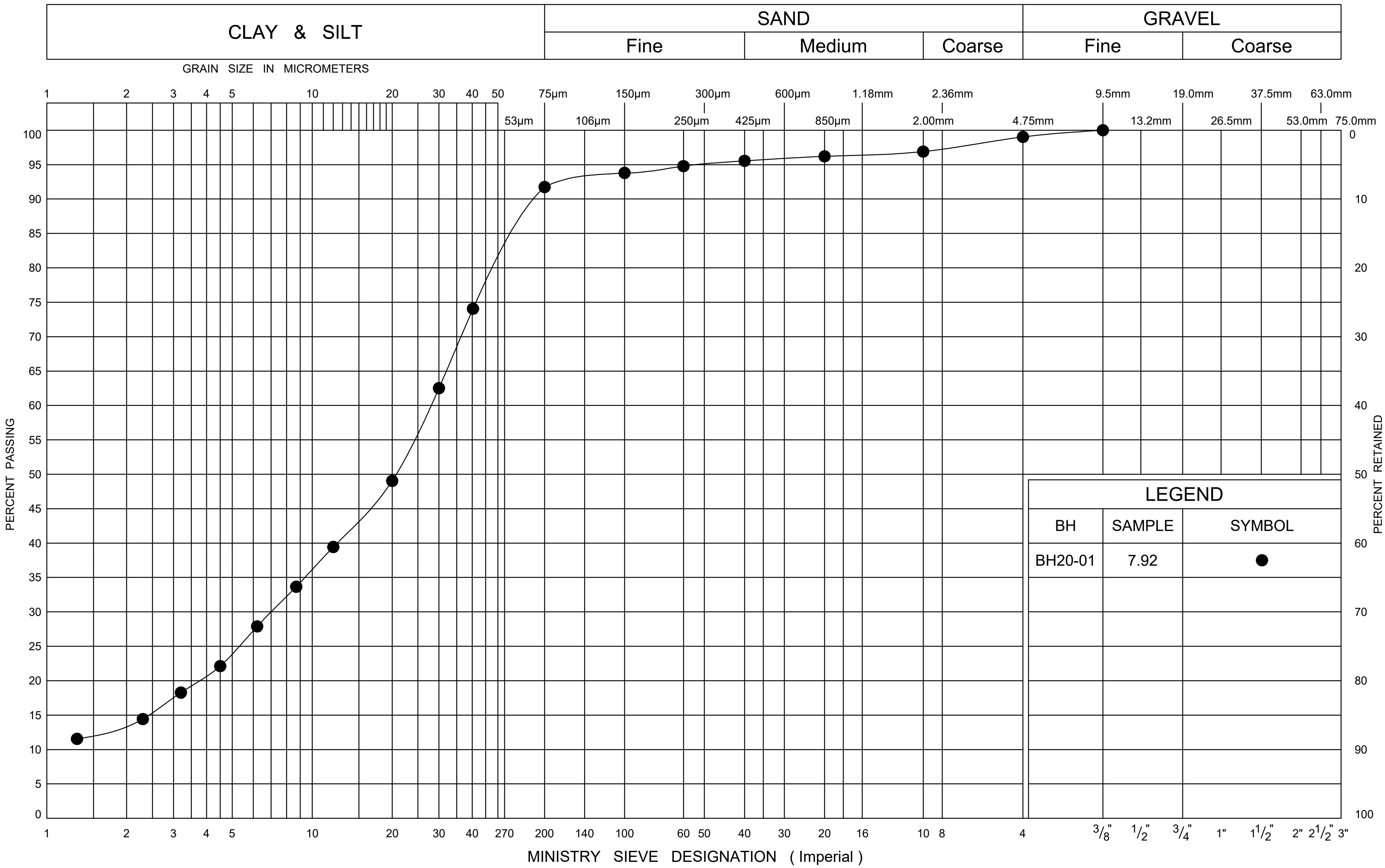
GRAIN SIZE DISTRIBUTION

SAND (FILL)

FIG No A1

W P 408-88-00

78 12 M



LEGEND		
BH	SAMPLE	SYMBOL
BH20-01	7.92	●

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Ontario

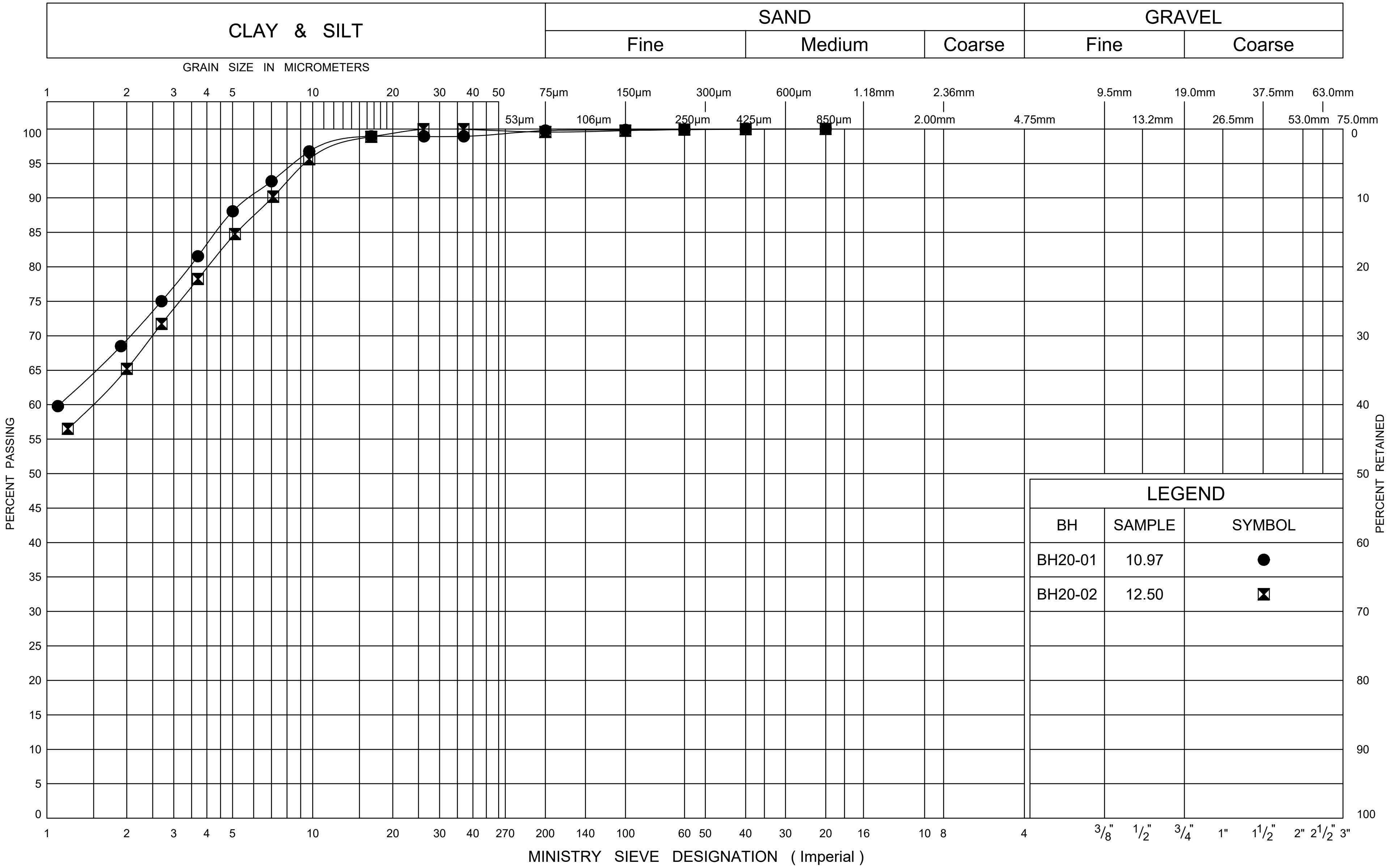
GRAIN SIZE DISTRIBUTION

Clayey SILT

FIG No A2

W P 408-88-00

ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 11/26/20



ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 11/26/20

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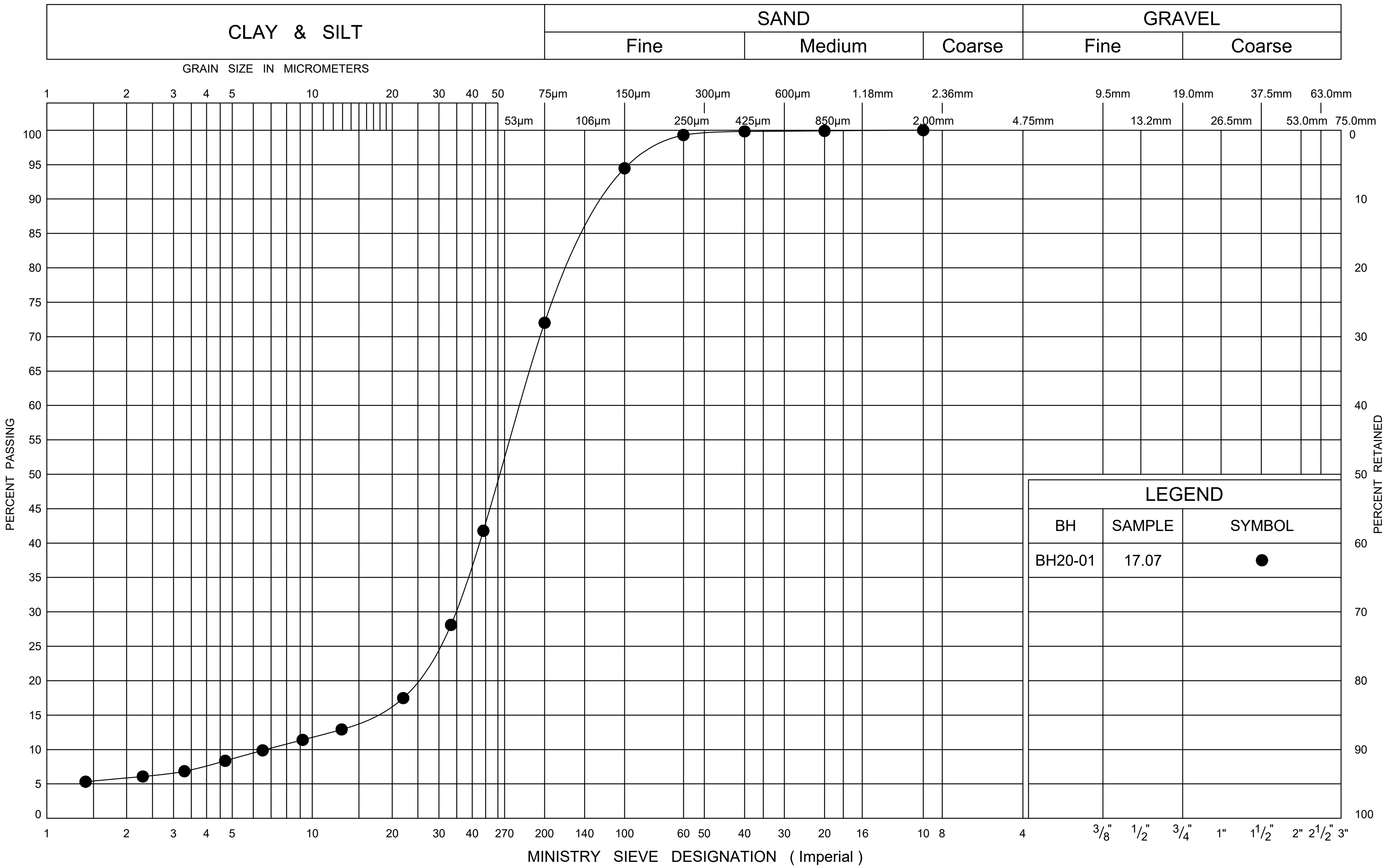
GRAIN SIZE DISTRIBUTION

Upper Silty CLAY

FIG No A3

W P 408-88-00



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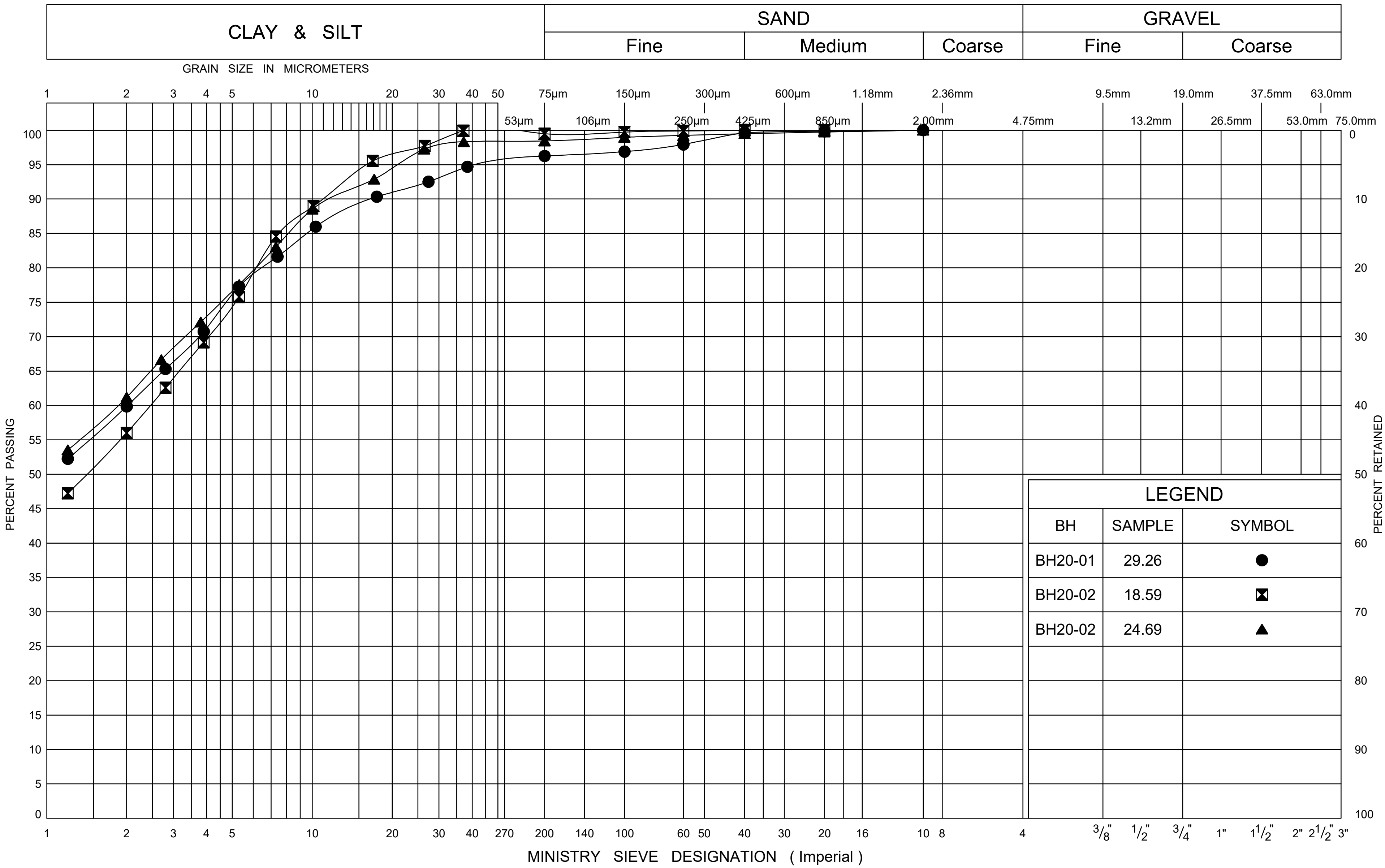
GRAIN SIZE DISTRIBUTION

Sandy SILT to Silty SAND

FIG No A4

W P 408-88-00

78 12 M



BH	SAMPLE	SYMBOL
BH20-01	29.26	●
BH20-02	18.59	⧗
BH20-02	24.69	▲

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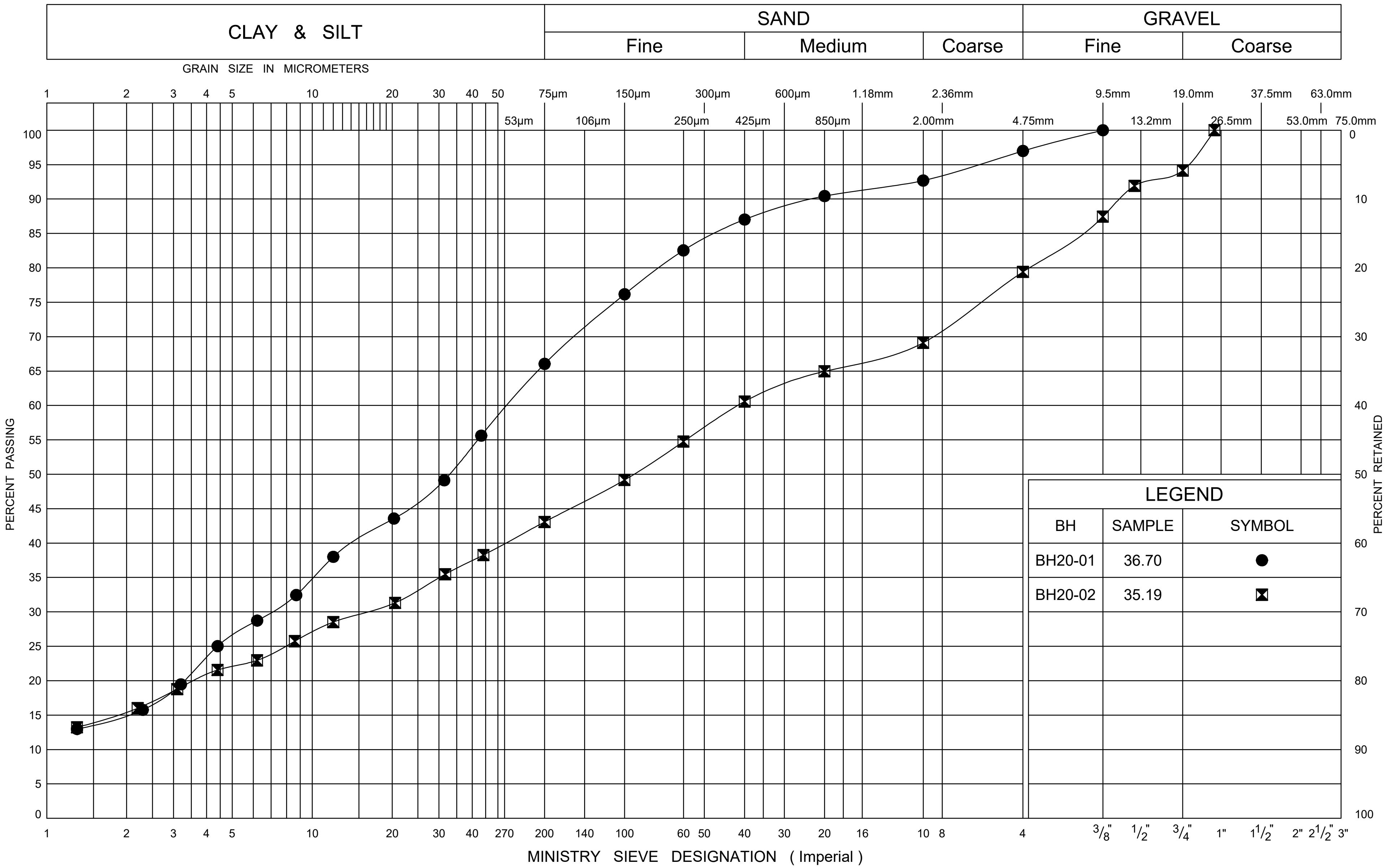
GRAIN SIZE DISTRIBUTION

