



REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT

Highway 401/Elgin Road Underpass Replacement, Site 19-304

GWP 3153-16-00

Contract Number 2017-3017

Ministry of Transportation, Ontario - West Region

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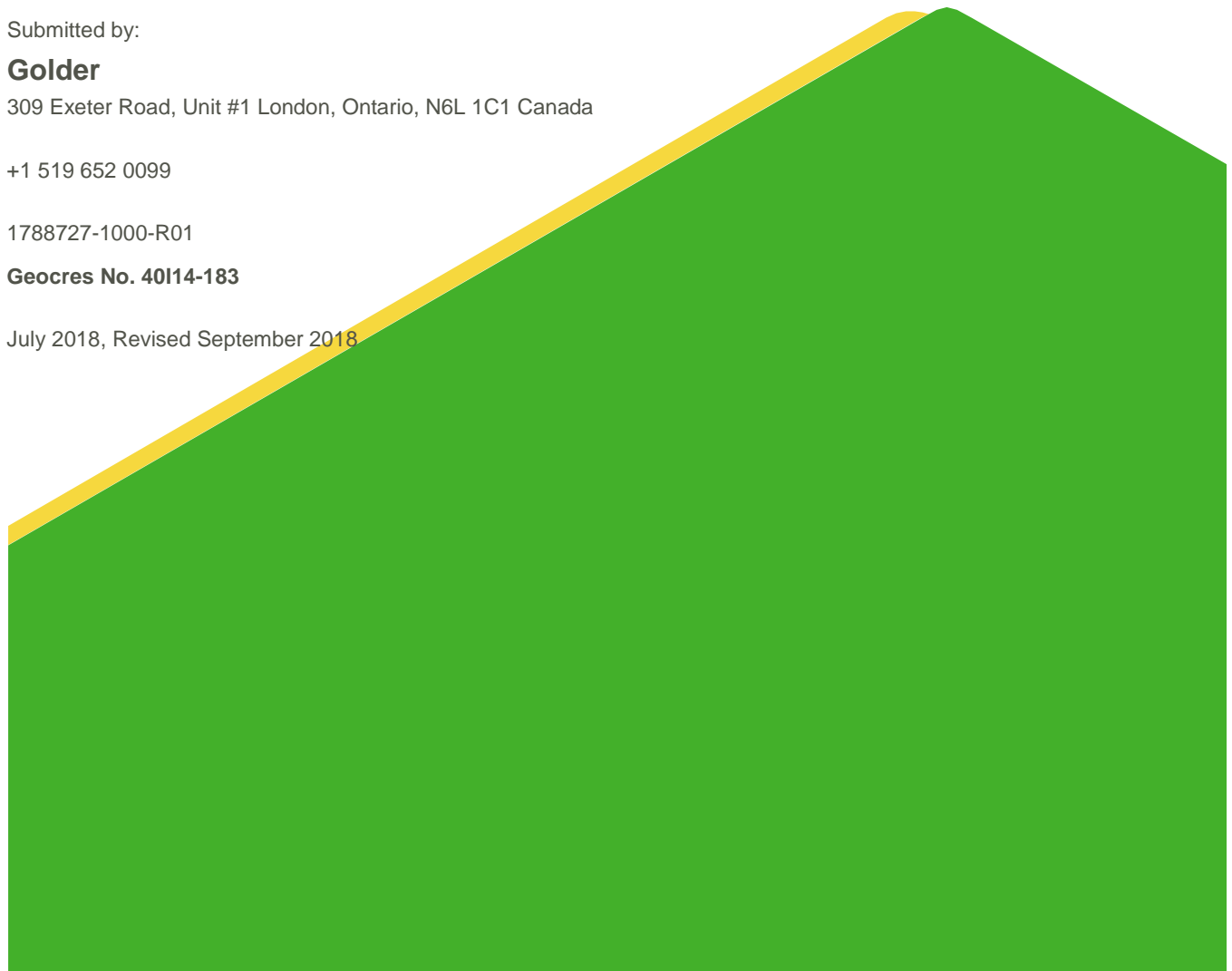
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APPENDIX A

Record of Boreholes and Laboratory Data – Golder, GEOCRES No. 40114-160

APPENDIX B

Record of Borehole and Laboratory Data - Peto MacCallum Ltd., GEOCRES 40114-173

PART A

FOUNDATION INVESTIGATION REPORT
Highway 401 / Elgin Road Underpass
Replacement – Site No.19-304
Ministry of Transportation, Ontario – West Region
GWP 3153-16-00, Contract No. 2017-3017

1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of Coco Paving (Coco) to carry out detailed foundation investigations as part of the Design-Build (DB) project for the Highway 401/Elgin Road Underpass Replacement, Interchange Improvements and Highway 401 pavement rehabilitation and reconstruction (GWP 3153-16-00, Contract No. 2017-3017). This report addresses the replacement of the Highway 401/Elgin County Road Underpass (Site 19-304).

The terms of reference for the scope of work are outlined in the MTO's Request for Proposal and in Golder Associates' proposal dated January 28, 2018. The work was carried out in accordance with our Quality Control Plan for Foundations Engineering dated November 2012.

2.0 SITE DESCRIPTION

2.1 General

The Highway 401/Elgin Road Underpass is located near the Town of Dorchester in the Municipality of Thames Centre, Ontario. The location of the site is shown on the Key Plan, Figure 1.

This section of Highway 401 is currently a six lane, divided highway. The existing Elgin Road pavement surface is at about elevation 270.5 metres at the bridge location. The existing underpass was constructed in 1957 and consists of a single span, concrete, rigid frame structure with "tee" type girders. The area adjacent to the site consists of relatively flat-lying, undeveloped lands. Dillon has indicated that the preferred alternative consists of replacing the existing structure and maintaining the current alignment. The replacement bridge will be a two-span structure with approximately 42 metre long spans.

For the purposes of this report, Highway 401 and Elgin Road are assumed to be oriented in east-west and north-south directions, respectively.

2.2 Site Geology

This project lies within the physiographic region of southern Ontario known as the Mount Elgin ridges. The physiographic mapping indicates that the Elgin Road Underpass site is located in a former glacial spillway.¹ The available geological mapping indicates that the surficial soils consist of glacial valley trains of gravel and gravelly sand.²

The bedrock in the area of the site is mapped as the Anderdon Member of the Lucas Formation, described as brown and tan, microcrystalline and sublithographic limestone, which belongs to the Detroit River Group of Middle

¹ Chapman, L.J. and Putnam, D.F., 1984: The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey, Special Volume 2.

² Dreimanis, A., 1963: Pleistocene Geology of the St. Thomas Area (East Half), Southern Ontario. Ontario Department of Mines, Preliminary Geological Map P.606, scale 1:50,000.

Devonian Age.³ The bedrock surface, based on the available mapping, is estimated to be at about elevation 232 metres, or about 30 metres below ground surface at the site.⁴

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation (Golder Associates Ltd, 2016)

Golder Associates completed the preliminary foundation investigation and design for the structure replacement and the results were reported in:

- Golder Associates Report entitled “Preliminary Foundation Investigation and Design Report, Middlesex Road 73 (Elgin Road) Underpass, Site Number 19-304, Highway 401, Structural Replacements, GWP 3053-11-00, Assignment #2 (3011-E-0047), Ministry of Transportation, Ontario – West Region”, (Report Number 12-1132-0076-2001-R03) GEOCREs No. 40I14-160, dated July 2016.

The Records of Boreholes (405 to 408) and the related laboratory test data from that report are attached in Appendix A.

3.2 Previous Investigation (Peto MacCallum Ltd, 2017)

Peto MacCallum Ltd. (Peto) carried out a subsequent foundation investigation at this site, the results of which were provided in:

- “Foundation Investigation Report for Highway 401 and Elgin Road Underpass Replacement, Site No. 19-304, Highway 401, London, Ontario, Assignment No. 3016-E-0009, GWP No. 3153-16-00”, GEOCREs No. 40I14-173, dated August 28, 2017.

The Record of Boreholes (N-1 to N-3, C-1, C-2 and S-1 to S-3) and the related laboratory test data from that report are attached in Appendix B.

3.3 Investigation Borehole Summary

The borehole locations and ground surface elevations at the borehole locations are shown on the Record of Borehole sheets in Appendices A and B are shown together on Drawing 1. The table below summarizes the coordinates, ground surface elevations and depths of the previous boreholes.

³ Sanford, B.V., 1969: Geology, Toronto-Windsor Area, Ontario. Geological Survey of Canada, Map 1263A, scale 1:250,000.

⁴ Dreimanis, A., 1968: Ontario Department of Mines, Bedrock Topography Series, St. Thomas Sheet, Southern Ontario. Preliminary Map No.482, scale 1:50,000.

Borehole	Investigation	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing	Easting		
405	Golder 2016	4 759 510	425 799	270.1	24.0
406		4 759 432	425 805	270.4	19.5
407		4 759 447	425 802	270.5	23.8
408		4 759 525	425 796	270.0	19.8
N-1	Peto 2017	4 759 556	425 777	269.8	15.8
N-2		4 759 505	425 759	262.6	17.4
N-3		4 759 521	425 824	262.3	17.4
C-1		4 759 478	425 788	263.2	18.5
C-2		4 759 485	425 816	263.2	18.9
S-1		4 759 408	425 820	270.5	18.4
S-2		4 759 436	425 772	262.3	17.4
S-3		4 759 450	425 836	262.1	15.8

4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are provided on the Record of Borehole sheets in Appendices A and B. The results of the in situ field tests (i.e., SPT N-values) as presented on the Record of Borehole sheets and discussed below are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

The locations and elevations of the boreholes from the previous investigations, together with the interpreted stratigraphic profile and sections, are shown on Drawings 1 and 2. Detailed descriptions of the subsurface conditions encountered in the boreholes are provided on the Record of Borehole sheets and are summarized in the following sections.

Groundwater levels/conditions encountered in the boreholes during drilling and shortly after drilling may not be representative of static groundwater levels since groundwater levels in the boreholes may not have stabilized.

Groundwater levels in the area are subject to seasonal fluctuations and fluctuations after precipitation events and snowmelt.

In general, the subsurface conditions encountered in the boreholes drilled at the site generally consisted of the existing pavement structure and granular embankment fill which was underlain by silty sand to sand, sand and gravel and clayey silt till.

4.1.1 Pavement Structure

Boreholes 405 to 408 were advanced through the paved shoulders on Elgin Road and encountered between 140 and 200 millimetres of asphaltic concrete at the ground surface underlain by 0.1 to 1.0 metres of crushed granular base and/or subbase. Boreholes C-1 and C-2 were advanced in the Highway 401 median shoulder and encountered 200 millimetres of asphaltic concrete and 0.6 metres of gravelly sand base or subbase. The standard penetration testing carried out in the granular base material indicated N values of 39 to 53 blows per 0.3 metres. A buried pavement structure was encountered beneath embankment fill materials in borehole 405 at about elevation 262.4 metres, or about 7.8 metres below the ground surface. The buried pavement structure consisted of 80 millimetres of asphaltic concrete over 1.2 metres of granular material. The buried granular material had an N value of 41 blows per 0.3 metres.

Boreholes N-1 and S-1 were advanced through the shoulder on Elgin Road and encountered about 1.4 metres and 1.5 metres of gravelly sand base or subbase that had N values ranging from 17 blows to 57 blows per 0.3 metres.

4.1.2 Topsoil and Fill

Topsoil was encountered in boreholes N-2, N-3, S-2 and S-3 at the ground surface and was about 100 millimetres in thickness.

About 3.8 to 9.2 metres of embankment fill materials was encountered in boreholes 406 to 408, N-1 and S-1 and extended to between about elevation 260.5 and 265.3 metres. Due to the organics noted on Record of Borehole N-1 at about 260.7 metres, the fill material is interpreted to be about 7.6 metres thick at this location. The embankment fills were typically granular in nature and consisted of layers of sandy silt, silty sand, sand and sand and gravel. Layers of firm to hard clayey silt fill, approximately 0.3 metres thick, were encountered within the embankment fill in boreholes 406 and 407. Cobbles were encountered in the fill materials in boreholes 405, 406 and 408.

The very loose to very dense granular fill materials had SPT N-values ranging from 2 blows to greater than 100 blows per 0.3 metres. Samples of the embankment fills had water contents ranging from 4 to 27 per cent.

Silty sand fill was also encountered beneath the pavement structure in boreholes C-1 and C-2. The silty sand fill was about 1.4 metres thick and extended to about elevation 261.0 metres. The fill had N values of 37 to 60 blows per 0.3 metres and water contents of about 5 to 11 per cent.