Lower Silty CLAY

FIG No A5

W P 408-88-00



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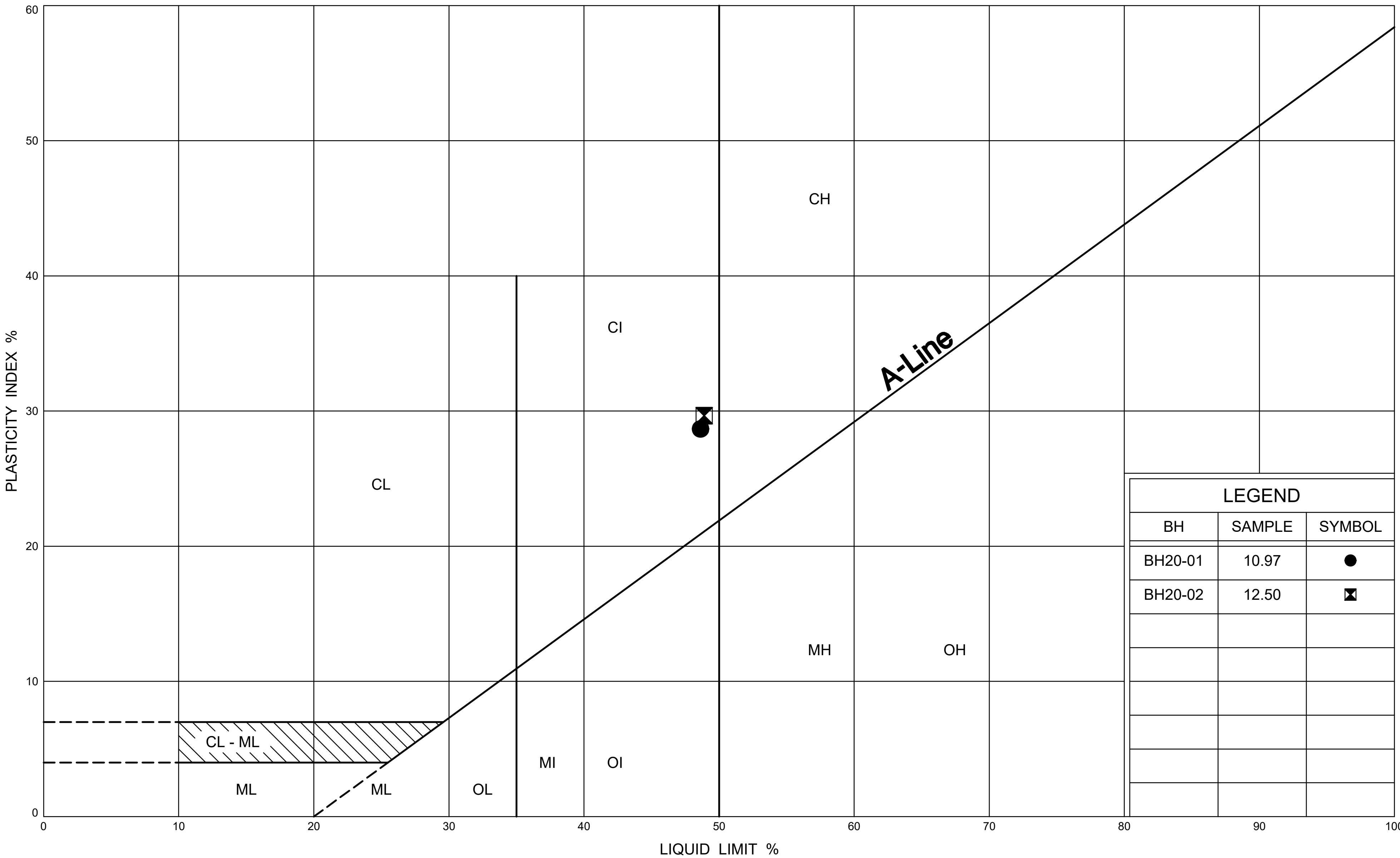
GRAIN SIZE DISTRIBUTION

Silty CLAY TILL

FIG No A6

W P 408-88-00



LEGEND		
BH	SAMPLE	SYMBOL
BH20-01	10.97	●
BH20-02	12.50	⧗

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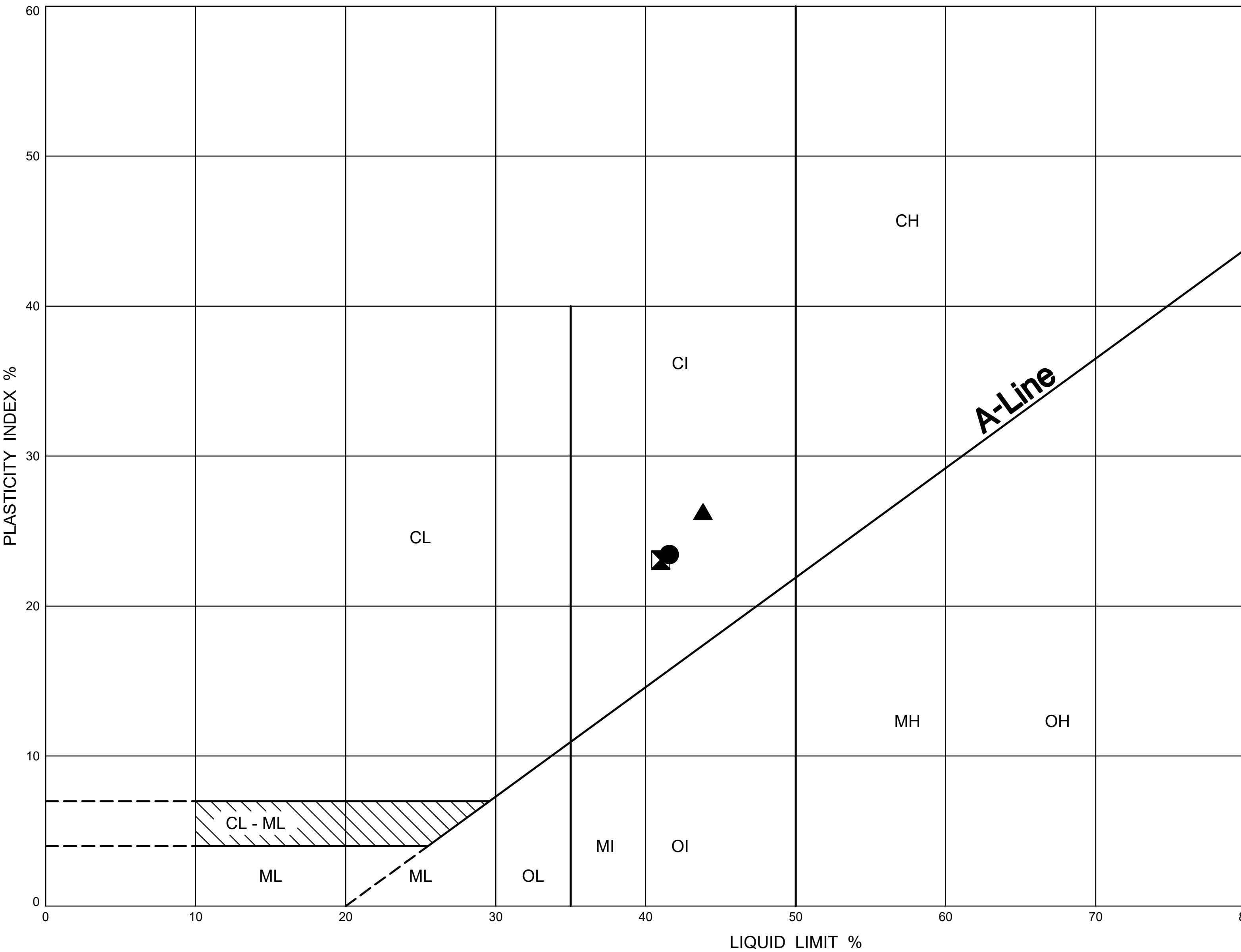
PLASTICITY CHART
Upper Silty CLAY

FIG No A7

W P 408-88-00

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
BH20-01	29.26	●
BH20-02	18.59	⧗
BH20-02	24.69	▲

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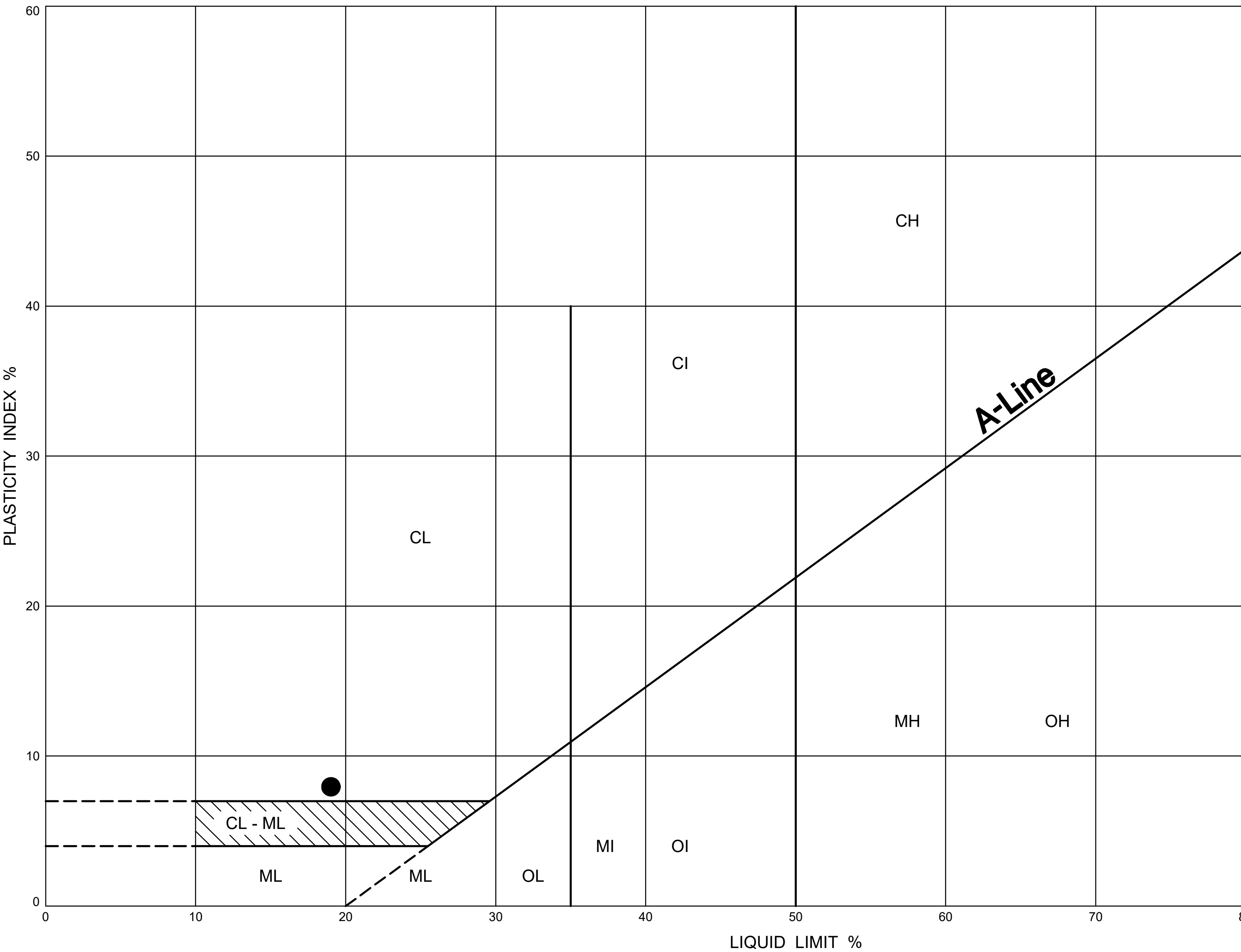
PLASTICITY CHART

Lower Silty CLAY

FIG No A8

W P 408-88-00

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
BH20-02	35.19	●

ONTARIO MOT PLASTICITY CHART MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 11/26/20

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PLASTICITY CHART

Silty CLAY TILL

FIG No A9

W P 408-88-00

FINAL REPORT

CA14882-AUG20 R1

1375 Frederick St.

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Geoff Lay	Telephone	2165
Telephone	905-829-8666	Facsimile	705-652-6365
Facsimile		Email	jill.campbell@sgs.com
Email	glay@thurber.ca	SGS Reference	CA14882-AUG20
Project	1375 Frederick St.	Received	08/28/2020
Order Number		Approved	09/03/2020
Samples	Soil (2)	Report Number	CA14882-AUG20 R1
		Date Reported	09/03/2020

COMMENTS

Temperature of Sample upon Receipt:7 degrees C
Cooling Agent Present:YES
Custody Seal Present:YES

Chain of Custody Number:NA

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

SIGNATORIES

Jill Campbell, B.Sc.,GISAS

TABLE OF CONTENTS

FINAL REPORT

Client: Thurber Engineering Ltd.

Project: 1375 Frederick St.

Project Manager: Geoff Lay

Samplers: Brett Thomas

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

			Sample Number	5	6
			Sample Name	BH20-01 SS#4	BH20-02 SS#3
			Sample Matrix	Soil	Soil
			Sample Date	17/08/2020	20/08/2020
Parameter	**Units**	**RL**		**Result**	**Result**
Corrosivity Index					
Corrosivity Index	none	1		8	13
Soil Redox Potential	mV	-		287	285
Sulphide	%	0.04		< 0.04	< 0.04
pH	pH Units	0.05		9.66	9.37
Resistivity (calculated)	ohms.cm	-9999		1830	892

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

			Sample Number	5	6
			Sample Name	BH20-01 SS#4	BH20-02 SS#3
			Sample Matrix	Soil	Soil
			Sample Date	17/08/2020	20/08/2020
Parameter	**Units**	**RL**		**Result**	**Result**
General Chemistry					
Conductivity	uS/cm	2		547	1120

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

			Sample Number	5	6
			Sample Name	BH20-01 SS#4	BH20-02 SS#3
			Sample Matrix	Soil	Soil
			Sample Date	17/08/2020	20/08/2020
Parameter	**Units**	**RL**		**Result**	**Result**
Metals and Inorganics					
Moisture Content	%	0.1		3.8	4.4
Sulphate	µg/g	0.4		8.3	21

FINAL REPORT

Client: Thurber Engineering Ltd.
Project: 1375 Frederick St.
Project Manager: Geoff Lay
Samplers: Brett Thomas

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

Parameter	Units	RL		Result	Result
			Sample Number	5	6
			Sample Name	BH20-01 SS#4	BH20-02 SS#3
			Sample Matrix	Soil	Soil
			Sample Date	17/08/2020	20/08/2020
Other (ORP)					
Chloride	μg/g	0.4		210	750

QC SUMMARY

Anions by IC

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0461-AUG20	µg/g	0.4	<0.4	2	20	96	80	120	103	75	125
Sulphate	DIO0461-AUG20	µg/g	0.4	<0.4	8	20	98	80	120	95	75	125

Carbon/Sulphur

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0001-SEP20	%	0.04	< 0.04	ND	20	100	80	120			

Conductivity

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0414-AUG20	uS/cm	2	< 0.002	1	20	99	90	110	NA		

QC SUMMARY

pH

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0414-AUG20	pH Units	0.05	NA	1		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.

-- 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:

Laboratory Information Section - Lab use only

Received By: Scott R
Received Date: 08/28/2020 (mm/dd/yy)
Received Time: 16:20 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐
Cooling Agent Present: Yes ☑ No ☐ Type: Ice
Temperature Upon Receipt (°C): 12, 2, 2°C
LAB LIMS #: 14882

REPORT INFORMATION

Company: Thurber Engineering Ltd.
Contact: Geoff Lay
Address: 2010 Winston Park Drive #103, Oakville, ON L6H 5R7
Phone: (905) 829-8666
Fax:
Email: glay@thurber.ca

INVOICE INFORMATION

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

Quotation #:
P.O. #:
Project #: 11375
Site Location/ID: Frederick St

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:

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 ____
☑ Res/Park ☐ Ind/Com ☐ Agri/Other
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

M & I: Field Filtered (Y/N); Metals & Inorganics (incl CrVI, CN, Hg pH, (B(HWS), EC, SAR-soil) (Cl, Na-water)); Full Metals Suite (ICP metals plus B(HWS-soil only) Hg, CrVI); ICP Metals only (Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Pb, Mo, Ni, Se, Ag, Tl, U, V, Zn)
SVOC: PAHs only; SVOCs (all incl PAHs, ABNs, CPs)
PCB: PCBs Total ☐ Aroclor ☐
PHC: F1-F4 + BTEX; F1-F4 only (no BTEX)
VOC: VOCs (all incl BTEX); BTEX only
Pest: Pesticides (Organochlorine or specify other)
Other (please specify): Corrosivity; Sewer Use: (Specify pkg); Water Characterization Pkg (General ☐ Extended ☐)
TCLP: Specify TCLP tests: ☐ M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit.

#	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Corrosivity	COMMENTS
1	BH20-01 SS #4	Aug.17/2020	9 AM	2	Soil	✓	
2	BH20-02 SS #3	Aug. 20/2020	9 AM	2	Soil	✓	
3							
4							
5							
6							
7							4day
8							
9							
10							Soil
11							
12							

Observations/Comments/Special Instructions

Sampled By (NAME): Brett Thomas — Signature: [signature] — Date: 08/28/2020 (mm/dd/yy) — Pink Copy - Client

Relinquished by (NAME): Brett Thomas — Signature: [signature] — Date: 08/28/2020 (mm/dd/yy) — Yellow & White Copy - SGS

Revision # 1.5
Date of Issue: 13 Oct, 2016

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. (2) Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). (3) Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

THURBER ENGINEERING LTD.

APPENDIX C

Current Investigation: Record of Borehole Logs

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.

RECORD OF BOREHOLE No FS23-01

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 678.4 E 226 147.3 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.04.26 - 2023.05.03 | LATITUDE 43.458887 | LONGITUDE -80.471937 | CHECKED BY KS

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
327.7	GROUND SURFACE
0.0	**ASPHALT:** (50 mm)
0.0	**SAND**, some gravel Compact Brown Moist (FILL)
327.0 / 0.7	Silty **SAND**, trace gravel Compact Brown Moist (FILL)
325.5 / 2.2	Sandy **SILT**, some clay, trace gravel Very Loose to Loose Brown Moist (FILL)
324.0 / 3.7	Silty **SAND**, trace gravel Compact Brown Wet
320.5 / 7.2	Silty **CLAY**, trace to sand, trace gravel Stiff to Hard Grey Moist to Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	13				
2	SS	10				
3	SS	16	9	60	24	7
4	SS	WH				
5	SS	5				
6	SS	20				
7	SS	26	6	80	11	3
8	SS	28				
9	SS	13				
10	SS	47	0	10	52	38

Columns: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (327, 326, 325, 324, 323, 322, 321, 320, 319, 318); 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

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

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

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RECORD OF BOREHOLE No FS23-01

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 678.4 E 226 147.3 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.04.26 - 2023.05.03 | LATITUDE 43.458887 | LONGITUDE -80.471937 | CHECKED BY KS

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Silty **CLAY**, trace to sand, trace gravel Stiff to Hard Grey Moist to Wet 300 mm silty sand at a depth of 11.0 m	11	SS	47				
		12	SS	40				
313.5		13	SS	46				
14.2	Sandy **SILT**, trace gravel Very Dense Grey Wet	14	SS	71				
		15	SS	102	0	32	63	5
		16	SS	134				

Elevation scale: 317, 316, 315, 314, 313, 312, 311, 310, 309, 308

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 (%)

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No FS23-01

METRIC

GWP# 3025-20-00 LOCATION N 4 813 678.4 E 226 147.3 ORIGINATED BY HC

DIST Western HWY 7/85 BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) COMPILED BY AK

DATUM Geodetic DATE 2023.04.26 - 2023.05.03 LATITUDE 43.458887 LONGITUDE -80.471937 CHECKED BY KS

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
307.6 / 20.1	Silty **CLAY**, trace sand Very Stiff to Hard Grey Wet				307					
		17	SS	44	306	w ≈ 22				
					305					
					304					
		18	SS	55	303	wP ≈ 19, w ≈ 21, wL ≈ 32	0	2	38	60
					302					
					301					
		19	SS	64	300	w ≈ 22				
					299					
					298					

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; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No FS23-01

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 678.4 E 226 147.3 | ORIGINATED BY HC

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DATUM Geodetic | DATE 2023.04.26 - 2023.05.03 | LATITUDE 43.458887 | LONGITUDE -80.471937 | CHECKED BY KS

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**, trace sand Very Stiff to Hard Grey Wet						
		20	SS	39	297		
					296		
					295		
		21	SS	25	294		
					293		
292.3 / 35.4	Sandy Silty **CLAY**, trace gravel Hard Grey Wet (TILL)				292		
		22	SS	128	291		6 26 51 17
					290		
					289		
		23	SS	103/0.100	288		

Continued Next Page

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/m³

$+^3, \times^3$: Numbers refer to Sensitivity; (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No FS23-01

METRIC

GWP# 3025-20-00 LOCATION N 4 813 678.4 E 226 147.3 ORIGINATED BY HC

DIST Western HWY 7/85 BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) COMPILED BY AK

DATUM Geodetic DATE 2023.04.26 - 2023.05.03 LATITUDE 43.458887 LONGITUDE -80.471937 CHECKED BY KS

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 γ kN/m³	GR	SA	SI	CL
	Continued From Previous Page													
	Sandy Silty **CLAY**, trace gravel Hard Grey Wet (TILL)						287							
286.5			24	SS	107/ 0.175						3	27	53	17
41.2	END OF BOREHOLE AT 41.2 m.													