Layers of buried topsoil were encountered beneath the buried pavement structure in borehole 405 and beneath the fill materials in borehole 408. The topsoil layers were 0.6 and 0.5 metres thick in boreholes 405 and 408, respectively, and were encountered at elevations 261.1 and 260.5 metres. In borehole 405, the topsoil had an N value of 19 blows per 0.3 metres with a water content of 13 per cent. A layer of buried topsoil was interpreted

to be present beneath the embankment fill in borehole N-1. The buried topsoil at this location was encountered at about elevation 260.7 metres and was about 0.8 metres thick with an N value of 4 blows per 0.3 metres.

Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.1.3 Silt

A 0.4 metre thick layer of compact silt was encountered beneath the fill in borehole 406 at elevation 261.0 metres. An N value of 13 blows per 0.3 metres was recorded for a partial sample of the silt. The silt had a water content of 22 per cent.

4.1.4 Sand to Silty Sand

Sand to silty sand was encountered beneath the embankment fill and/or topsoil/organics in all of the boreholes. The sand to silty sand ranged from 9.8 to 13.5 metres in thickness where fully penetrated. Boreholes 406, 408, N-1 and S-1 were terminated in the sand to silty sand after exploring it for about 5.9 to 10.6 metres. The sand to silty sand was encountered between about elevation 257.8 and 265.3 metres. A 0.5 metre thick layer of dense sandy silt was encountered beneath the upper layer of sand in borehole 406 at about elevation 257.7 metres. The sandy silt had an N value of 46 blows per 0.3 metres.

The sand to silty sand had N values of 1 to 100 blows per 0.3 metres with water contents ranging from about 12 to 24 per cent.

Cobbles and boulders should be expected in the sand.

4.1.5 Sand and Gravel to Silty Sand and Gravel

Compact to very dense sand and gravel (identified on Peto's Records of Boreholes as gravelly sand) to silty sand and gravel was encountered in all of the boreholes except N-1, S-1 and S-3. The sand and gravel was encountered between elevations 249.7 and 258.5 metres and were 0.2 to 4.8 metres thick where fully penetrated. Boreholes 405 and 407 were terminated in sand and gravel after exploring it for about 3.9 metres. The lower layer of sand and gravel in borehole 405 was noted to be silty and contained cobbles.

The sand and gravel had N values of 24 to greater than 100 blows per 0.3 metres with water contents of 5 to 21 per cent. Cobbles and boulders should be expected in the sand and gravel.

4.1.6 Glacial Till

Clayey silt till was encountered in boreholes N-2, N-3, S-2, C-1 and C-2 between elevation 247.1 and 248.8 metres. All of these boreholes were terminated in the clayey silt till after exploring it for 2.2 to 3.7 metres.

The clayey silt till N values ranging from 50 blows for 8 centimetres of penetration to 114 blows per 23 centimetres of penetration with water contents of about 5 to 15 per cent. Atterberg limits determinations, the results of which are provided in Appendix B, indicate classifications of CL-ML and CI for the clayey silt till.

A layer of silty sand till was encountered at about elevation 248.5 metres in borehole S-3. The silty sand till was explored for about 4.8 metres prior to terminating the borehole. The silty sand till had an N value of 60 blows for 100 millimetres of penetration.

Cobbles and boulders should be expected in the glacial till.

4.2 Groundwater Conditions

Groundwater conditions were observed in the boreholes during drilling. A piezometer was installed in borehole 406 as shown on the Record of Borehole sheets. The encountered and measured groundwater levels are summarized in the following table.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Level		Measured Groundwater Elevation (m)		
		Depth (m)	Elevation (m)	April 23, 2014	April 24, 2014	April 25, 2014
405	270.1	9.8	260.3	-	-	-
406	270.4	9.4	261.0	260.95	260.95	260.95
407	270.5	10.0	260.5	-	-	-
408	270.0	9.8	260.2	-	-	-
N-1	270.0	9.1	260.7	-	-	-
N-2	262.6	3.1	259.5*	-	-	-
N-3	262.3	0.8	261.5	-	-	-
C-1	263.2	2.3	260.9	-	-	-
C-2	263.2	2.5	260.7	-	-	-
S-1	270.5	12.2	258.3	-	-	-
S-2	262.3	2.3	260.0	-	-	-
S-3	262.1	0.9	261.2	-	-	-

The encountered water levels are not necessarily considered to be representative of the long-term, stabilized groundwater conditions as the readings were taken only during the relatively short duration of the drilling. Based on the encountered and measured groundwater levels, the groundwater level is inferred to be at about elevation 261 metres. Groundwater levels should be expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring melt conditions.

5.0 MISCELLANEOUS

This report was prepared by Mr. Adam Core, P.Eng. and the report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the MTO Foundations Designated Contact and Quality Control Auditor for this assignment, conducted an independent quality review of the report.

Golder Associates Ltd.



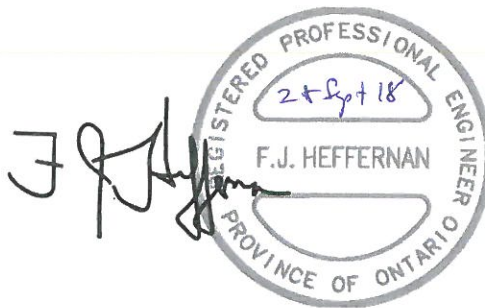
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PART B

FOUNDATION DESIGN REPORT
Highway 401 / Elgin Road Underpass
Replacement – Site No.19-304
Ministry of Transportation, Ontario – West Region
GWP 3153-16-00, Contract No. 2017-3017

6.0 ENGINEERING RECOMMENDATIONS

This section of the report provides our recommendations on the foundation aspects of the design of the replacement of the existing Middlesex Road 73 (Elgin Road) Underpass (Site 19-304). The recommendations are based on our interpretation of the factual information obtained during the investigation. This foundation investigation and design report with the interpretation and recommendations are intended for the use of the design engineer. 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.

6.1 General

The existing underpass was constructed in 1957 and consists of a single span, three lane concrete rigid frame structure. The structure was constructed perpendicular to Highway 401, has a clear span of about 33 metres and is about 17 metres wide. The superstructure is comprised of eight reinforced concrete Tee girders at about 2.3 metre spacing on centres. Based on the original design drawings, the existing single span structure is supported by 560 millimetre (22 inch) outer diameter reinforced concrete caisson type piles driven to refusal at about Elevation 256 m and were noted to possibly be a “Franki” type pile.

Based on the General Arrangement (GA) drawing provided by Dillon, we understand that the bridge is to be replaced with a two-span, steel box girder bridge with an overall length of 84 metres (two 42 metre spans) and approximately 16 metres wide. The proposed bridge will be constructed on the existing alignment with approximately 0.2 metre grade raises at the north and south approaches. The proposed abutments are approximately 24 m behind the existing abutments with graded fore slopes. The Highway 401 pavements at the bridge location are at about elevation 263 metres and the proposed grade at the north and south abutments are at about elevations 270.6 metres and 270.9 metres, respectively.