NOTE:

1. WATER LEVEL NOT MEASURED UPON COMPLETION OF DRILLING DUE TO INTRODUCTION OF DRILLING MUD.

Well installation consists of 25 mm diameter Schedule 40 PVC pipe with a 3.05 m slotted screen.

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2023.06.01	5.9	321.8
2023.08.09	5.7	322.0

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

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-02

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 623.3 E 226 139.9 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.04 - 2023.05.10 | LATITUDE 43.458390 | LONGITUDE -80.472020 | CHECKED BY KS

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.3	GROUND SURFACE				
0.0	**TOPSOIL:** (100 mm)				
0.1	Clayey **SAND**, trace gravel, containing rootlets, Firm, Dark Brown, Wet (FILL)	1	SS	6	6 47 37 10
326.6 / 0.7	Clayey **SILT**, some sand, trace gravel, Compact, Light Brown, Moist (FILL)	2	SS	10	
		3	SS	14	
325.5 / 1.8	Silty **SAND**, Compact, Light Brown, Moist to Wet	4	SS	18	
		5	SS	14	0 83 14 3
	Wet	6	SS	25	
		7	SS	23	
320.9 / 6.4	Silty **CLAY**, trace sand, Hard, Grey, Moist to Wet	8	SS	35	
		9	SS	40	0 2 52 46
		10	SS	53	

Elevation scale: 327, 326, 325, 324, 323, 322, 321, 320, 319, 318

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

RECORD OF BOREHOLE No FS23-02

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 623.3 E 226 139.9 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.04 - 2023.05.10 | LATITUDE 43.458390 | LONGITUDE -80.472020 | CHECKED BY KS

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**, trace sand Hard Grey Moist to Wet				317		
		11	SS	54		o	
					316		
		12	SS	84	315	o	
314.0 13.3	**SILT** and **SAND** Very Dense Grey Wet				314		
		13	SS	110/0.279	313	o	0 41 54 5 Non-Plastic
		14	SS	120/0.279	312	o	
		15	SS	104	311 / 310	o	
309.5 17.8	Silty **CLAY**, trace sand, trace gravel Very Stiff to Hard Grey Wet						
		16	SS	49	309	o	
					308	o	

Continued Next Page

Legend: 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 FS23-02

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Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Silty **CLAY**, trace sand, trace gravel Very Stiff to Hard Grey Wet		17	SS	58		307					
							306					
							305					
			18	SS	42		304					
							303					
							302					
			19	SS	38		301					
							300					
							299					
			20	SS	42		298		0	1	36	63

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No FS23-02

METRIC

Ministry of Transportation Ontario — THURBER

GWP# 3025-20-00	LOCATION N 4 813 623.3 E 226 139.9		ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary)		COMPILED BY AK
DATUM Geodetic	DATE 2023.05.04 - 2023.05.10	LATITUDE 43.458390 LONGITUDE -80.472020	CHECKED BY KS

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	Silty **CLAY**, trace sand, trace gravel Very Stiff to Hard Grey Wet				297
					296
		21	SS	26	295
					294
293.5 33.8	Sandy **SILT**, some clay Very Dense Grey Wet (TILL)				293
		22	SS	124/ 0.254	292
291.9 35.4	Clayey **SILT**, some sand, trace gravel Hard Grey Wet (TILL)				291
					290
		23	SS	114/ 0.152	289
					288

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; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

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RECORD OF BOREHOLE No FS23-02

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 623.3 E 226 139.9 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.04 - 2023.05.10 | LATITUDE 43.458390 | LONGITUDE -80.472020 | CHECKED BY KS

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										
286.9			24	SS	125/		287				
40.4	END OF BOREHOLE AT 40.4 m. NOTES: 1. WATER LEVEL NOT MEASURED UPON COMPLETION OF DRILLING DUE TO INTRODUCTION OF DRILLING MUD.				0.127						

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

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

RECORD OF BOREHOLE No FS23-03

METRIC

GWP# 3025-20-00	LOCATION N 4 813 689.5 E 226 188.4		ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary)		COMPILED BY AK
DATUM Geodetic	DATE 2023.03.29 - 2023.04.10	LATITUDE 43.458991 LONGITUDE -80.471431	CHECKED BY KS

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
320.5	GROUND SURFACE
0.0	**ASPHALT:** (330 mm)
320.1 / 0.3	Gravelly Silty **SAND**, Dense, Brown, Moist (FILL)
319.5 / 0.9 (319.4) / 1.1	Clayey **SILT**, trace gravel, Very Stiff, Brown, Moist (FILL)
319.0 / 1.4	Silty **SAND**, trace gravel, Compact, Brown, Moist (FILL)
	Clayey **SILT**, trace sand to sandy, trace to some gravel, Very Stiff to Hard, Brown, Moist (TILL)
316.0 / 4.5	**CLAY**, Very Stiff to Hard, Brown, Moist

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
			32	50	16	2
1	SS	41				
2	SS	18				
3	SS	20	0	4	50	46
4	SS	26				
5	SS	58				
6	SS	40	16	32	33	19
7	SS	42				
8	SS	44				
9	SS	27	0	0	29	71
10	SS	34				

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (320, 319, 318, 317, 316, 315, 314, 313, 312, 311); 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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No FS23-03

METRIC

GWP# 3025-20-00	LOCATION N 4 813 689.5 E 226 188.4		ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary)		COMPILED BY AK
DATUM Geodetic	DATE 2023.03.29 - 2023.04.10	LATITUDE 43.458991 LONGITUDE -80.471431	CHECKED BY KS

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
310.3							
10.2	Silty **SAND** to Sandy **SILT**, Very Dense, Brown to Grey, Moist					310	
			11	SS	68		0 19 73 8
						309	
			12	SS	40	308	
						307	
			13	SS	86		0 59 39 2
						306	
305.7 / 14.8	Silty **CLAY**, trace sand, Hard, Brown, Moist						
			14	SS	56	305	
						304	
			15	SS	36	303	
			16	SS	48	302	0 3 40 57
						301	

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
GROUND WATER CONDITIONS; UNIT WEIGHT γ kN/m³

Continued Next Page

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

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Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-03

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 689.5 E 226 188.4 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.03.29 - 2023.04.10 | LATITUDE 43.458991 | LONGITUDE -80.471431 | CHECKED BY KS

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY**, trace sand Hard Brown Moist		17	SS	51		300	
							299	
							298	
			18	SS	34		297	
							296	
							295	
			19	SS	30		294	
							293	
292.7 27.7	**SAND**, some non-plastic fines Compact Brown Wet						292	
			20	SS	22		291	0 80 20 (SI+CL)

Plot headings: 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/m^3

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 FS23-03

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 689.5 E 226 188.4 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.03.29 - 2023.04.10 | LATITUDE 43.458991 | LONGITUDE -80.471431 | CHECKED BY KS

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SAND, some non-plastic fines Compact Brown Wet				290					
289.7 30.8	Sandy Clayey **SILT**, trace gravel Hard Grey Wet (TILL)				289					
		21	SS	128/0.101	288	○				
					287, 286					
		22	SS	109/0.279	285	⊢○⊣	3	26	51	20
					284, 283					
		23	SS	142/0.075	282	○				
					281					

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No FS23-03

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 689.5 E 226 188.4 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY AK

DATUM Geodetic | DATE 2023.03.29 - 2023.04.10 | LATITUDE 43.458991 | LONGITUDE -80.471431 | CHECKED BY KS

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										
	Sandy Clayey **SILT**, trace gravel Hard Grey Wet (TILL)						280				
279.1			24	SS	100/ 0.075						
41.4	END OF BOREHOLE AT 41.4 m.										

NOTE:

1. WATER LEVEL NOT MEASURED UPON COMPLETION OF DRILLING DUE TO INTRODUCTION OF DRILLING MUD

Well installation consists of 25 mm diameter Schedule 40 PVC pipe with a 3.05 m slotted screen.

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2023.04.19	2.1	318.4

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-04

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 656.3 E 226 188.4 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY JW

DATUM Geodetic | DATE 2023.04.11 - 2023.04.21 | LATITUDE 43.458692 | LONGITUDE -80.471426 | CHECKED BY AK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
320.8	GROUND SURFACE				
0.0 / 320.5	**ASPHALT:** (300 mm)				
0.3	Gravelly **SAND** Compact to Dense Brown Moist (FILL)	1	SS	17	35 53 12 (SI+CL)
		2	SS	21	
319.6 / 1.2	Clayey **SILT**, some sand Hard Brown Moist (FILL)	3	SS	30	0 10 55 35
319.0 / 1.8	**SAND**, trace silt, trace gravel Dense Brown Moist (FILL)				
318.6 / 2.2	Silty **CLAY**, trace sand Very Stiff to Hard Brown to Grey Moist to Wet	4	SS	21	0 4 45 51
		5	SS	22	
		7	SS	25	
		8	SS	24	
		9	SS	19	
		10	SS	48	

Elevation scale: 320, 319, 318, 317, 316, 315, 314, 313, 312, 311

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

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Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-04

METRIC

GWP# 3025-20-00	LOCATION N 4 813 656.3 E 226 188.4		ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary)		COMPILED BY JW
DATUM Geodetic	DATE 2023.04.11 - 2023.04.21	LATITUDE 43.458692 LONGITUDE -80.471426	CHECKED BY AK

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
310.6										
10.2	**SILT**, some sand Very Dense Grey Wet				310					
		11	SS	67		○	0	18	74	8
					309					
308.4 12.4	Silty **CLAY**, trace sand Very Stiff Grey Moist	12	SS	54		○ ○				
					308					
					307					
		13	SS	57		├○──┤	0	2	39	59
					306					
		14	SS	49		○				
					305					
					304					
		15	SS	50		○				
					303					
		16	SS	60		○				
					302					
					301					

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 Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-04

METRIC

GWP# 3025-20-00	LOCATION N 4 813 656.3 E 226 188.4				ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary)				COMPILED BY JW
DATUM Geodetic	DATE 2023.04.11 - 2023.04.21	LATITUDE 43.458692	LONGITUDE -80.471426		CHECKED BY AK

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	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 Very Stiff Grey Moist		17	SS	49			~20		
							300			
							299			
							298			
			18	SS	42			~22		
							297			
							296			
							295			
			19	SS	28			~25		
							294			
293.1 27.7	Silty **SAND** Very Dense Brown Wet						293			
							292			
			20	SS	60			~20		0 84 16 (SI+CL)
							291			

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

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 FS23-04

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 656.3 E 226 188.4 | ORIGINATED BY HC

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) | COMPILED BY JW

DATUM Geodetic | DATE 2023.04.11 - 2023.04.21 | LATITUDE 43.458692 | LONGITUDE -80.471426 | CHECKED BY AK

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
290.1 / 30.8	Clayey **SILT**, trace sand to sandy Hard Grey Wet (TILL)				290					
					289					
		21	SS	125/ 0.275		plotted	8	34	47	11
					288					
					287					
					286					
		22	SS	75/ 0.200		plotted	5	60	28	7
					285					
					284					
					283					
282.5		23	SS	100/ 0.225						
38.3	END OF BOREHOLE AT 38.3 m. NOTE: 1. ARTESIAN CONDITIONS ENCOUNTERED WHEN AT A DEPTH OF 38.1 m. WATER LEVEL MEASURED AT 1.6 m ABOVE GROUND SURFACE IN RODS WHEN END OF TRICONE AT A DEPTH OF 29.4 m BELOW									

Continued Next Page

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/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

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

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

RECORD OF BOREHOLE No FS23-04

METRIC

GWP# 3025-20-00 LOCATION N 4 813 656.3 E 226 188.4 ORIGINATED BY HC

DIST Western HWY 7/85 BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger, 125 mm diameter tricone (Mud Rotary) COMPILED BY JW

DATUM Geodetic DATE 2023.04.11 - 2023.04.21 LATITUDE 43.458692 LONGITUDE -80.471426 CHECKED BY AK

SOIL PROFILE			SAMPLES			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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	GROUND SURFACE. BOREHOLE DECOMMISSIONED WITH CEMENTITIOUS GROUT.										

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

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

RECORD OF BOREHOLE No FS23-05

METRIC

GWP# 3025-20-00	LOCATION N 4 813 712.3 E 226 247.1		ORIGINATED BY HC/KO
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary		COMPILED BY AK
DATUM Geodetic	DATE 2023.05.11 - 2023.05.18	LATITUDE 43.459202 LONGITUDE -80.470709	CHECKED BY KS

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)

ELEV / DEPTH	DESCRIPTION
325.3	GROUND SURFACE
0.0	**TOPSOIL:** (125 mm)
0.1	**SAND**, some gravel Very Loose to Compact Brown Moist to Wet
	Wet below a depth of 3.0 m
318.1 / 7.2	Sandy Clayey **SILT**, some gravel Firm to Very Stiff Grey Moist to Wet (TILL)

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	5				
2	SS	5				
3	SS	3				
4	SS	6				
5	SS	16				
6	SS	15	15	73	11	1
7	SS	16				
8	SS	18				
9	SS	19				
10	SS	7	12	30	45	13
11	SS	25				

Elevation scale: 325, 324, 323, 322, 321, 320, 319, 318, 317, 316

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No FS23-05

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 712.3 E 226 247.1 | ORIGINATED BY HC/KO

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.11 - 2023.05.18 | LATITUDE 43.459202 | LONGITUDE -80.470709 | CHECKED BY KS

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Sandy Clayey **SILT**, some gravel Firm to Very Stiff Grey Moist to Wet (TILL)				315					
314.6 / 10.7	Silty **CLAY**, trace sand Hard Grey Moist	12	SS	36	314					
		13	SS	41	313					
		14	SS	36	312 / 311		0	1	35	64
310.5 / 14.8	Clayey **SILT**, some sand Hard Grey Wet	15	SS	86	310		0	16	67	17
		16	SS	67	309 / 308					
		17	SS	113	307					
306.0 / 19.3	Silty **CLAY** to **CLAY** Hard Grey Wet				306					

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. REMARKS & GRAIN SIZE DISTRIBUTION (%).

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No FS23-05

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 712.3 E 226 247.1 | ORIGINATED BY HC/KO

DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.11 - 2023.05.18 | LATITUDE 43.459202 | LONGITUDE -80.470709 | CHECKED BY KS

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **CLAY** to **CLAY** Hard Grey Wet	18	SS	42	305					
					304					
					303					
		19	SS	47	302					
					301					
					300					
		20	SS	38	299					
					298					
					297					
		21	SS	37	296		0	0	20	80

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; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No FS23-05

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 712.3 E 226 247.1 | ORIGINATED BY HC/KO
DIST Western HWY 7/85 | BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK
DATUM Geodetic | DATE 2023.05.11 - 2023.05.18 | LATITUDE 43.459202 | LONGITUDE -80.470709 | CHECKED BY KS

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **CLAY** to **CLAY** Hard Grey Wet				295, 294					
293.0 32.3	Sandy **SILT** Very Dense Grey Wet	22	SS	85	293, 292, 291	○	0	30	62	8
289.9 35.4	Sandy Silty **CLAY**, trace gravel Hard Grey Wet (TILL)	23	SS	99	290, 289, 288	○				
		24	SS	124/ 0.228	287, 286	○	2	28	51	19

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No FS23-05

METRIC

GWP# 3025-20-00	LOCATION N 4 813 712.3 E 226 247.1				ORIGINATED BY HC/KO
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary				COMPILED BY AK
DATUM Geodetic	DATE 2023.05.11 - 2023.05.18	LATITUDE 43.459202	LONGITUDE -80.470709		CHECKED BY KS

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Sandy Silty **CLAY**, trace gravel Hard Grey Wet (TILL)						285				
			25	SS	114		284		~20		
283.8 41.5	END OF BOREHOLE AT 41.5 m. NOTE: 1. WATER LEVEL NOT MEASURED UPON COMPLETION OF DRILLING DUE TO INTRODUCTION OF MUD FOR TRICONE MUD ROTARY.										

Legend: DCPT scale 20 40 60 80 100; ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; water content scale 20 40 60.

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-06

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 673.8 E 226 235.5 | ORIGINATED BY LS/HC

DIST Western HWY 7/85 | BOREHOLE TYPE Hydroexcavation; 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.19 - 2023.05.26 | LATITUDE 43.458854 | LONGITUDE -80.470847 | CHECKED BY KS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
325.4	GROUND SURFACE									
0.0	Silty **SAND**, trace gravel Brown Moist (FILL) Contains asphalt fragments and rootlets	1	GS	-	325	○				
		2	GS	-	324	○				
		3	GS	-	323	○	5	79	16 (SI+CL)	
321.6 3.8	**SAND** Compact Brown Moist (FILL)	4	SS	25	321	○				
319.8 5.6	Sandy Silty **CLAY**, trace gravel Stiff to Hard Brown Moist (TILL)	5	SS	10	319	○				
		6	SS	65	318	├○┤	5	28	43	24
316.4 9.0	Silty **SAND** Very Dense Brownish Grey Wet	7	SS	78	316	○	0	78	22 (SI+CL)	

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 Next Page

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

(%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-06

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 673.8 E 226 235.5 | ORIGINATED BY LS/HC

DIST Western HWY 7/85 | BOREHOLE TYPE Hydroexcavation; 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.19 - 2023.05.26 | LATITUDE 43.458854 | LONGITUDE -80.470847 | CHECKED BY KS

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.2					
10.2	Silty **CLAY**, Very Stiff to Hard, Grey, Moist				
		8	SS	36	
		9	SS	54	
		10	SS	37	
		11	SS	21	0 0 29 71
		12	SS	34	
307.6 17.8	Silty **SAND**, Very Dense, Grey, Wet				
		13	SS	96	

Elevation scale: 315, 314, 313, 312, 311, 310, 309, 308, 307, 306

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

RECORD OF BOREHOLE No FS23-06

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 673.8 E 226 235.5 | ORIGINATED BY LS/HC

DIST Western HWY 7/85 | BOREHOLE TYPE Hydroexcavation; 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.19 - 2023.05.26 | LATITUDE 43.458854 | LONGITUDE -80.470847 | CHECKED BY KS

SOIL PROFILE | SAMPLES | 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

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT	GR	SA	SI	CL
	Silty **SAND** Very Dense Grey Wet		14	SS	82		305	~18					
							304						
303.8 21.6	Silty **CLAY** Hard Grey Wet						303						
			15	SS	51		302	~19					
							301						
							300						
			16	SS	56		299	~20					
							298						
							297						
			17	SS	33		296	~22					

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 FS23-06

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 673.8 E 226 235.5 | ORIGINATED BY LS/HC

DIST Western HWY 7/85 | BOREHOLE TYPE Hydroexcavation; 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.19 - 2023.05.26 | LATITUDE 43.458854 | LONGITUDE -80.470847 | CHECKED BY KS

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **CLAY**, Hard, Grey, Wet								
294.6 / 30.8	**SILT**, trace sand, Very Dense, Grey, Wet (TILL)	18	SS	102	~20	0	7	66	27
291.6 / 33.8	**GRAVEL** and **SAND**, trace non-plastic fines, Very Dense, Grey, Wet	19	SS	52	~15	52	41	7 (SI+CL)	
289.9 / 35.5	Sandy Clayey **SILT**, trace gravel, Hard, Grey, Wet (TILL)	20	SS	102	~15				

Elevation scale: 295, 294, 293, 292, 291, 290, 289, 288, 287, 286

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 (%)

Continued Next Page

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

(%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No FS23-06

METRIC

GWP# 3025-20-00 | LOCATION N 4 813 673.8 E 226 235.5 | ORIGINATED BY LS/HC

DIST Western | HWY 7/85 | BOREHOLE TYPE Hydroexcavation; 205 mm O.D. Hollow Stem Augers; 125 mm diameter tricone mud rotary | COMPILED BY AK

DATUM Geodetic | DATE 2023.05.19 - 2023.05.26 | LATITUDE 43.458854 | LONGITUDE -80.470847 | CHECKED BY KS

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy Clayey **SILT**, trace gravel Hard Grey Wet (TILL)						285				
283.9			21	SS	102		284		o		
41.5	END OF BOREHOLE AT 41.5 m. NOTE: 1. WATER LEVEL NOT MEASURED UPON COMPLETION OF DRILLING DUE TO INTRODUCTION OF DRILLING MUD FOR TRICONE ADVANCEMENT.										

Legend: SHEAR STRENGTH kPa — O 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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SS23-01

METRIC

GWP# 3025-20-00	LOCATION N 4 813 767.4 E 226 134.9		ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers		COMPILED BY AK
DATUM Geodetic	DATE 2023.05.03 - 2023.05.04	LATITUDE 43.459686 LONGITUDE -80.472103	CHECKED BY AK

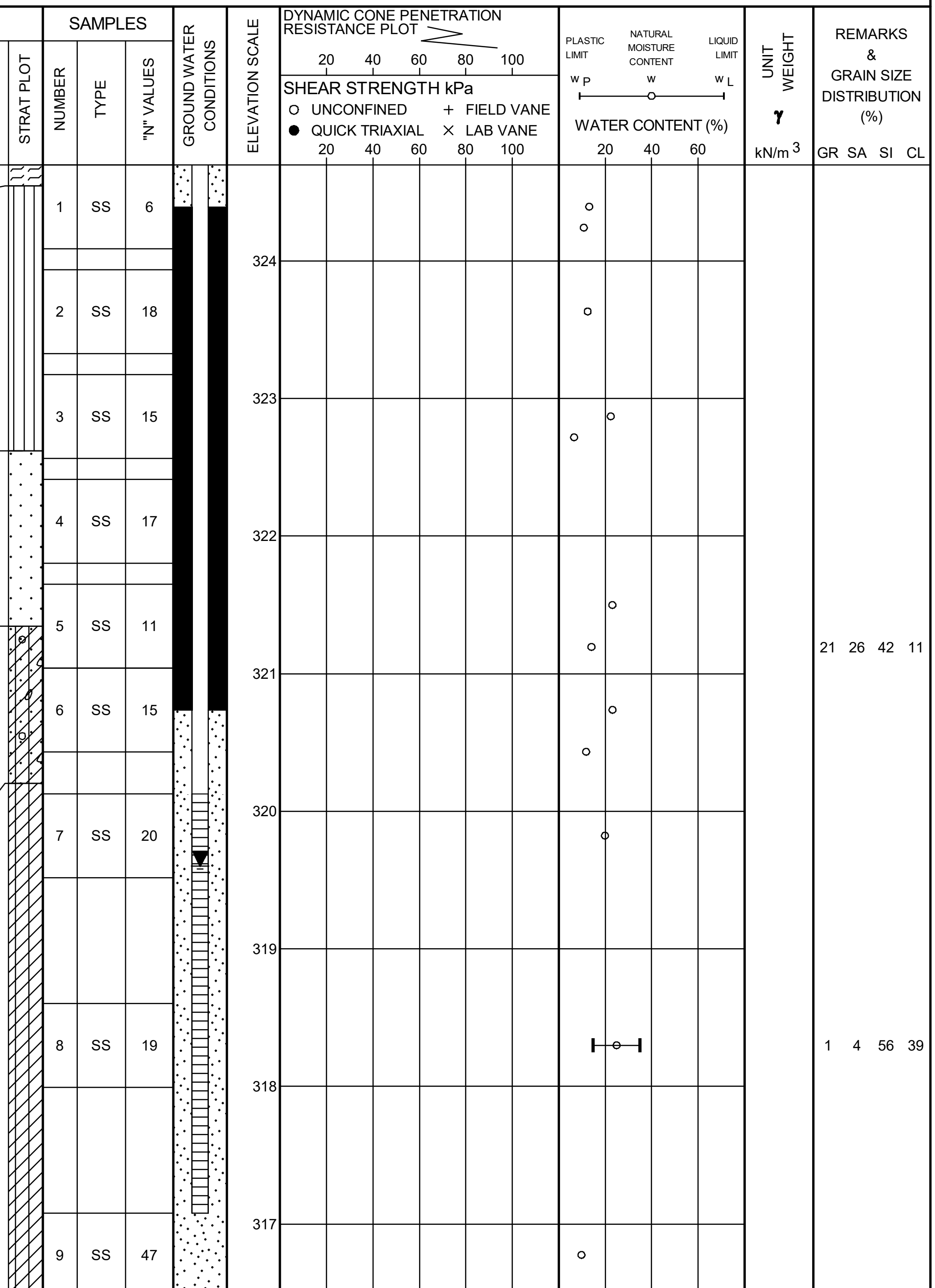
SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
324.7	GROUND SURFACE							
0.0	**TOPSOIL:** (150 mm)							
0.2	**SILT**, some sand, trace gravel, containing organics Loose to Compact Brown Moist	1	SS	6				
		2	SS	18				
		3	SS	15				
322.6 / 2.1	**SAND** Compact Brown Moist	4	SS	17				
321.3 / 3.4	Silty **CLAY**, trace sand to sandy, trace gravel Stiff to Hard Brown to Grey Moist to Wet (TILL) 200 mm sand layer at a depth of 3.7 m	5	SS	11	21	26	42	11
		6	SS	15				
320.2 / 4.5	Silty **CLAY**, trace gravel, trace sand Stiff to Hard Grey Moist	7	SS	20				
		8	SS	19	1	4	56	39
		9	SS	47				
316.5 / 8.2	END OF BOREHOLE AT 8.2 m.							

NOTE:

1. WATER LEVEL MEASURED AT A DEPTH OF 4.2 m BELOW GROUND SURFACE UPON COMPLETION OF DRILLING.

Well installation consists of 25 mm diameter Schedule 40 PVC pipe with



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SS23-01

METRIC

GWP# 3025-20-00 LOCATION N 4 813 767.4 E 226 134.9 ORIGINATED BY HC

DIST Western HWY 7/85 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.05.03 - 2023.05.04 LATITUDE 43.459686 LONGITUDE -80.472103 CHECKED BY AK

SOIL PROFILE			SAMPLES			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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION (Continued From Previous Page)	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	a 3.05 m slotted screen. WATER LEVEL READINGS DATE / DEPTH(m) / ELEV.(m) 2023.06.01 / 4.9 / 319.8 2023.08.09 / 5.1 / 319.6										

+ 3, × 3: Numbers refer to Sensitivity

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

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THURBER

RECORD OF BOREHOLE No SS23-02

METRIC

GWP# 3025-20-00	LOCATION N 4 813 724.3 E 226 141.6		ORIGINATED BY HC
DIST Western HWY 7/85	BOREHOLE TYPE 205 mm I.D. Hollow Stem Auger		COMPILED BY AK
DATUM Geodetic	DATE 2023.04.24 - 2023.04.24	LATITUDE 43.459299 LONGITUDE -80.472014	CHECKED BY AK

ELEV DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
327.4	GROUND SURFACE				
0.0	**ASPHALT:** (50 mm)				
0.0	Silty **SAND** and **GRAVEL**, Dense, Brown, Moist (FILL)	1	SS	33	38 49 11 2
326.6 / 0.8	Gravelly Clayey **SAND**, Stiff, Brown, Moist (FILL)	2	SS	10	27 34 29 10
		3	SS	14	
325.2 / 2.2	Silty **SAND** to **SAND**, Very Loose to Compact, Brown, Moist to Wet	4	SS	3	0 54 37 9
		5	SS	WH	
		6	SS	17	
		7	SS	20	
321.8 / 5.6	Sandy Clayey **SILT**, trace gravel, Stiff to Very Stiff, Brown to Grey, Moist to Wet (TILL); 150 mm silty sand interlayer at a depth of 6.6 m; Grey below a depth of 7.6 m	8	SS	10	
		9	SS	17	7 28 49 16
319.2 / 8.2	END OF BOREHOLE AT 8.2 m.				

NOTE:

WATER LEVEL NOT MEASURED UPON COMPLETION OF DRILLING

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (327, 326, 325, 324, 323, 322, 321, 320); 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

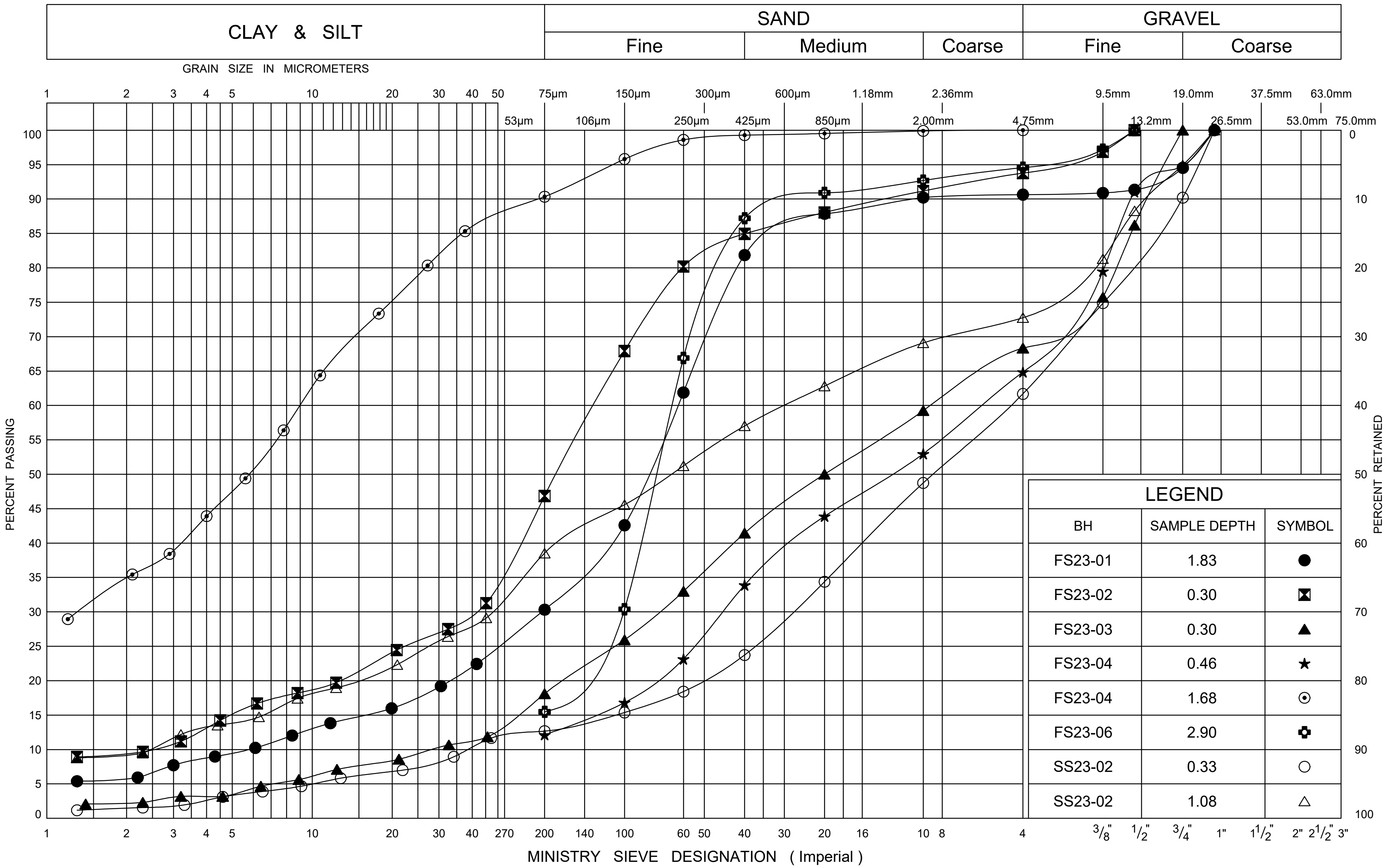
+³, ×³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

THURBER ENGINEERING LTD.

APPENDIX D

Current Investigation: Laboratory Test Results



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	1.83	●
FS23-02	0.30	⧗
FS23-03	0.30	▲
FS23-04	0.46	★
FS23-04	1.68	⊙
FS23-06	2.90	✥
SS23-02	0.33	○
SS23-02	1.08	△

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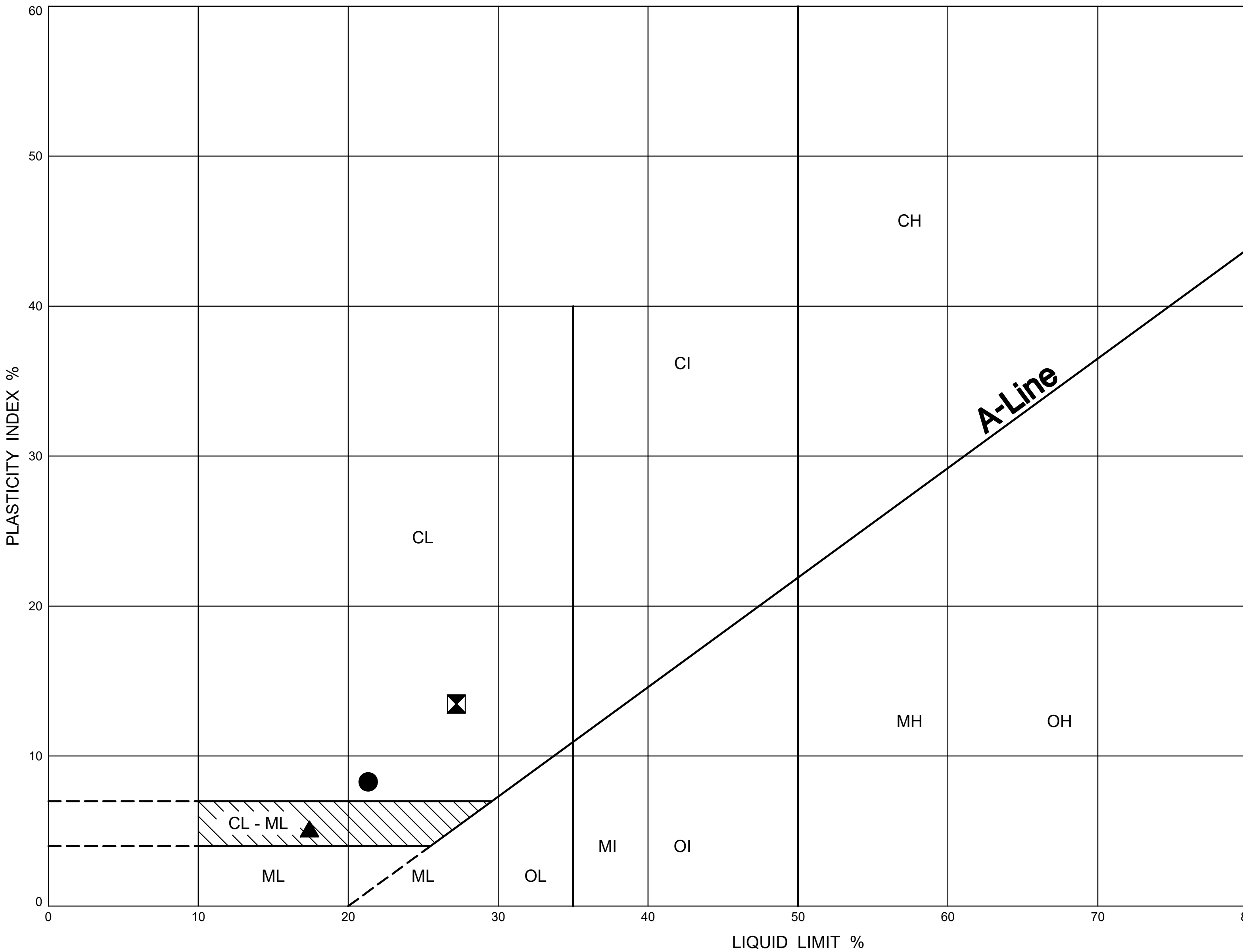
GRAIN SIZE DISTRIBUTION

Fill (Plastic and Non-Plastic)

FIG No D1

W.P.



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-02	0.30	●
FS23-04	1.68	⧗
SS23-02	1.08	▲

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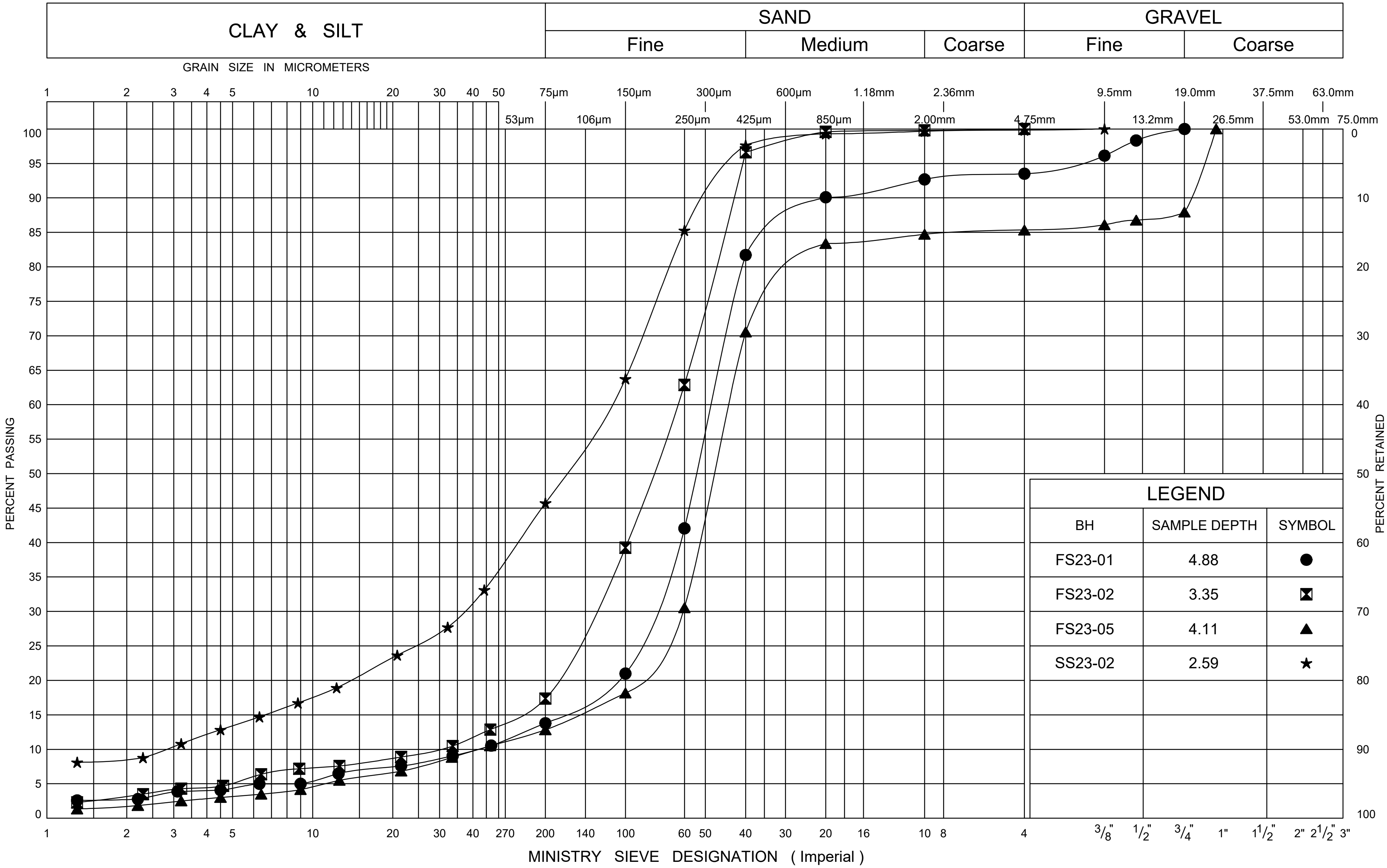
PLASTICITY CHART

Fill (Plastic)

FIG No D2

W.P.