6.2 Consequence and Site Understanding Classification

The replacement bridge is being designed in accordance with the current Canadian Highway Bridge Design Code CAN/CSA-S6-14 (CHBDC 2014). In accordance with Section 6.5 of CHBDC (2014) and its Commentary, the proposed bridge and its foundation system is considered to be classified as having a “typical consequence level” associated with exceeding limits states design. The degree of understanding, based on the scope of the current foundation investigation and design, is considered ‘typical’ as described in Clause 6.5.3.2 of CHBDC (2014). The appropriate corresponding Ultimate Limit States (ULS) and Serviceability Limit States (SLS) consequence factors, Ψ , and geotechnical resistance factors at ULS (ϕ_{gu}) and SLS (ϕ_{gs}), respectively, from Tables 6.1 and 6.2 of the CHBDC have been used for design in this report.

6.3 Bridge Foundations – Deep Foundations

Based on the proposed bridge geometry and subsurface conditions, deep foundations are being considered for support of the new bridge abutments and centre pier.

Based on the GA drawing provided by Dillon, we understand that driven steel H-piles to support integral abutment design will be used at both the north and south abutments and drilled concrete caissons will be used for the pier.

6.3.1 Design Tip Elevation

The estimated pile and caisson tip elevations and the estimated lengths have been calculated based on the underside of pile cap elevations shown on the GA drawing. There should be provision made for dealing with varying pile lengths due to the variability of the surface of the hard/very dense founding layer; therefore, the lengths given below should be considered minimum lengths.

Foundation Element (Relevant Boreholes)	Deep Foundation Type	Proposed Underside of Pile Cap (m)	Estimated Pile Tip Elevation (m)	Estimated Pile Design Length (m)
North Abutment (405, 408, N-2, N-3)	Driven, Steel H-Pile	266.2	246	19.2
Centre Pier (C-1 and C-2)	Drilled Caisson	N/A	246.5	N/A
South Abutment (406, 407, S-2, S-3)	Driven, Steel H-Pile	266.4	247	19.4

6.3.2 Geotechnical Axial Resistance – Driven Piles

For design, the factored geotechnical axial resistances at ULS and geotechnical reactions at SLS for HP 310 x 110 piles are provided in the following table. The SLS values correspond to an estimated total settlement of 25 millimetres.

Pile Location	Founding Strata	Maximum Founding Elevation (m)	Pile Type	Factored Geotechnical Resistance at ULS (kN)	Geotechnical Reaction at SLS (kN)
North Abutment	Very dense sand and gravel	246	HP 310 x 110	1,800	1,400
			HP 310 x 132	2,150	1,650
South Abutment		247	HP 360 x 132	2,150	1,650

The actual pile penetration and pile set characteristics will be dependent, to some extent, upon the driving equipment selected by the contractor. The pile driving hammer should be selected such that the energy delivered to the piles is sufficient to achieve the termination criteria (ultimate geotechnical resistances and tip elevations). It is recommended that, following the selection of the driving equipment, the piling contractor submit for review the proposed pile driving criteria based on the characteristics of the hammer and equipment intended for use.

The pile capacity must be verified in the field by the use of the Hiley Formula in accordance with Standard Drawing SS103-11 (MTO, 2008) "Pile Driving Control" during the final stages of driving, starting at about 1 to 2 m higher than the tip elevations provided above. The ultimate geotechnical axial resistance predicted from the Hiley Formula should then be multiplied by a geotechnical resistance factor equal to 0.5 in accordance with current

MTO practice to verify that the factored ULS design value has been achieved. Given that the piles will be driven to refusal in very dense/hard materials (N values greater than 100 blows per 0.3 metres), PDA testing is not considered warranted.

6.3.3 Geotechnical Axial Resistance – Drilled Caissons

The vertical load carrying capacity of caissons founded in the very dense sand and gravel at or below elevation 250 metres are presented in the following table:

Pile Diameter (m)	Approximate Tip Elevation (m)	Factored Geotechnical Resistance at ULS (kN0)
1.22	248	5,000
1.37	248	5,650
1.52	248	7,000

The SLS values for 25 millimetres of settlement is not provided since the corresponding resistances will exceed the ultimate value. The values above assume that the resistance is provided by both skin friction and end-bearing. Provided that the caissons are installed using the precautions noted in Section 6.6, this assumption will be valid.

6.3.4 Frost Protection

The pile caps should be provided with a minimum of 1.2 metres of soil cover or thermal equivalent for frost protection.

6.3.5 Downdrag Load (Negative Skin Friction)

The replacement structure will be constructed on the existing alignment, and a nominal 0.2 metre grade raise is proposed will be required at the approach embankments. Considering the presence of predominantly dense granular soils, negative skin friction can be neglected.

6.3.6 Resistance to Lateral Loads

The design of pile foundations subjected to lateral loads should take into account such factors as the batter of the pile (if any), the relative rigidity of the pile to the surrounding soil, the fixity condition at the head of the pile (pile cap level), the structural capacity of the pile to withstand bending moments, the soil resistance that can be mobilized, the tolerable lateral deflections at the head of the pile and pile group effects. For a longer, more flexible pile, the maximum yield moment of the pile may be reached prior to mobilization of the lateral geotechnical resistance. For design purposes, both the structural and geotechnical resistances should be evaluated to establish the governing case. Lateral loading could be resisted fully or partially by the use of battered piles.

It is understood that an integral abutment foundation design is being considered for the replacement bridge. The integral abutment design should include the installation of 3 m long corrugated steel pipe (CSP) liners, with the annular space between the pile and the liner backfilled with uniformly graded, loose sand (outlined further in Section 6.6.2), so that the upper portion of the H-piles will be free to flex and move laterally within the limits of the CSP. With this design, the passive lateral resistance over the length of the pile within the CSP liner should be based on the resistance provided by loose sand.

Where ground conditions are generally competent and the lateral loads on piles are relatively small such that the maximum lateral pile deflections will be relatively small, the resistance to lateral loading in front of a single pile can be estimated using subgrade reaction theory as outlined below. However, it should be noted that the response of a pile to lateral loads is highly nonlinear and methods that assume linear behavior (such as subgrade reaction theory) are only appropriate where the maximum pile deflections are less than 1 percent of the pile diameter, where the loading is static (no cycling) and where the pile material is linear (CFEM, 2006). Where these conditions are not met, the non-linear lateral behavior of the soil should be considered by the use of P-y curves.

The factored serviceability geotechnical response of the soil in front of the piles under lateral loading at this site may be calculated using subgrade reaction theory suggested in the 2014 CHBDC Commentary (Section C6.11.2.2), where the coefficient of horizontal subgrade reaction, k_h , (kPa/m) is based on the equation given below, as described by Terzaghi (1955) and the Canadian Foundation Engineering Manual (CFEM 2006).

Lateral loading could be resisted fully or partially by the use of battered piles. In the case of integral abutments, the vertical piles must provide the resistance to the lateral loading. The stratigraphy presented in the table below has been simplified for the purposes of this report.

For cohesionless soils:

$$k_h = \frac{n_h z}{B}$$

where:

- n_h = constant of horizontal subgrade reaction (kPa/m), as given below;
- z = depth (m)
- B = pile diameter or width (m)

The following values of n_h may be incorporated into the calculations of the coefficient of horizontal subgrade reaction (k_h) for structural analysis for a single vertical HP pile or concrete caisson. The ranges in values reflect the variability in the subsurface conditions, the soil properties and the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that k_h is a function of deflection).

Foundation Element (Relevant Boreholes)	Soil Type	Elevation (m)	n_h (MPa/m)
North Abutment (405, 408, N-2, N-3)	CSP Liner – Sand, loose	266.2 – 263.2	2-4
	Existing Granular Fill – Sand and Gravel to Sand, compact to dense	263.2 – 260.1	2-10
	Sand to Silty Sand, loose to very dense	260.1 – 250.7	2-8

Foundation Element (Relevant Boreholes)	Soil Type	Elevation (m)	n_h (MPa/m)
	Sand and Gravel to Gravelly Sand, very dense	250.7 – 244.9	11-25
Centre Pier (C-1, C-2)	Existing Granular Fill, Gravelly Sand to Silty Sand, dense	263.2 – 261.0	2-10
	Sand to Silty Sand, very Loose to compact	261.0 – 248.0	2-6
	Clayey Silt (Till), Hard	248.0 – 244.3	11-25
South Abutment (406, 407, S-2, S-3)	CSP Liner – Sand, loose	266.4 – 263.4	2-4
	Existing Granular Fill – Sand and Gravel to Sand, compact to dense	263.4 – 260.5	2-10
	Sand to Silty Sand, loose to very dense	260.5 – 250.7	2-8
	Sand and Gravel to Gravelly Sand, very dense	250.7 – 244.9	11-25

The lateral resistances for the various foundation options are summarized in the following table.

Pile Type	Lateral Resistance ¹	
	Factored ULS ² (kN)	SLS ³ (kN)
Driven Integral Abutment HP 310 x 110 HP 310 x 132 HP 360 x 132	175 (S) / 65 (W) 200 (S) / 95 (W) 225 (S) / 110 (W)	20 (S) / 15 (W) 25 (S) / 20 (W) 30 (S) / 20 (W)
Drilled Concrete Caissons 1.2 m 1.37 m 1.52 m	2,000 2,600 3,250	1,500 2,100 2,750

Note:

- Resistances are for 10 millimetres of deflection unless otherwise noted.
- 3) S – strong axis bending for integral abutment; W - weak axis bending for integral abutment.

The lateral resistances above are based on Brom's Method from "Design and Construction of Driven Pile Foundations Workshop Manual – Volume 1, FHWA, Pub. No. FHWA H1 97-013, Revised November 1998". Fixed-head conditions were assumed for the H-pile, while free head conditions were assumed for concrete caissons. In cases where the applied loads approach those in the above table or if the design is sensitive to lateral loads and displacements, horizontal subgrade reaction theory should be used. For integral abutments the horizontal load was assumed to be applied at the underside of the abutment stem or at elevation 266.2 metres for the north abutment and elevation 266.4 metres for the south abutment. A compressive strength of 32 megapascals was assumed for the concrete caissons.

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor, R , as follows:

Pile Spacing in Direction of Loading, d = Pile Diameter	Subgrade Reaction Reduction Factor, R
8d	1.00
6d	0.70
4d	0.40
3d	0.25

6.4 Liquefaction Potential and Seismic Analysis

6.4.1 Seismic Considerations

Subsurface ground conditions for seismic site characterization were established based on the results of the borehole investigations. Based on the anticipated foundation levels, the site may be classified as Site Class C in accordance with Table 4.1 of the CHBDC (2014). This site should be considered to be located in Seismic Performance Zone 1. In accordance with Section 4.4.5.1 of the CHBDC, no seismic analysis is required for structures located in Seismic Performance Zone 1, however minimum requirements specified in Clauses 4.4.5.3 and 4.4.5.3 still apply.

6.4.2 Seismic Hazard Assessment

A preliminary screening of the soil stratigraphy was carried out using the procedure outlined by the FHWA.⁵ Although saturated granular materials are present at the site, they have normalized N values of greater than 22 blows per 0.3 metres. The liquefaction potential is considered to be low based on the soil profile type, age of the deposits, relative density and the historically low seismicity. Therefore, a detailed evaluation of the liquefaction potential of the foundation soils, impact of liquefaction on the bridge foundations, and the effect of seismic forces on embankment stability is not considered warranted unless the structure is deemed to be a lifeline bridge.

⁵ FHWA, 1997: "Design Guidance: Geotechnical Earthquake Engineering For Highways. Volume I – Design Principles." *Geotechnical Engineering Circular No. 3: FHWA-SA-97-076*, Washington, D.C.

6.5 Lateral Earth Pressures for Design

The lateral pressures acting on the bridge abutments and associated wing/retaining walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the freedom of lateral movement of the structure and the drainage conditions behind the walls.

- Select, free-draining granular fill meeting the specifications of Ontario Provincial Standards Specifications (OPSS) Granular A or Granular B Type II or III should be used as backfill behind the abutments and walls. This fill should be compacted in loose lifts not greater than 200 millimetres in thickness in accordance with OPSS.PROV 501. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the abutment granular backfill requirements with respect to subdrains and frost taper should be in accordance with Ontario Provincial Standard Drawing (OPSD) 3101.150 and 3190.100.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC (2014) Section 6.12.3 and Figure 6.6. Care must be taken during the compaction operation not to overstress the wall. Heavy construction equipment should be maintained at a distance of at least 1 m away from the walls while the backfill soils are being placed. Hand-operated compaction equipment should be used to compact the backfill soils immediately behind the walls as per OPSS.PROV 501. Other surcharge loadings should be accounted for in the design as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.2 m behind the back of the wall (in accordance with Figure C6.20 (a) of the Commentary to the CHBDC). For unrestrained walls, granular fill should be placed within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing in accordance with Figure C6.20(b) of the Commentary to the CHBDC (2014).
- For Case a, the restrained case, the pressures are based on the proposed embankment fill materials and the following parameters (unfactored) may be used assuming the use of Select Subgrade Material (SSM).