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	4.88	●
FS23-02	3.35	⊠
FS23-05	4.11	▲
SS23-02	2.59	★

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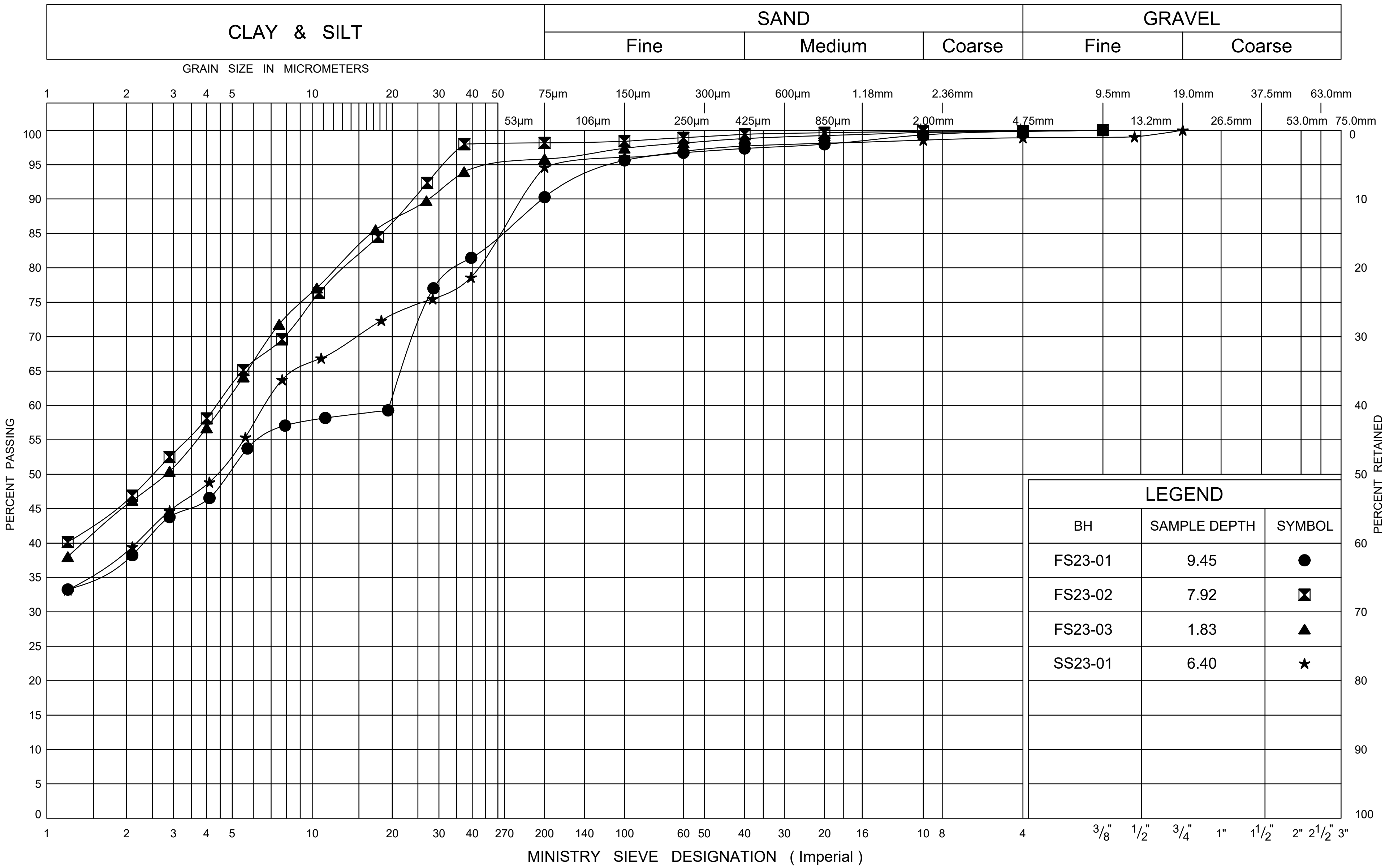
GRAIN SIZE DISTRIBUTION

Upper SAND to SILTY SAND to SILT

FIG No D3

W.P.



ONTARIO MOT GRAIN SIZE 3 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

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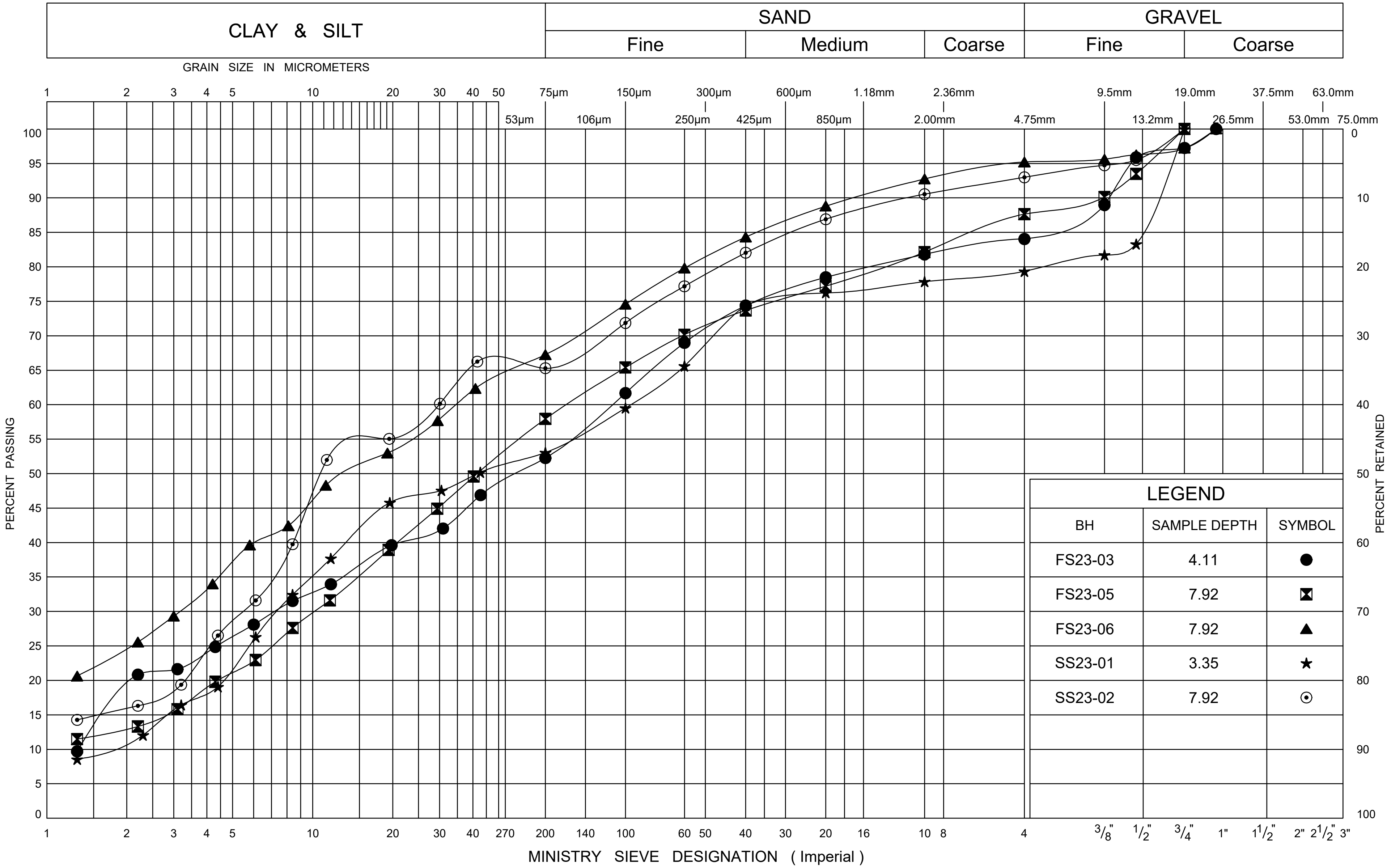
GRAIN SIZE DISTRIBUTION

SILTY CLAY to CLAYEY SILT TILL

FIG No D4A

W.P.

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-03	4.11	●
FS23-05	7.92	⊠
FS23-06	7.92	▲
SS23-01	3.35	★
SS23-02	7.92	⊙

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GRAIN SIZE DISTRIBUTION

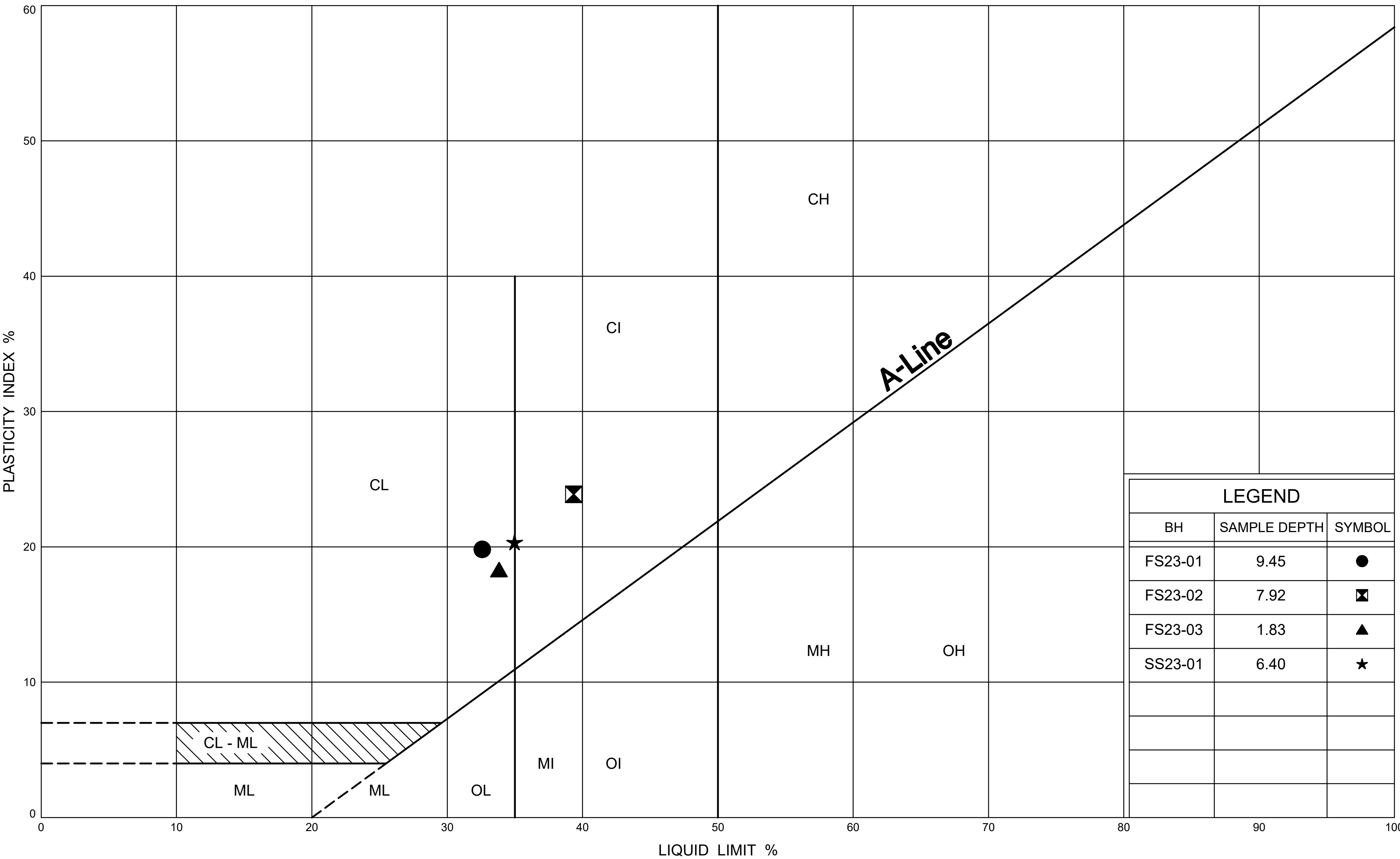
Sandy SILTY CLAY to CLAYEY SILT TILL

FIG No D4B

W.P.

ONTARIO MOT GRAIN SIZE 3 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	9.45	●
FS23-02	7.92	⧗
FS23-03	1.83	▲
SS23-01	6.40	★

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Ontario

PLASTICITY CHART

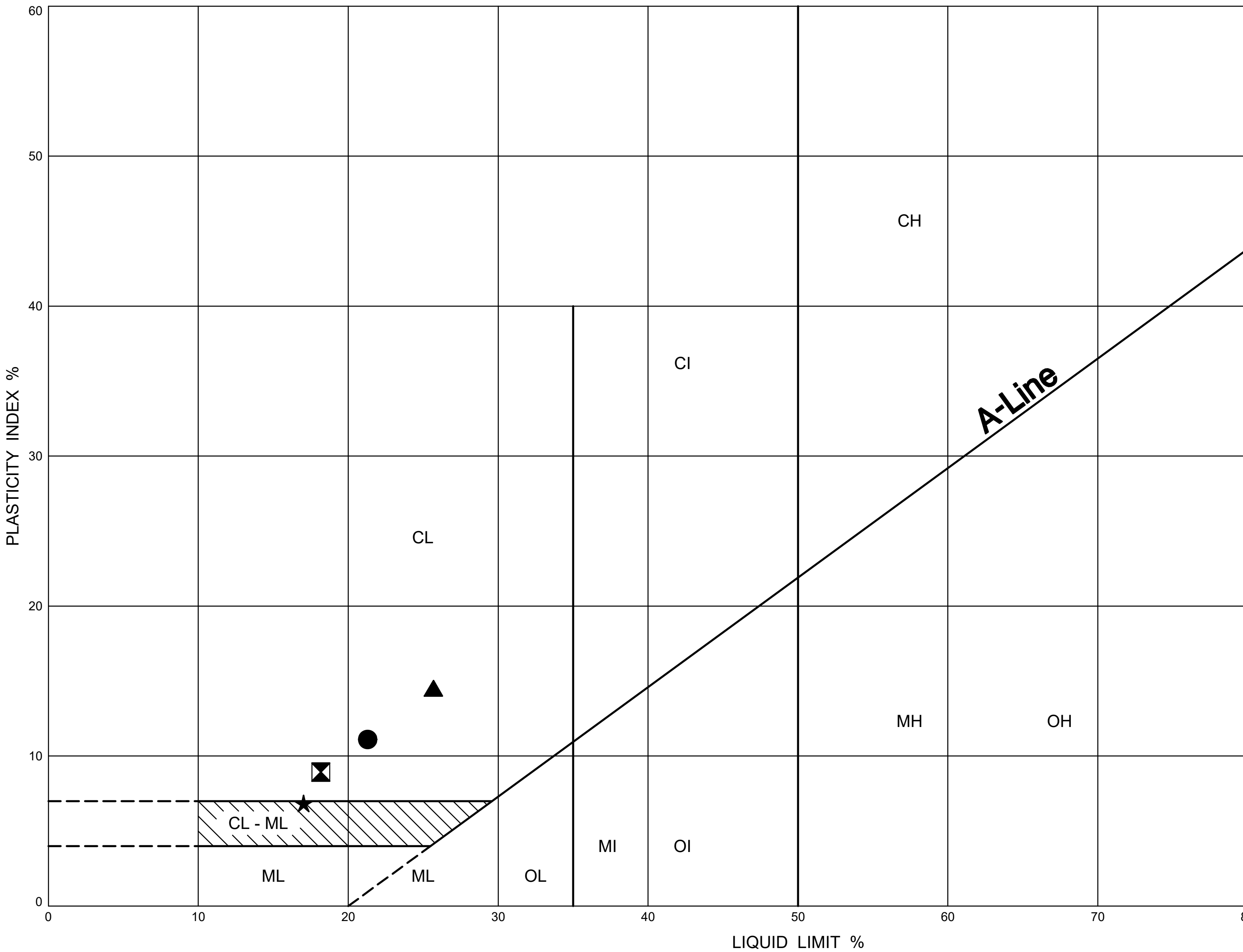
SILTY CLAY to CLAYEY SILT TILL

FIG No D5A

W.P.

ONTARIO MOT PLASTICITY CHART 2 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
FS23-03	4.11	●
FS23-05	7.92	⧗
FS23-06	7.92	▲
SS23-02	7.92	★

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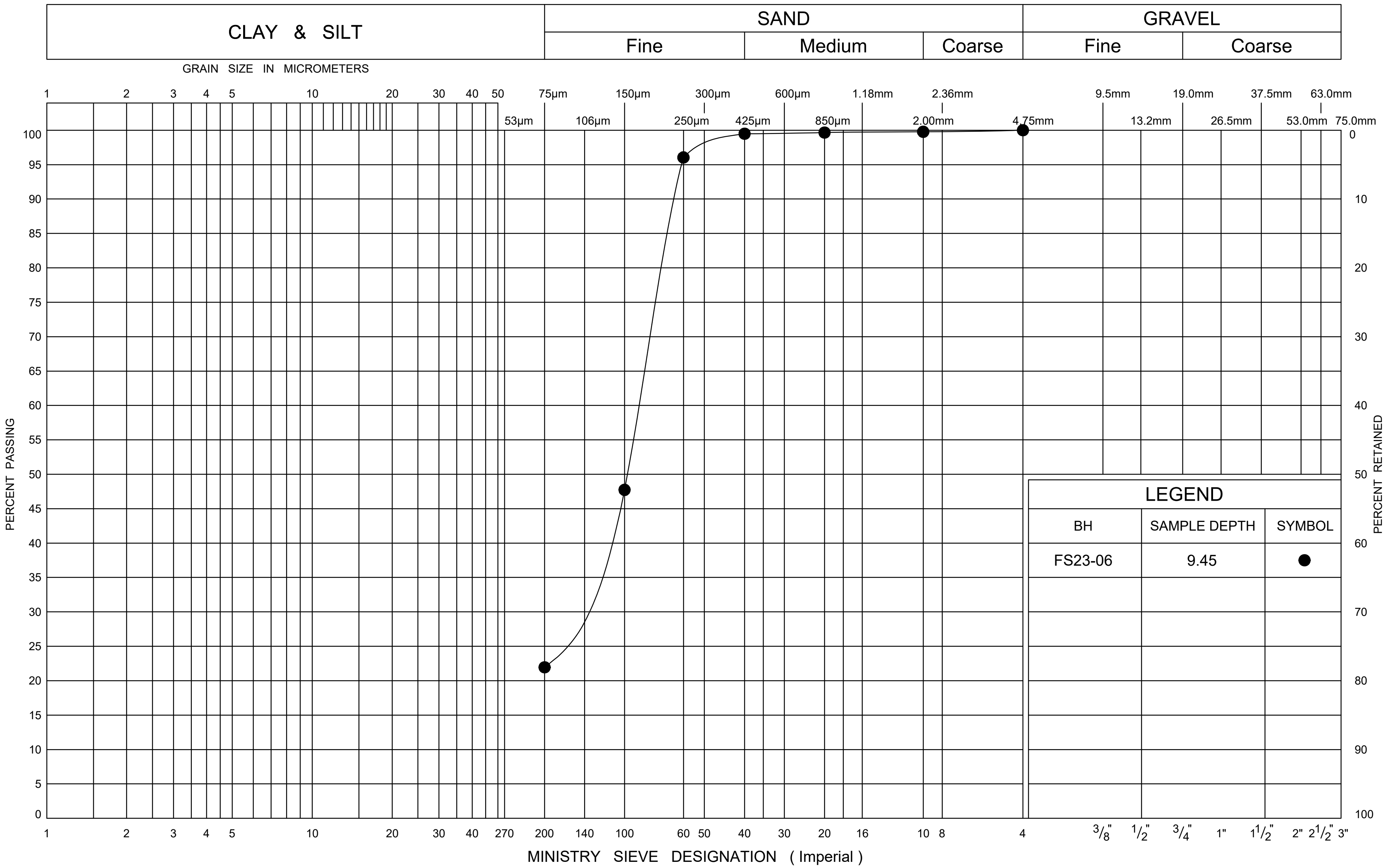
PLASTICITY CHART

Sandy SILTY CLAY to CLAYEY SILT TILL

FIG No D5B

W.P.