Soil unit weight: 20 kN/m³

Coefficient of lateral earth pressure:
At rest, K_0 0.50

- For Case b, the unrestrained case, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	GRANULAR A	GRANULAR B Type II	GRANULAR B Type III
Soil unit weight:	22 kN/m ³	21 kN/m ³	21 kN/m ³
Coefficients of lateral earth pressure:			
Active, K_a	0.27	0.27	0.31
At rest, K_p	3.7	3.7	3.3

- If the wall support and superstructure allow lateral yielding of the stem, active earth pressures may be used in the foundation design of the structure. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as:

- Rotation of approximately 0.002 about the base of a vertical wall (where the rotation is calculated as the horizontal displacement divided by the height of the wall).
- Horizontal translation of 0.001 times the height of the wall.
- A combination of both.
- If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.
- For integral abutments, passive earth pressures may be used in the geotechnical design of the structure. The movements required to fully mobilize passive pressure or resistance are much larger than those required to mobilize active pressure. In practice, movements may not be sufficient to mobilize the full passive resistance. A resistance factor equal to 0.5 should be applied to the calculated total passive resistance in accordance with Table 6.1 of the CHDBC.

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. The lateral earth pressure coefficients should be adjusted if there is sloping ground at the back of the wall.

6.6 Construction Considerations

6.6.1 Deep Foundations

Cobbles and boulders should be expected in the fill, and glacial till at the site which may impact pile driving/caisson drilling operations. Cobbles can be split or displaced during pile driving. Provided capacity is achieved, a pile obstructed by a boulder can be left short assuming few piles encounter boulders. The risk of several adjacent piles being obstructed by boulders is considered low. For caissons, appropriate auger teeth, rock bits or large diameter core barrels can address boulders.

All pile installation/driving/drilling operations for the driven steel H-piles and caissons should be in accordance with OPSS.PROV 903 (Deep Foundations). The piles at the abutments to be driven to a tip elevation within the very dense sand and gravel and/or clayey silt till deposit should be fitted with driving shoes or flange plates (reinforced tips) in accordance with OPSD 3000.100 (Steel H-Pile Driving Shoe) to minimize damage to the pile tip during driving.

Drilled shafts/caissons will be installed through saturated granular deposits. Therefore a temporary liner will be required to protect the integrity of the augered excavation and should extend to elevation 248 metres. To address the potential impacts resulting from unbalanced water heads inside and outside of the temporary liner, the caisson excavations should be advanced maintaining a head of slurry or drilling mud sufficient to balance or exceed the water head outside of the liner. The slurry/mud should be specified by the contractor and a mix design submitted in accordance with OPSS 903. The slurry and structural concrete should be compatible and this should be confirmed in the slurry and concrete mix design submittals. The concrete should be placed using tremie methods from the base of the caisson upwards. The base must be effectively cleaned prior to the commencement of concrete placement. The final 2 metres of augering should be monitored by qualified geotechnical personnel to confirm that appropriate down-hole cleaning tools are used and that the base of the caisson excavation has been properly prepared.

6.6.2 CSPs for Integral Abutment

CSP shall be in accordance with OPSS 1801 and shall be from a supplier listed under DSM#4.60.80. The CSP shall be of the diameter and wall thickness specified, and shall be galvanized in accordance with CSA G164-M.

The sand fill for backfilling the CSP shall meet the gradation requirements of Table 1 below:

MTO Sieve Designation		Percentage Passing by Weight
2 mm	#10	100%
600 µm	#30	80% to 100%
425 µm	#40	40% to 80%
250 µm	#60	5% to 25%
150 µm	#100	0% to 6%

The sand fill shall be placed dry of optimum and free-flowing, completely filling the volume between the CSP and pile. No additional compaction effort other than the action of placing the sand itself shall be applied to the sand fill.

6.6.3 Obstructions

The native soils at this site are glacially derived and as such are very dense and contain coarse gravel, cobbles and boulders, which could affect the installation of deep foundations, excavations for foundations and installation of temporary protection systems. Further, asphalt was encountered within the embankment fill in Borehole 405.

6.7 High Fill Approach Embankments

The proposed bridge is to be replaced on the existing alignment and a nominal grade raise of about 0.2 metres is being proposed. Should embankment widening be required, all surficial topsoil, organic, loose, soft, and/or otherwise deleterious materials should be stripped from areas of proposed embankment widenings, including the existing embankment slope. Prior to placement of embankment fill material, the exposed subgrade should be proof rolled. The embankment fills should consist of an approved granular borrow such as SSM, except for the top approximately 0.5 to 1.0 metres where pavement base and subbase materials will be placed. The lower 1.0 metres should consist of Granular B Type III to reduce the risk of build-up of hydrostatic pressures. Embankment fill materials should be placed in maximum 300 millimetre thick loose lifts and properly benched into the existing embankments and compacted. Upon completion of filling to the pavement subgrade level, the embankment side slopes should be trimmed to a final inclination of two horizontal to one vertical or flatter. Embankment modifications constructed in this manner are expected to have an adequate factor of safety against instability and given the nominal grade raise proposed, there are no anticipated settlement concerns.

To reduce surface water erosion on the embankment side slopes, topsoil and seeding as per OPSS 802 (Topsoil) and OPSS 804 (Seed and Cover) should be carried out as soon as possible after construction of the embankments.

6.8 Excavations and Temporary Cut Slopes

Excavations for the pile caps will extend into the existing fill (Elevation 266.2 metres and 266.4 metres at the north and south abutments respectively) and based on the measured groundwater level is expected to be at about elevation 261 metres and will fluctuate seasonally. Should excavations be required to extend appreciably below elevation 261 metres, proactive dewatering of the granular soils will be required. If required, pumping from properly constructed and filtered sumps in the base of the excavation to control surface water or perched water within the embankment fill may be required. Sumps should be maintained outside of the actual pile cap and/or abutment limits. Surface water runoff should be directed away from the excavations at all times.

All excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The native granular soils below the water level and the fill materials at this site would be classified as Type 3 soils. Properly dewatered cohesionless soils would be classified as Type 2.

6.8.1 Temporary Protection Systems

Temporary protection systems (if required) to allow for construction of the approach embankments and replacement bridge. Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems), provided that any existing adjacent structures or utilities can tolerate this magnitude of deformation. The lateral movement of the temporary shoring systems should meet Performance Level 2 as specified in OPSS.PROV 539.

Temporary support systems could consist of soldier piles and lagging, where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds, or driven steel sheet piling. Support to the system(s) could be in the form of struts and walers or rakers and anchors. The support system must be designed to accommodate the loads applied from pressures and surcharge pressures from area, line or point loads as well as address the impact(s) of sloping ground behind the system.

The selection and design of the excavations, temporary protection systems or cofferdams and ground water control system will be ultimately the responsibility of the Contractor.

7.0 MISCELLANEOUS

This report was prepared by Mr. Adam Core, P.Eng. and this report was reviewed by Mr. Michael E. Beadle, P.Eng. an Associate and Senior Geotechnical Engineer with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the MTO Foundation Designated Contact, conducted an independent quality review of the report.

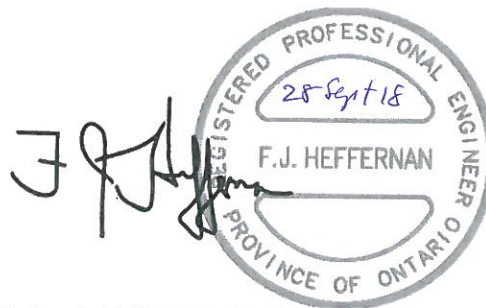
Golder Associates Ltd.



Adam Core, P.Eng.
Geotechnical Engineer



Michael E. Beadle, P. Eng.
Associate, Geotechnical Engineer

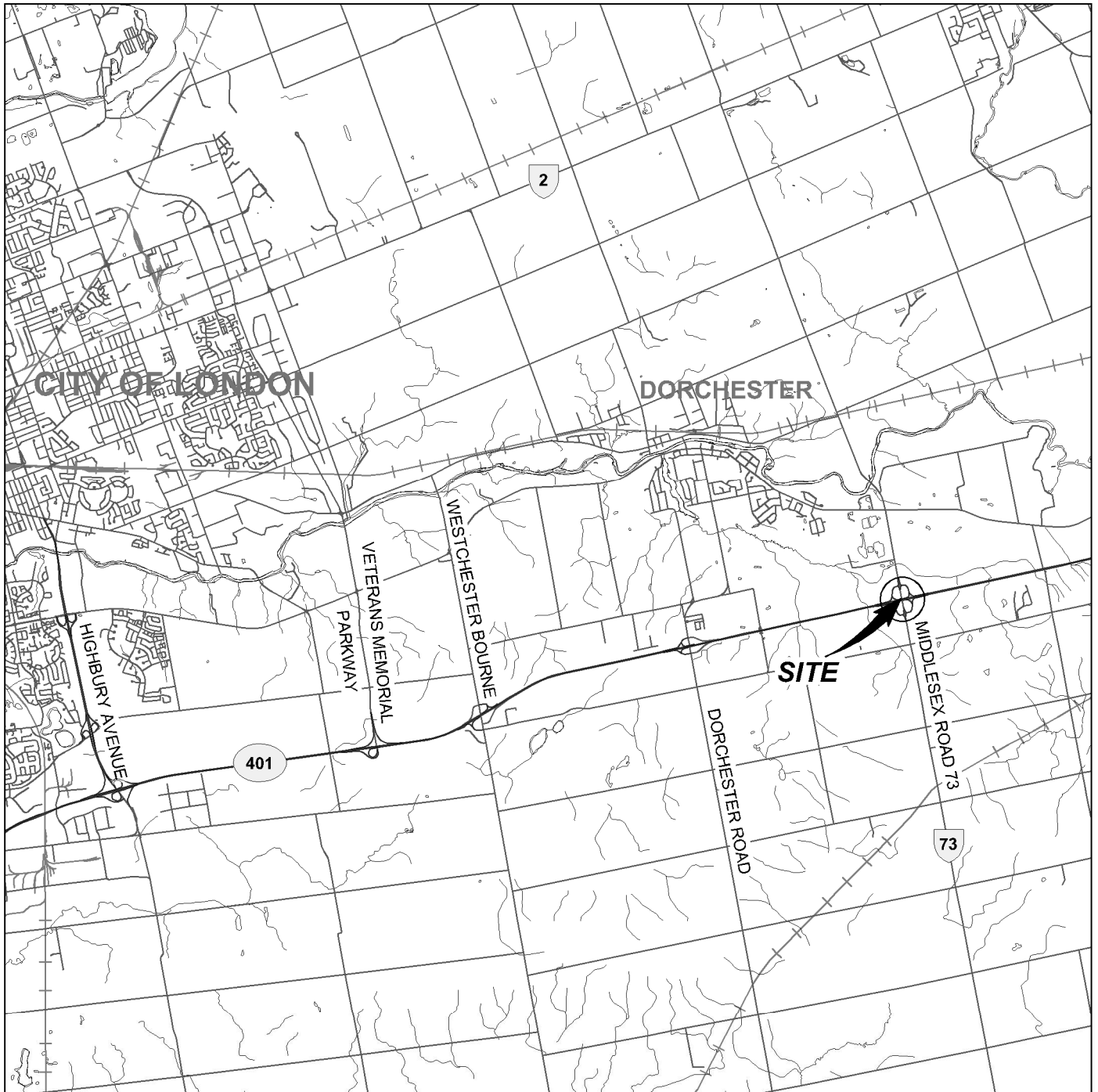


Fintan J. Heffernan, P. Eng.
MTO Foundations Designated Contact

AC/MEB/cr

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[https://golderassociates.sharepoint.com/sites/22429g/ph/1000fdns/3-deliverables/r01-elgin rd up/1788727-r01 sept 28 18 \(revised final\) fidr elgin road underpass.docx](https://golderassociates.sharepoint.com/sites/22429g/ph/1000fdns/3-deliverables/r01-elgin rd up/1788727-r01 sept 28 18 (revised final) fidr elgin road underpass.docx)