ONTARIO MOT PLASTICITY CHART 2 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23



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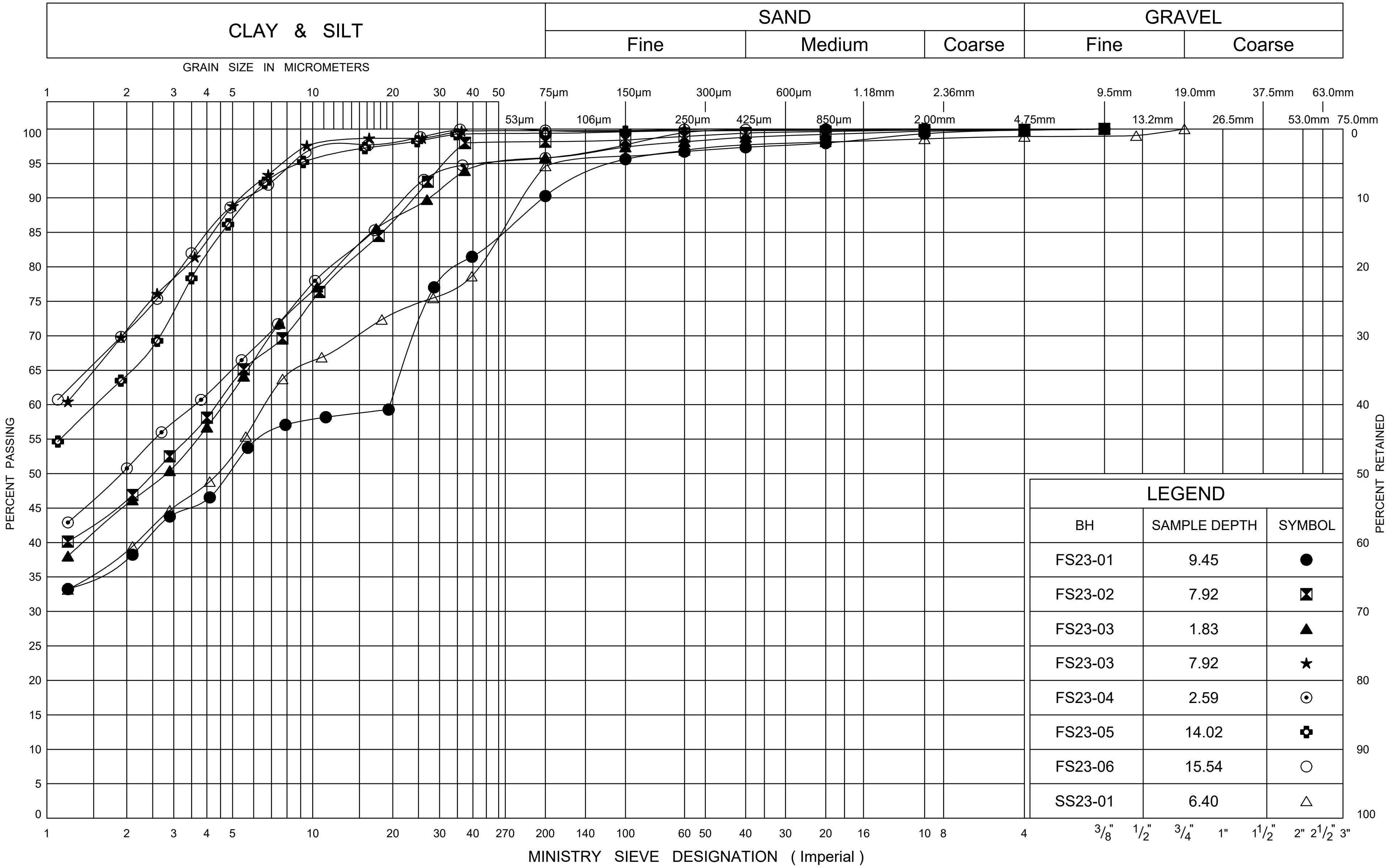
GRAIN SIZE DISTRIBUTION

SILTY SAND

FIG No D6

W.P.



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	9.45	●
FS23-02	7.92	⧗
FS23-03	1.83	▲
FS23-03	7.92	★
FS23-04	2.59	⊙
FS23-05	14.02	✤
FS23-06	15.54	○
SS23-01	6.40	△

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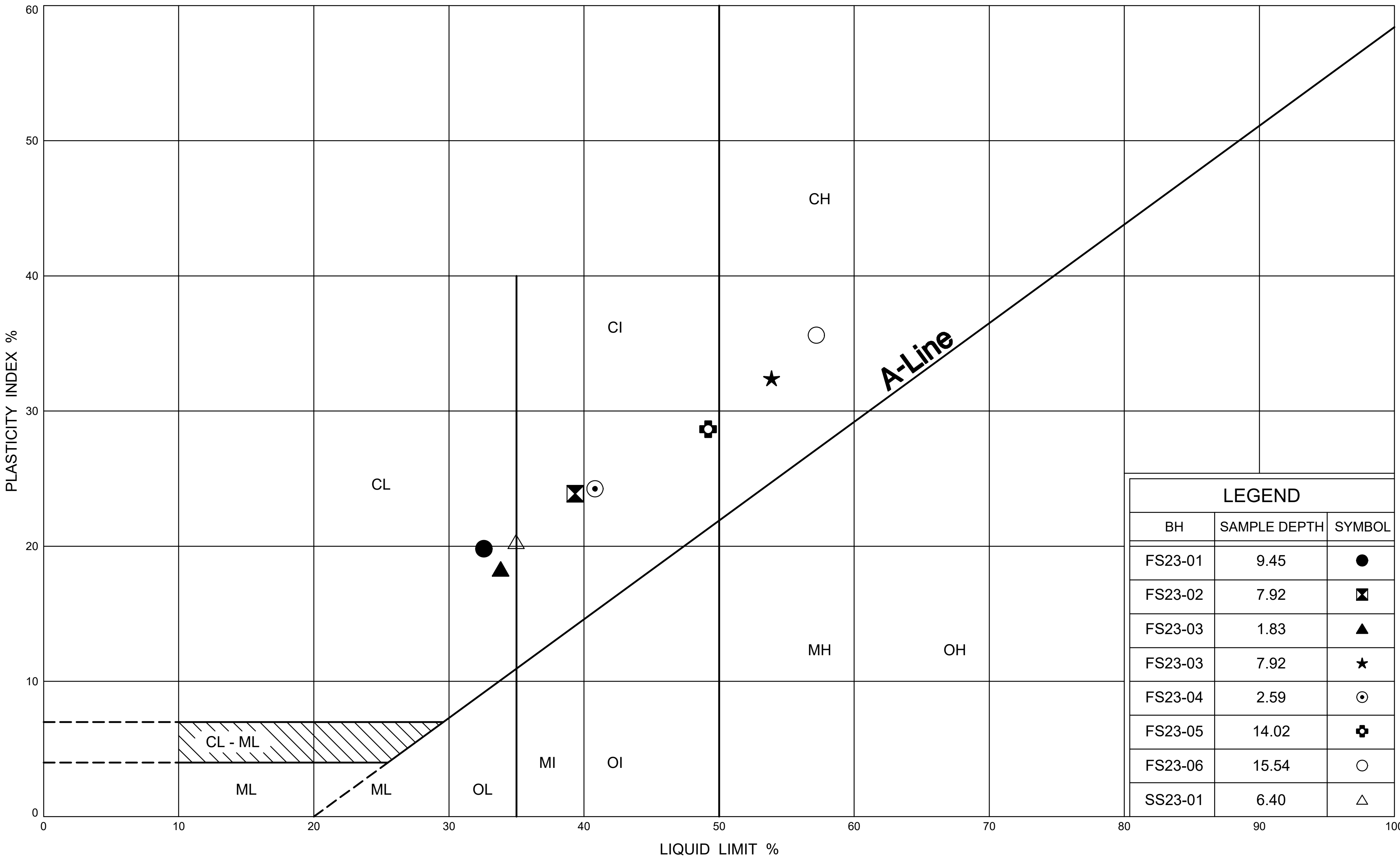
GRAIN SIZE DISTRIBUTION

Upper SILTY CLAY to CLAY

FIG No D7

W.P.

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	9.45	●
FS23-02	7.92	⧗
FS23-03	1.83	▲
FS23-03	7.92	★
FS23-04	2.59	⊙
FS23-05	14.02	✿
FS23-06	15.54	○
SS23-01	6.40	△

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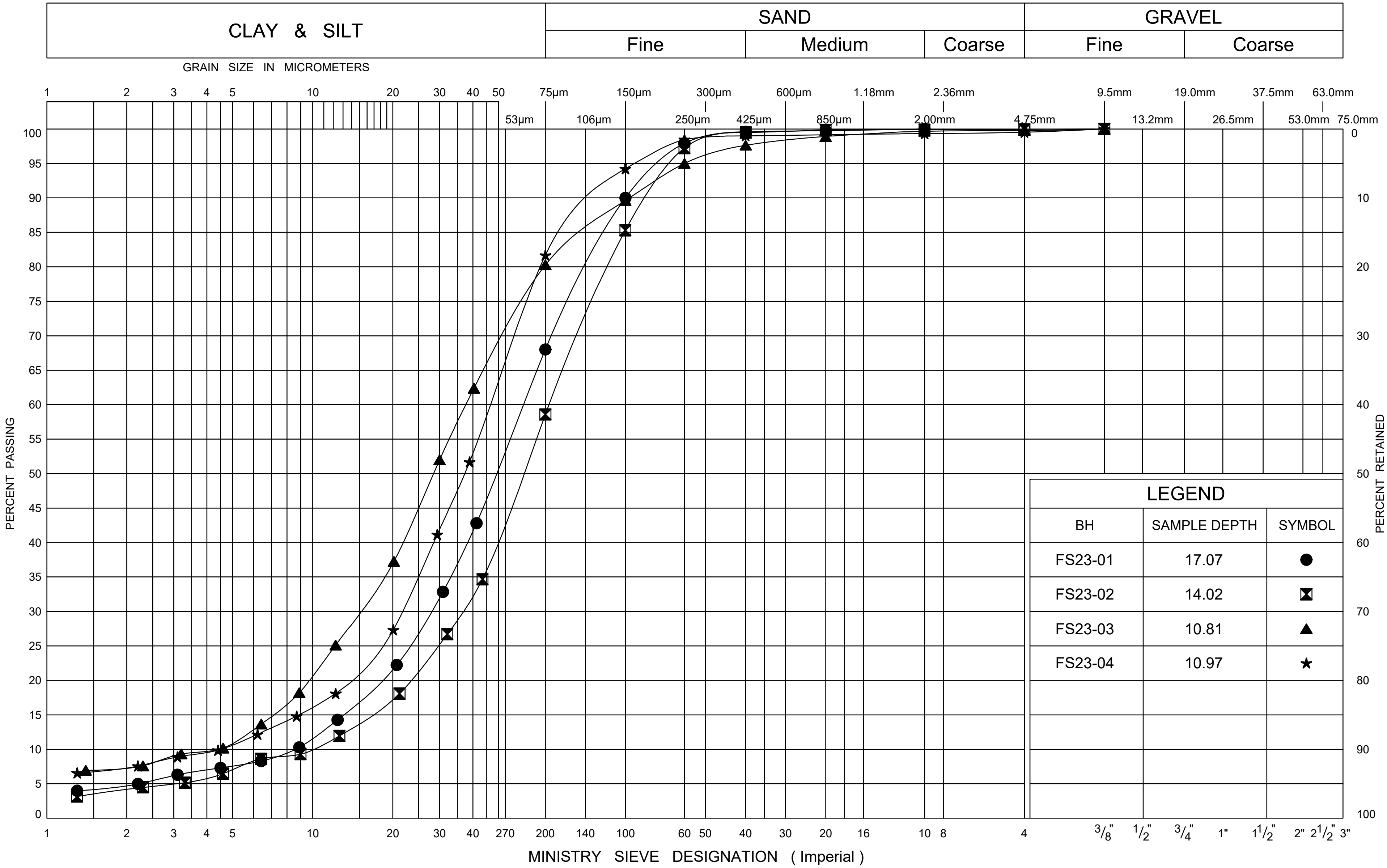
PLASTICITY CHART

Upper SILTY CLAY to CLAY

FIG No D8

W.P.

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	17.07	●
FS23-02	14.02	⊠
FS23-03	10.81	▲
FS23-04	10.97	★

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GRAIN SIZE DISTRIBUTION

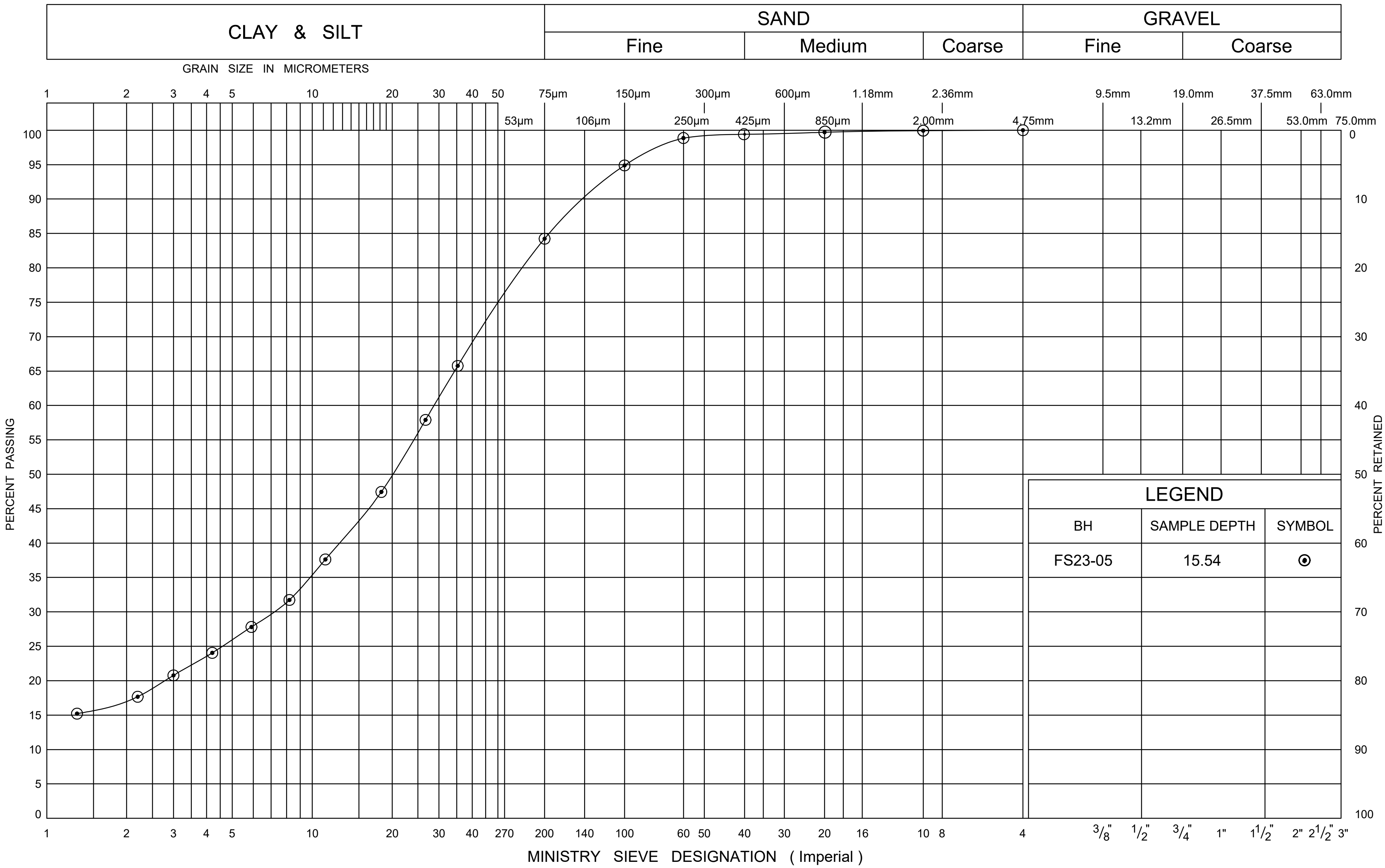
SILTY SAND to SILT

FIG No D9

W.P.

ONTARIO MOT GRAIN SIZE 3 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

78 12 M



ONTARIO MOT GRAIN SIZE 3 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

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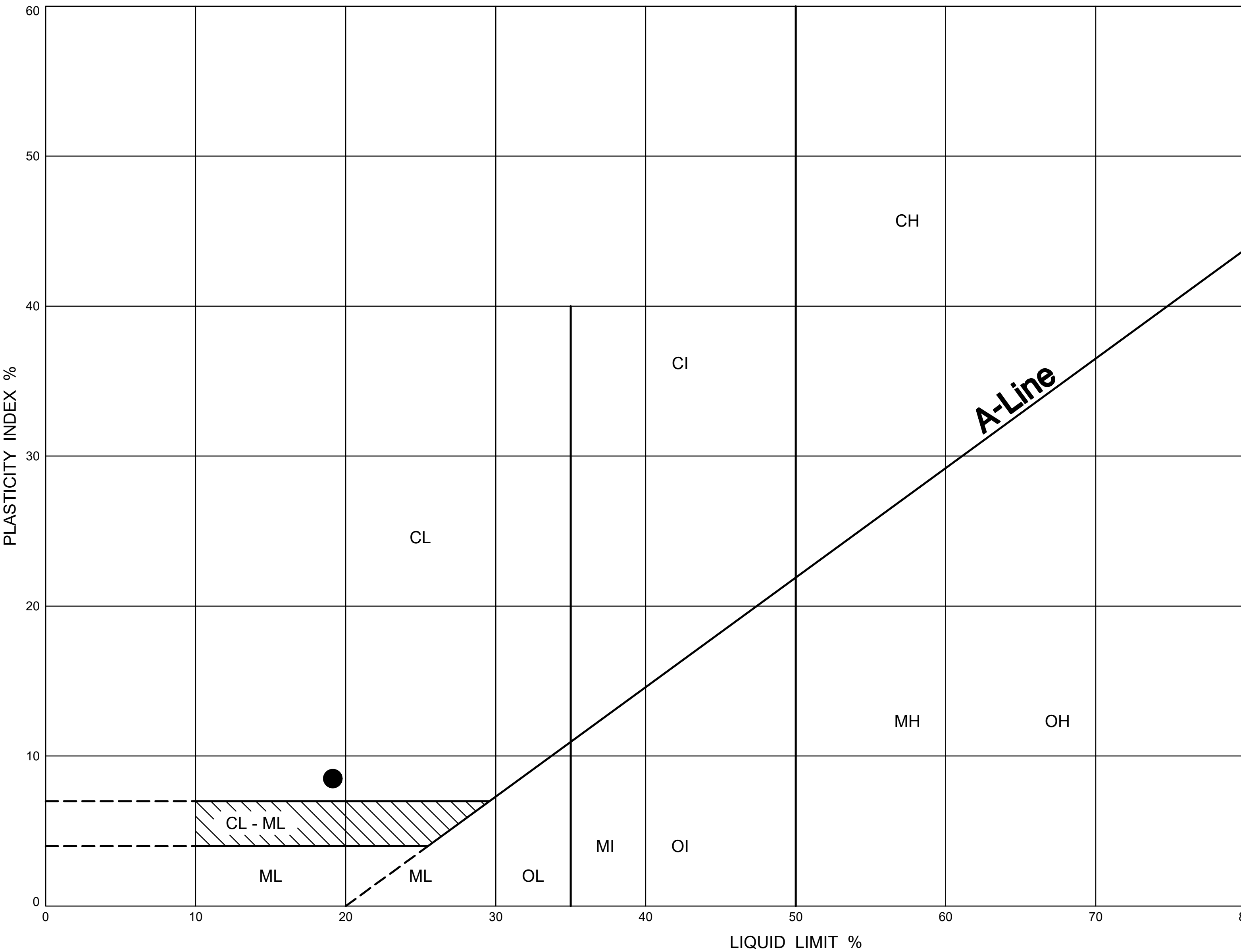
GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIG No D10

W.P.



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-05	15.54	●

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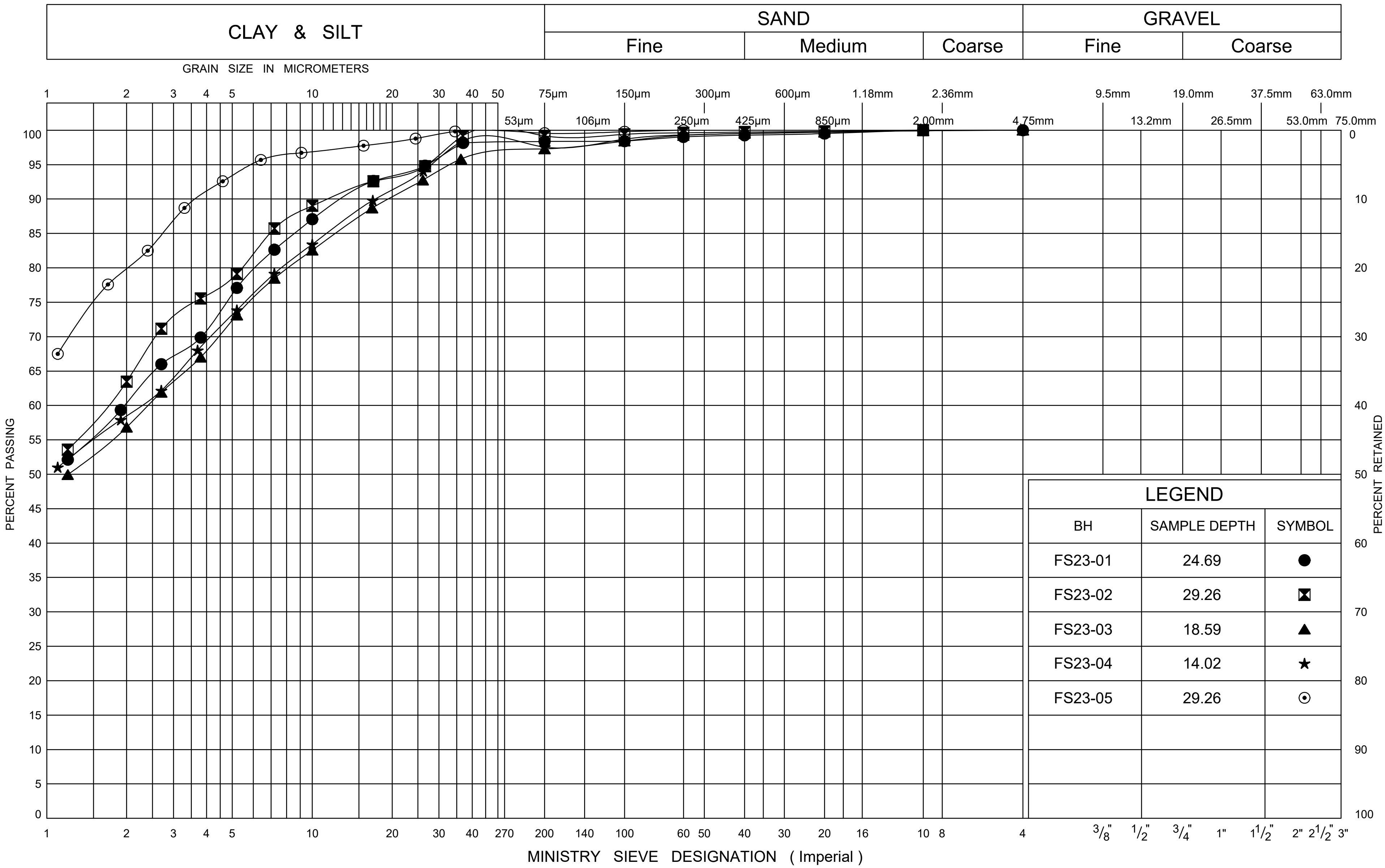
PLASTICITY CHART
SILTY CLAY

FIG No D11

W.P.

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-01	24.69	●
FS23-02	29.26	⊠
FS23-03	18.59	▲
FS23-04	14.02	★
FS23-05	29.26	⊙

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GRAIN SIZE DISTRIBUTION

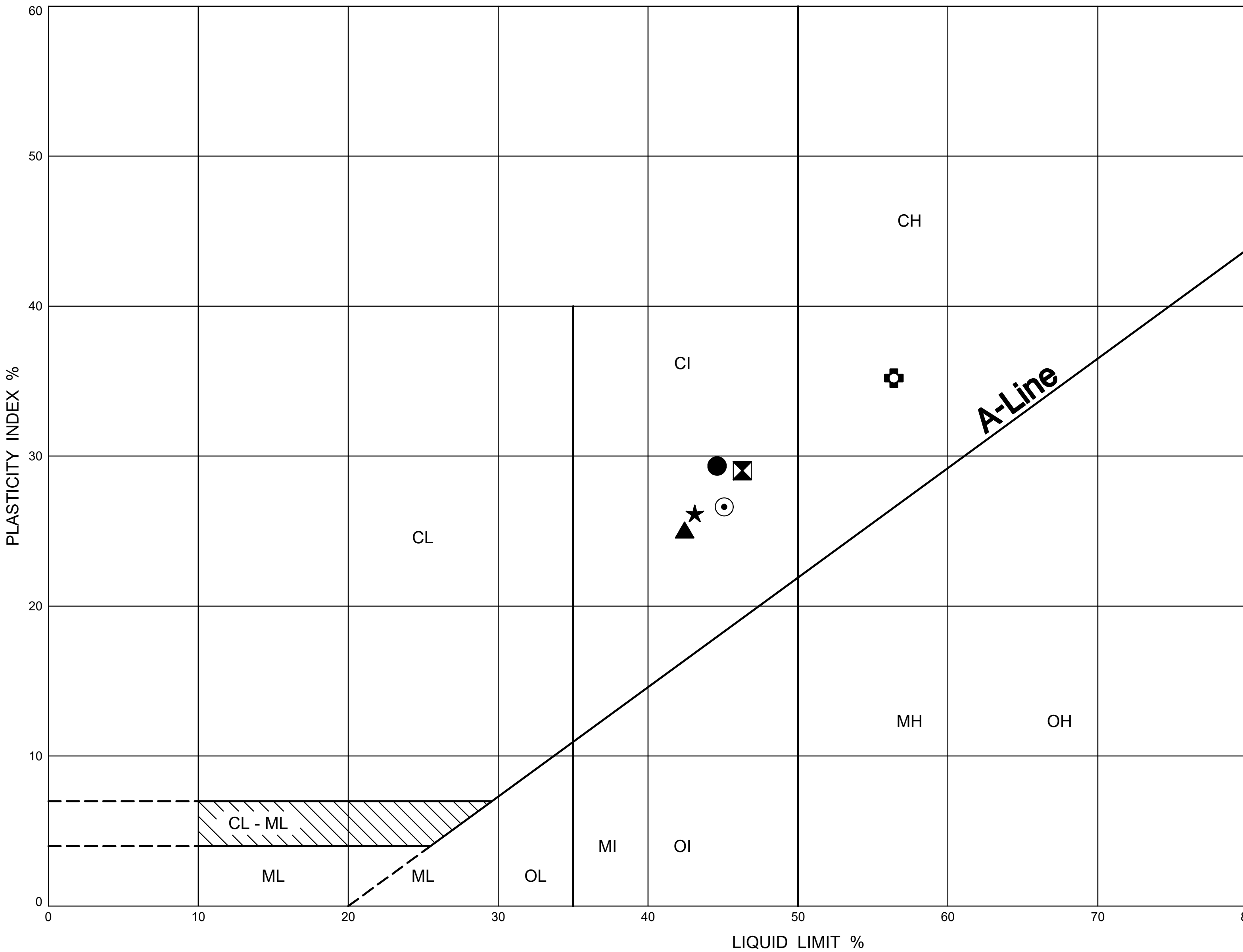
Lower SILTY CLAY to CLAY

FIG No D12

W.P.

ONTARIO MOT GRAIN SIZE 3 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
FS23-01	24.69	●
FS23-02	29.26	⧗
FS23-03	18.59	▲
FS23-04	14.02	★
FS23-05	26.21	⊙
FS23-05	29.26	✿

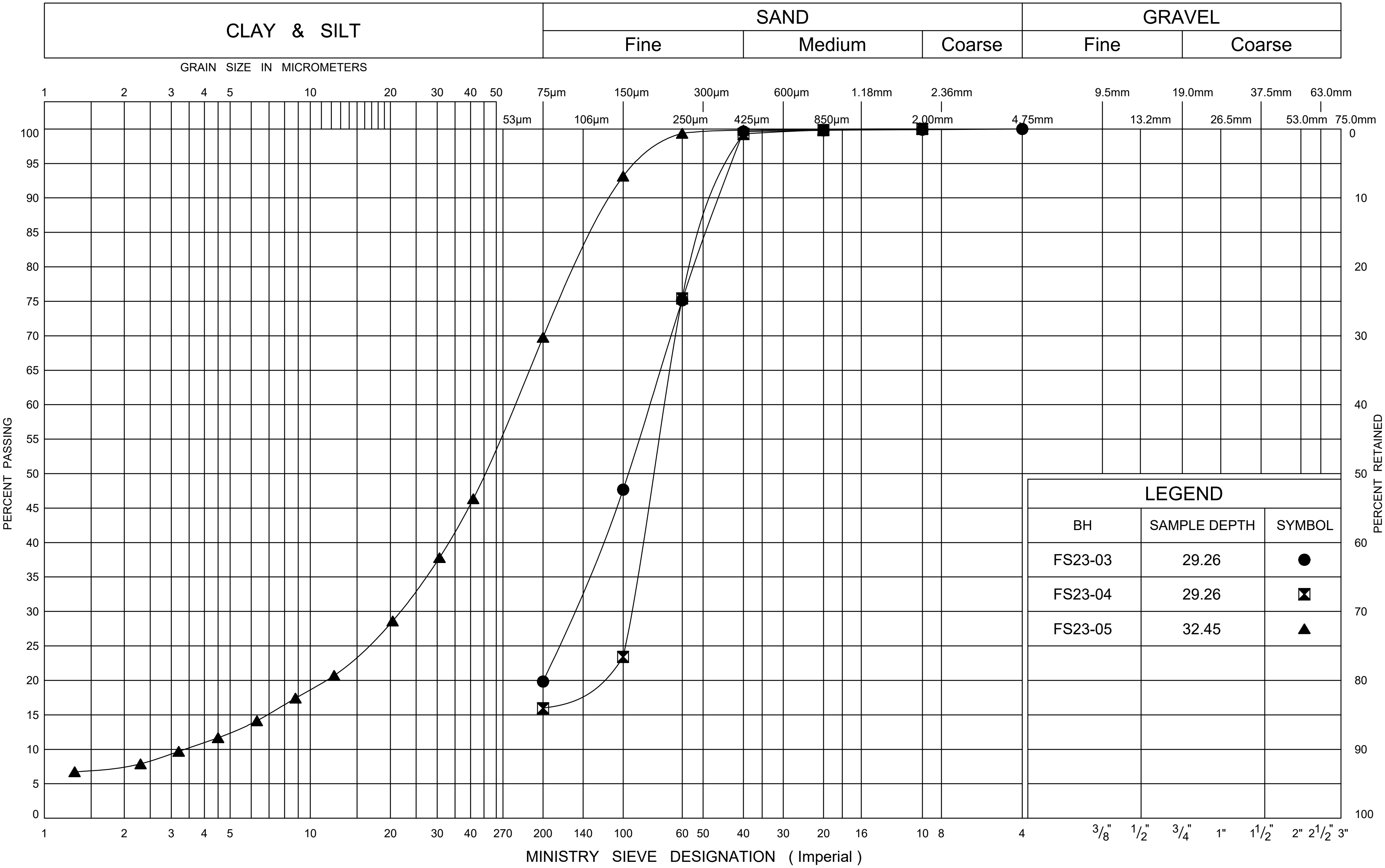
Ministry of Transportation
Ontario

PLASTICITY CHART

Lower SILTY CLAY to CLAY

FIG No D13

W.P.



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
FS23-03	29.26	●
FS23-04	29.26	⊠
FS23-05	32.45	▲

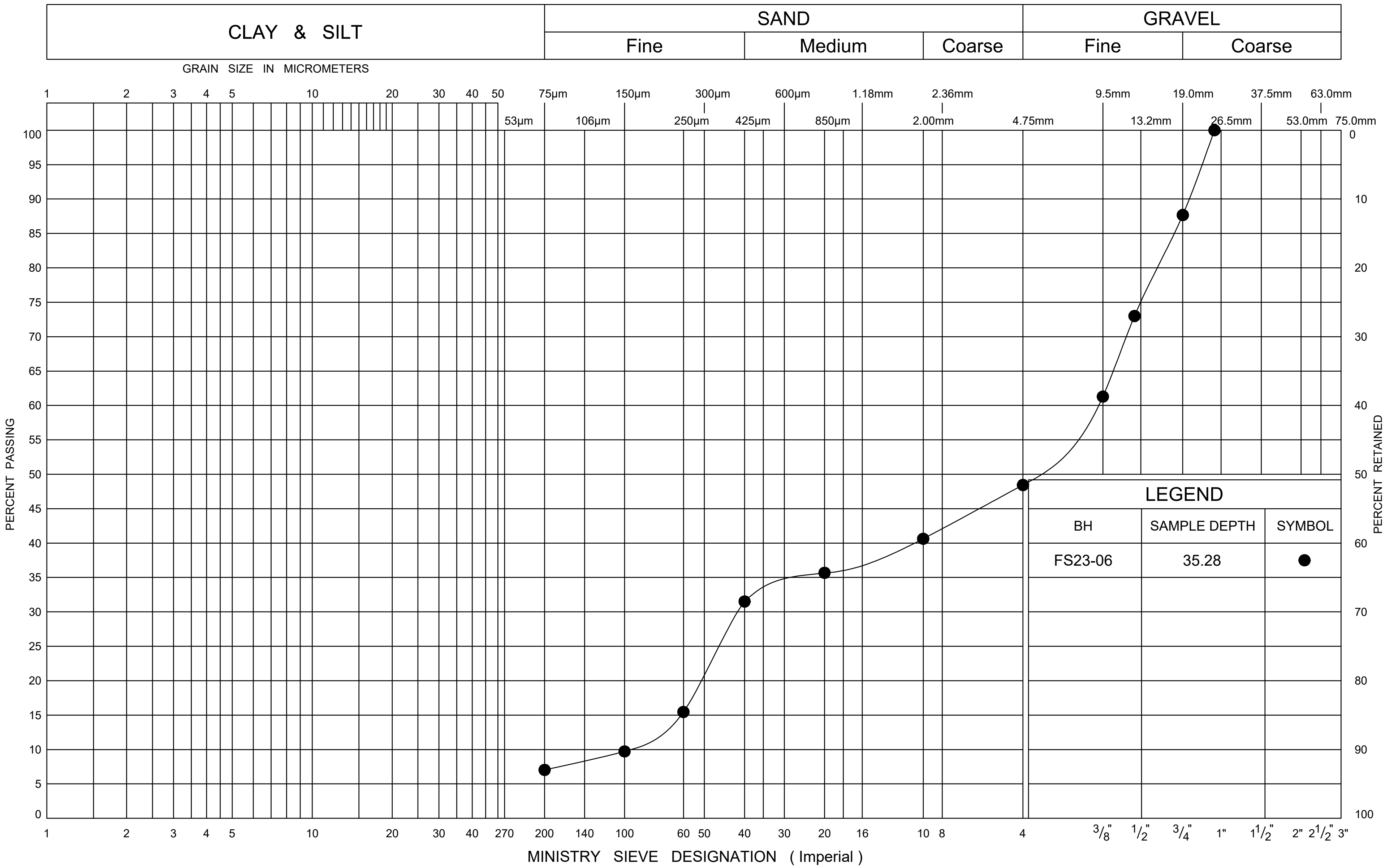
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Lower SAND to Sandy SILT

FIG No D14

W.P.



LEGEND

BH	SAMPLE DEPTH	SYMBOL
FS23-06	35.28	●

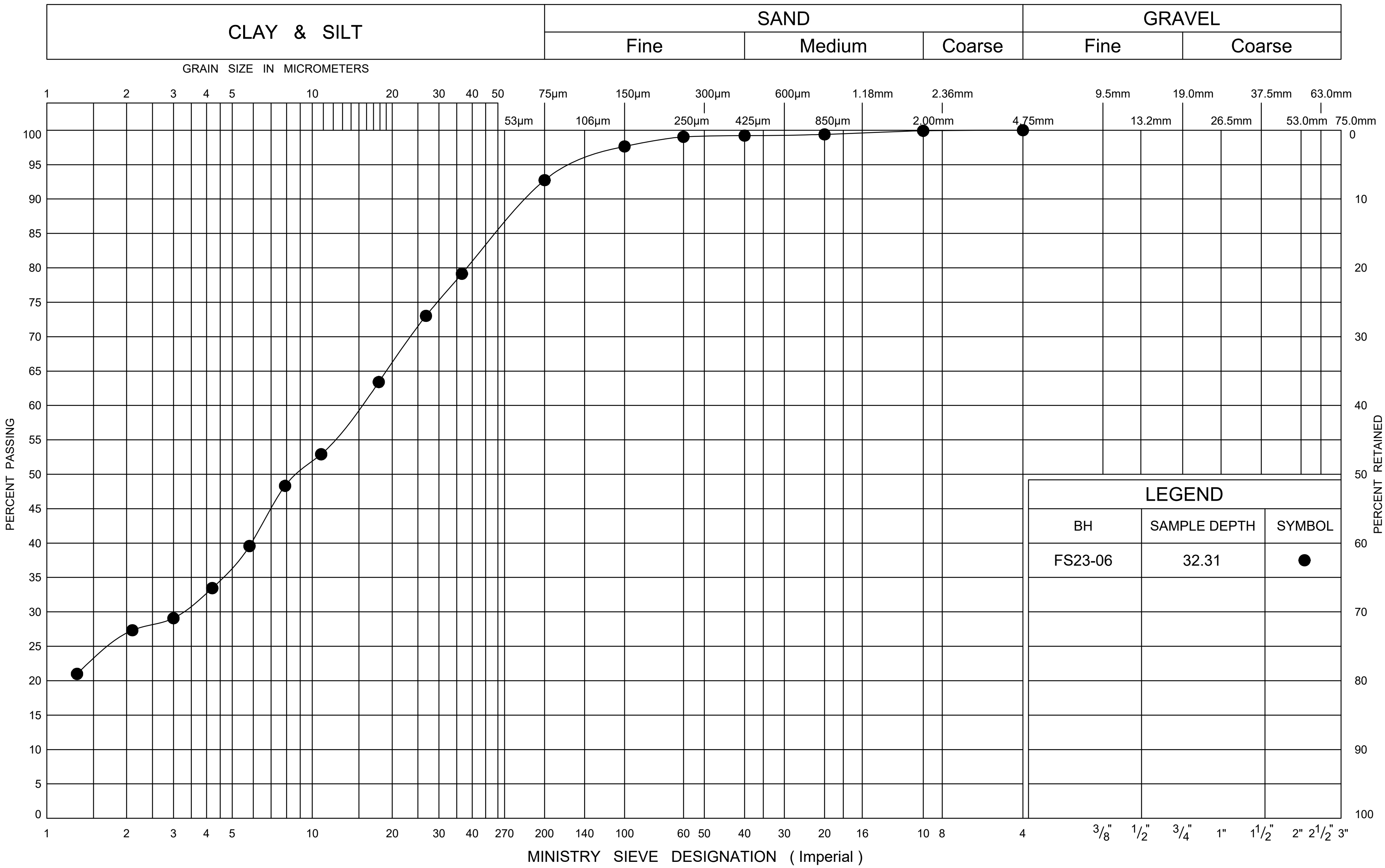
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

GRAVEL and Sand

FIG No D15

W.P.



BH	SAMPLE DEPTH	SYMBOL
FS23-06	32.31	●

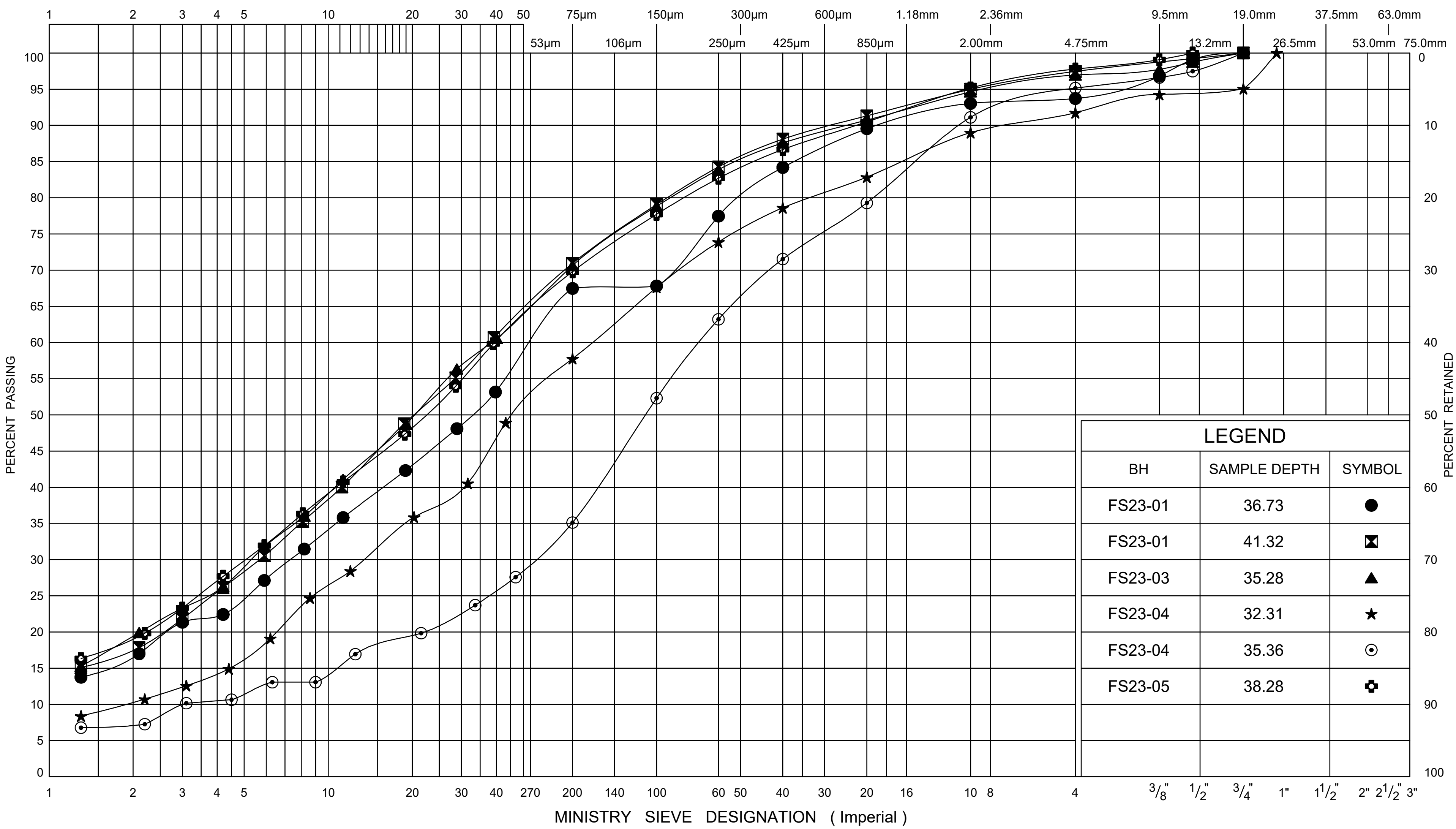
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Lower SILT TILL

FIG No D16A

W.P.



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
FS23-01	36.73	●
FS23-01	41.32	⧗
FS23-03	35.28	▲
FS23-04	32.31	★
FS23-04	35.36	⊙
FS23-05	38.28	✿

Ministry of Transportation
Ontario

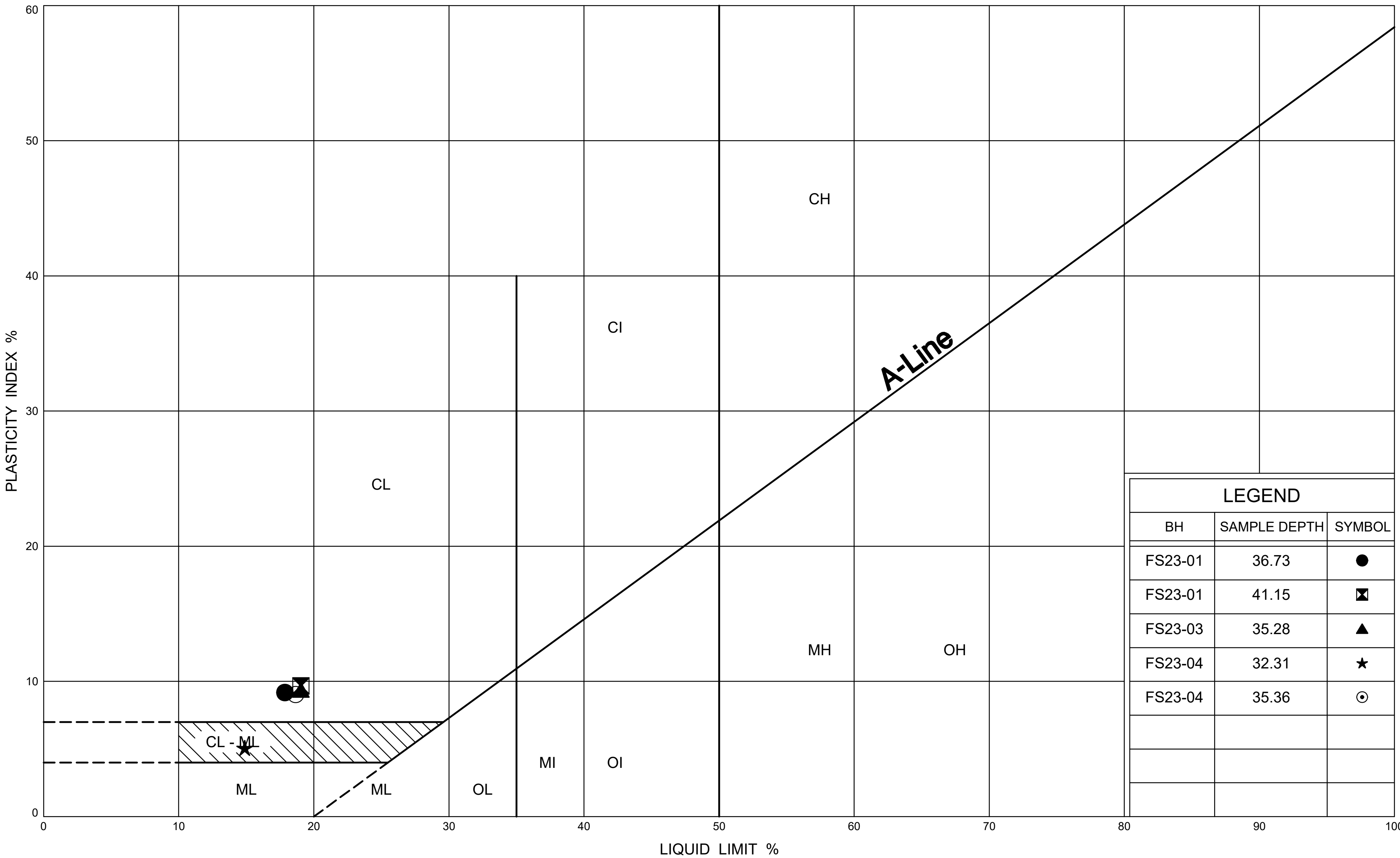
GRAIN SIZE DISTRIBUTION

Lower CLAYEY SAND to Sandy CLAYEY SILT to Sandy SILTY CLAY TILL

FIG No D16B

W.P.

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
FS23-01	36.73	●
FS23-01	41.15	⧗
FS23-03	35.28	▲
FS23-04	32.31	★
FS23-04	35.36	⊙

Ministry of Transportation
Ontario

PLASTICITY CHART

Lower CLAYEY SAND to Sandy CLAYEY SILT to Sandy SILTY CLAY TILL

FIG No D17

W.P.

ONTARIO MOT PLASTICITY CHART 2 MTO-35708.GPJ ONTARIO MOT.GDT 8/28/23

FINAL REPORT

CA40281-AUG23 R1

35708, Kitchener

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	250 Thompson Drive, Unit 3 Cambridge, ON N1T 2H9, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Alysha Kobylinski	Telephone	705-652-2143
Telephone	226-748-9593	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	akobylinski@thurber.ca	SGS Reference	CA40281-AUG23
Project	35708, Kitchener	Received	08/28/2023
Order Number		Approved	09/06/2023
Samples	Soil (3)	Report Number	CA40281-AUG23 R1
		Date Reported	09/06/2023

COMMENTS

Temperature of Sample upon Receipt: 7 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

Chain of Custody Number: 031835

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

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

SGS

FINAL REPORT

CA40281-AUG23 R1

Client: Thurber Engineering Ltd.

Project: 35708, Kitchener

Project Manager: Alysha Kobylinski

Samplers: HC

MATRIX: SOIL

			Sample Number	5	6	7
			Sample Name	FS23-02 SS7	FS23-04 SS5	FS23-05 SS12
			Sample Matrix	Soil	Soil	Soil
			Sample Date	04/05/2023	13/04/2023	12/05/2023
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**
Corrosivity Index						
Corrosivity Index	none	1		9	6	8
Soil Redox Potential	mV	no		197	283	190
Sulphide (Na2CO3)	%	0.04		< 0.04	0.04	0.04
pH	pH Units	0.05		8.38	8.43	9.23
Resistivity (calculated)	ohms.cm	-9999		1560	2330	6940
General Chemistry						
Conductivity	uS/cm	2		642	430	144
Metals and Inorganics						
Moisture Content	%	0.1		13.6	18.2	16.1
Sulphate	µg/g	0.4		17	350	260
Other (ORP)						
Chloride	µg/g	0.4		23	98	11

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	DIO0758-AUG23	µg/g	0.4	<0.4	5	35	102	80	120	104	75	125
Sulphate	DIO0758-AUG23	µg/g	0.4	<0.4	1	35	97	80	120	92	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 (Na2CO3)	ECS0011-SEP23	%	0.04	< 0.04	ND	20	115	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	EWL0580-AUG23	uS/cm	2	< 2	1	20	99	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	EWL0580-AUG23	pH Units	0.05	NA	1		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

Results relate only to the sample tested.
Data reported represent the sample as submitted to SGS. 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 and Excess Soil Quality" 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.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS

Request for Laboratory Services and CHAIN OF CUSTODY

No: 031835

Industries & Environment - 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

Page ____ of ____

Laboratory Information Section - Lab use only

Received By: ED
Received By (signature):
Received Date: 8/28/23 (mm/dd/yy)
Received Time: 12:20 (hr : min)
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☐ No ☐
Cooling Agent Present: Yes ☑ No ☐ Type: ICE
Temperature Upon Receipt (°C) 7.8, 3
LAB LIMS #: CA-40281-AUG23 SR.

REPORT INFORMATION

Company: Thurber Engineering Ltd.
Contact: Alysha Kobylinski
Address: Unit 3, 250 Thompson Drive
Cambridge, ON
Phone: 226-748-9593
Fax:
Email: akobylinski@thurber.ca

INVOICE INFORMATION

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

Quotation #: Thurber
P.O. #: 35708
Project #: 35708
Site Location/ID: 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:

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

REGULATIONS

☐ O.Reg 153/04 ☐ O.Reg 406/19
☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium/Fine
☐ Table ____ Appx. ____
Soil Volume ☐ <350m3 ☐ >350m3

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA
☐ ODWS Not Reportable *See note

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

M & I: Field Filtered (Y/N); Metals & Inorganics (incl CrVI, CN,Hg pH,(B(HWS),EC,SAR-soil) (Cl, Na-water)); Full Metals Suite (ICP metals plus B(HWS-soil only) Hg, CrVI); ICP Metals only (Sb,As,Ba,Be,B,Cd, Cr,Co,Cu,Pb,Mo,Ni,Se,Ag,Tl,U,V,Zn)
SVOC: PAHs only; SVOCs (all incl PAHs, ABNs, CPs)
PCB: PCBs Total ☐ Aroclor ☐
PHC: F1-F4 + BTEX; F1-F4 only (no BTEX)
VOC: VOCs (all incl BTEX); BTEX only
Pest: Pesticides (Organochlorine or specify other)
Other (please specify): Corrosivity Pkg; + Sulphide; Sewer Use: Specify pkg:; Water Characterization Pkg General ☐ Extended ☐
SPLP Specify tests: ☐ Metals ☐ VOC ☐ 1,4-Dioxane ☐ OCP ☐ ABN
TCLP Specify tests: ☐ M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit.

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Corrosivity Pkg	+ Sulphide	COMMENTS:
1	FS23-02 SS7	2023/05/04	PM	2	SOIL	X	X	2 jars
2	FS23-04 SS5	2023/04/13	PM	2	SOIL	X	X	2 jars
3	FS23-05 SS12	2023/05/12	PM	2	SOIL	X	X	2 jars.

Observations/Comments/Special Instructions

Sampled By (NAME): HC Signature: Date: / / (mm/dd/yy) Pink Copy - Client

Relinquished by (NAME): Alysha Kobylinski Signature: Alysha Kobylinski Date: 23/08/28 (mm/dd/yy) Yellow & White Copy - SGS

Revision #: 1.6
Date of Issue: 02 May 2022

THURBER ENGINEERING LTD.

APPENDIX E

Foundation Comparison Table

Appendix E
Comparison of Foundation Alternatives

Abutments		
Spread Footings	**Drilled Shafts (Caissons)**	**Driven H-Piles**
Advantages: - Generally less costly than deep foundation elements.	***Advantages:*** - High geotechnical resistance available for caissons founded in lower till. - High lateral resistance available for caissons installed through hard or very dense soils. - Construction of caissons could continue in freezing weather. - Excavation and dewatering requirements are minimized. - Minimal disruption to traffic, should a staged traffic approach be required.	***Advantages:*** - Higher bearing capacity than spread footings. - Minimal excavation and dewatering required. - Pile driving could continue in freezing weather. - Allows integral abutment design.
Disadvantages: - Deep excavation (7-9 m below Frederick Street grade) required to place abutment footings on competent bearing stratum - Space constraints in the depressed corridor preclude use of perched abutments on engineered fill pads. - Large excavation footprint and encroachment on adjacent properties and proximity to nearby utilities. - Construction dewatering will be required for excavation in the silty sand to sand below groundwater.	***Disadvantages:*** - Higher unit cost compared to other foundation options such as footings or driven piles. - Temporary liners and synthetic slurry will be required to install caissons through cohesionless soils below the water table. - Potential difficulty in cleaning and inspecting caisson base.	***Disadvantages:*** - Higher unit costs than footings. - Potential for pile deflection or refusal on cobbles, boulders and rock fragments within till. - Potential for varying pile lengths within a foundation unit. - Noise and vibrations resulting from piling activities may impact adjacent structures and utilities, and nearby residents - Retaining wall may be required below abutment stem due to limited space in the corridor to accommodate header slope.
NOT RECOMMENDED	RECOMMENDED	FEASIBLE

Pier		
Spread Footings	**Drilled Shafts (Caissons)**	**Driven H-Piles**
Advantages: - Generally less costly than deep foundation elements.	***Advantages:*** - High geotechnical resistance available for caissons extended to lower till. - Construction of caissons could continue in freezing weather. - Excavation and dewatering requirements are minimized. - Minimal disruption to traffic, particularly at the piers since pile caps are not required.	***Advantages:*** - Higher bearing capacity than spread footings. - Minimal excavation and dewatering required. - Pile driving could continue in freezing weather.
Disadvantages: - Larger footprint compared to deep foundations. - Construction dewatering may be required. - Will require roadway protection for footing construction in the highway median.	***Disadvantages:*** - Higher unit cost compared to other foundation options such as footings or driven piles. - Temporary liners and synthetic slurry will be required to install caissons under the water table. - Potential difficulty in cleaning and inspecting caisson base. - Artesian conditions were encountered at centre pier in the lower till deposit during drilling. Caisson installation methodology and procedure must adequately address artesian conditions during installation and minimize its impact on foundation performance in the long term.	***Disadvantages:*** - Higher unit costs than footings. - A larger quantity of piles will be required to support pier loads compared to caissons. - Potential for pile deflection or refusal on cobbles, boulders and rock fragments within till. - Potential for varying pile lengths within a foundation unit. - Will require roadway protection for pile cap construction at pier. - Noise and vibrations resulting from piling activities may impact adjacent structures and utilities, and nearby residents
RECOMMENDED	FEASIBLE	FEASIBLE

THURBER ENGINEERING LTD.

APPENDIX F

List of OPSS Documents and NSSPs

List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS PROV 539 (Temporary Protection Systems)
- OPSS PROV 804 (Construction Specification for Temporary Erosion Control)
- OPSS PROV 902 (Construction Specification for Excavating and Backfilling – Structures)
- OPSS PROV 903 (Construction Specification for Deep Foundations)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- Special Provision No. 109F57 to OPSS 903 (Construction for Deep Foundations)
- OPSD 3090.101 (Foundation Frost Depths for Southern Ontario)
- OPSD 3101.150 (Walls Abutment, Backfill Minimum Granular Requirements)

Suggested Text for NSSP on: "Pile Driving"

Hard driving conditions through the hard/very dense soils should be expected. Cobbles and boulders should also be anticipated within the silty clay till deposit which may affect pile installation. In order to minimize pile damage while driving the piles hard/dense zones, cobbles, and boulders, to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point).

If the piles meet refusal at a depth less than the anticipated depth, the Contractor must terminate driving before the pile is damaged due to over-driving. The Contractor must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.

Suggested Text for NSSP on: "Installation of Caissons"

All caissons shall be installed in accordance with OPSS.PROV 903 and SP 109F57 (April 2018). The caisson installation equipment should be able to dislodge and remove any obstructions such as cobbles and boulders and penetrate the silty clay till.

The caissons will extend below the groundwater table. Soil sloughing and water seepage will occur in unsupported holes primarily within the sand fill, sand, and silty sand/sandy silt layers. Therefore, construction of caissons will require the use of temporary steel liners with synthetic slurry to balance hydrostatic head to support the caisson sidewalls and to provide seepage cut-off where required.

The Contractor shall use appropriate means such as a cleanout bucket, air lift, hydraulic pump, or other devices approved by Engineer to clean the bottom of the excavation of all shafts. A clean-out bucket alone is not sufficient for final clean-out. The cleaning methods, inspection method, and any additional measures required to satisfy the acceptance criteria must be selected by the Contractor to ensure direct contact between the concrete and undisturbed soil. It is the Contractor's responsibility to apply means necessary (such as air lift pump or hydraulic pump, etc.) to clean the socket base and sidewalls.

The bottom of the excavated shaft shall be inspected using a Shaft Inspection Device (SID), Shaft Quantitative Inspection Device (SQUID), down-hole camera, and/or an approved alternate to verify socket cleanliness and thickness of base sediment at the time of concreting. A minimum of 50 percent of the base of each shaft shall have less than 15 mm of sediment at the time of concrete placement. The maximum depth of sediment or any debris at any place on the base of the shaft shall not exceed to 40 mm at the time of concrete placement.

A shaft inspection field report shall be submitted to the Engineer for acceptance prior to proceeding with construction. Concrete placement shall commence no later than 6 hours after acceptance of the excavation. Any accumulated water within the hole may have to be pumped out prior to placing concrete. If accumulated water in the caisson hole cannot be removed, tremie techniques shall be used to place concrete inside the caisson hole.

Suggested Text for NSSP on: "Vibration Monitoring"

- Vibrations produced during pile driving and existing structure demolition may disrupt residents and damage nearby structures and utilities. If driven piles are chosen as the foundation option, vibration monitoring is recommended during pile driving to limit potential impacts on existing facilities and residents, and conditions carefully monitored for signs of disturbance. A preconstruction condition survey of existing structures and utilities should be carried out prior to commencement of pile installation.
- It is understood that the City of Kitchener does not provide limits on vibration levels. Therefore, it is recommended that the vibration levels stipulated in the City of Toronto By-law 514-2008 be adopted for this project. The limits are provided in the table below.

Vibration Frequency (Hz)	Vibration Peak Particle Velocity (mm/s)
Less than 4	8
4 to 10	15
More than 10	25

Suggested Text for NSSP on: "Groundwater Control"

Water seepage into the temporary excavations from the fill and native soils, and from surface runoff and precipitation, should be expected. 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 systems must be installed and made operational prior to excavating below the groundwater level and 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.

Dewatering of all excavations should be carried out in accordance with OPSS. PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), NSP FOUN0003 and OPSS. PROV 902 and SP 109S12. It is recommended that a Professional Engineer with greater than 5 years of experience in designing dewatering systems be retained by the Contractor.

Suggested Text for NSSP on: Decommissioning of Standpipe Piezometers

Three standpipe piezometers in Boreholes FS23-01, FS23-03, and SS23-01 shall be decommissioned by the Contractor in accordance with O.Reg. 903 (as amended).