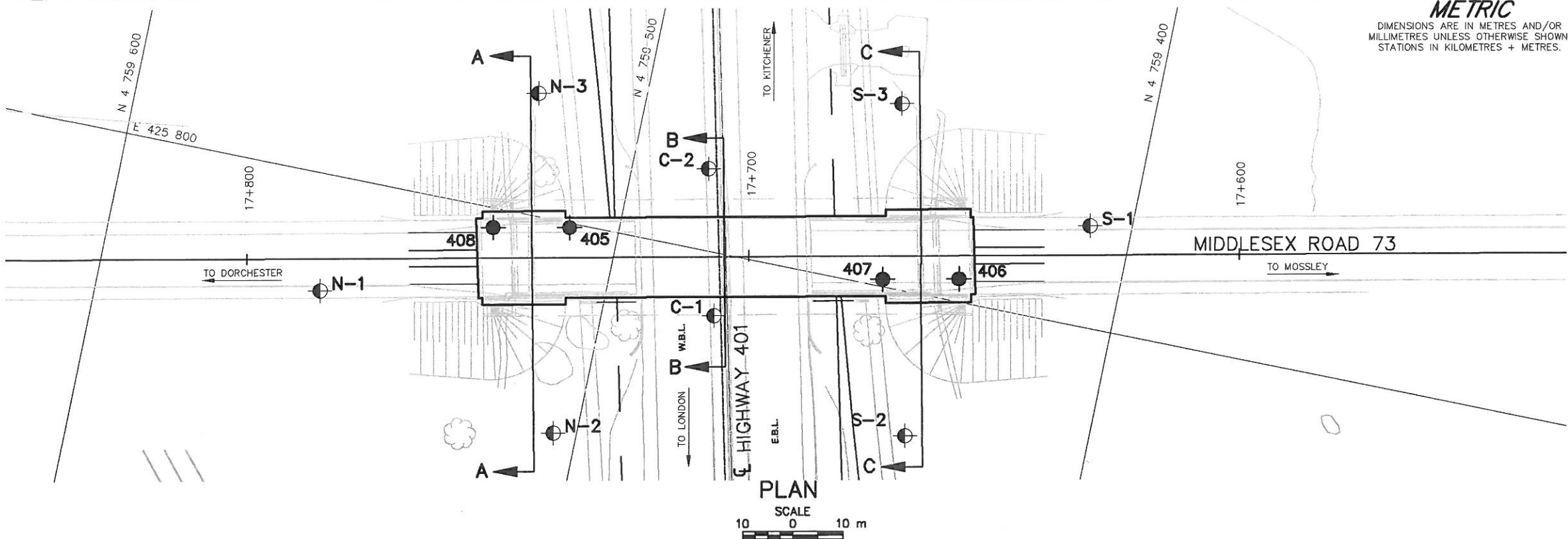
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PLAN BASED ON CANMAP STREETFILES V.2008.5.

NOTE

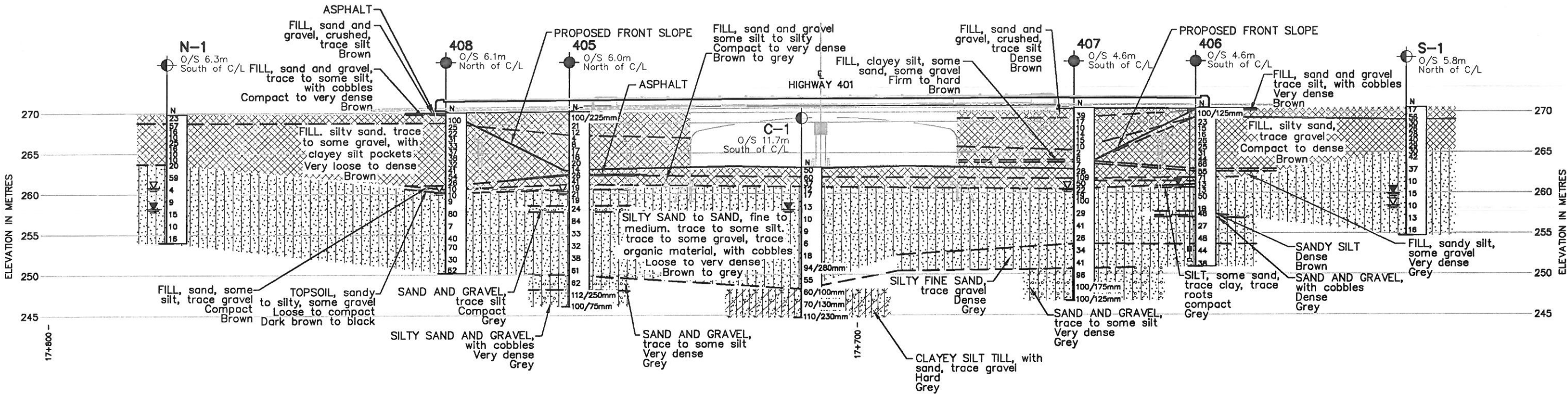
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT		MIDDLESEX ROAD 73 (ELGIN ROAD), SITE 19-304 HIGHWAY 401 UNDERPASS REPLACEMENT GWP 3153-16-00							
TITLE		KEY PLAN							
 GOLDER		PROJECT No.		1788727	FILE No.	1788727-F01001			
					SCALE	AS SHOWN	REV.	0	
		CADD	WDF/ZJB	Apr. 19/18	FIGURE 1				
		CHECK							



CONT No.
WP No. 3153-16-00

MIDDLESEX ROAD 73 (ELGIN ROAD)
HIGHWAY 401 UNDERPASS REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



LEGEND

Borehole (Previous Golder Investigation: 12-1132-0076-2001-R03)

Borehole (Geocres 40114-143)

Seal

Standpipe

Standard Penetration Test Value

Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)

WL measured on April 25, 2014

WL encountered during drilling

DRY Water level not established

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11)	
		NORTHING	EASTING
405	270.11	4 759 509.7	425 799.1
406	270.40	4 759 431.7	425 804.6
407	270.46	4 759 446.5	425 801.5
408	269.99	4 759 524.6	425 796.1
Geocres 40114-143			
C-1	263.2	4 759 478.0	425 787.7
C-2	263.2	4 759 485.0	425 816.1
N-1	269.8	4 759 555.8	425 777.0
N-2	262.6	4 759 504.6	425 758.5
N-3	262.3	4 759 521.1	425 824.0
S-1	270.5	4 759 408.3	425 820.1
S-2	262.3	4 759 435.9	425 771.9
S-3	262.1	4 759 449.8	425 836.4

PROFILE ALONG \bar{C} MIDDLESEX ROAD 73

HORIZONTAL SCALE
5 0 5m

VERTICAL SCALE
5 0 5m

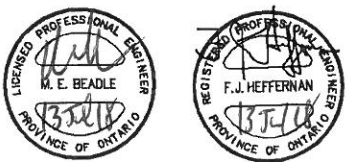
NOTES

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by Dillon Consulting.



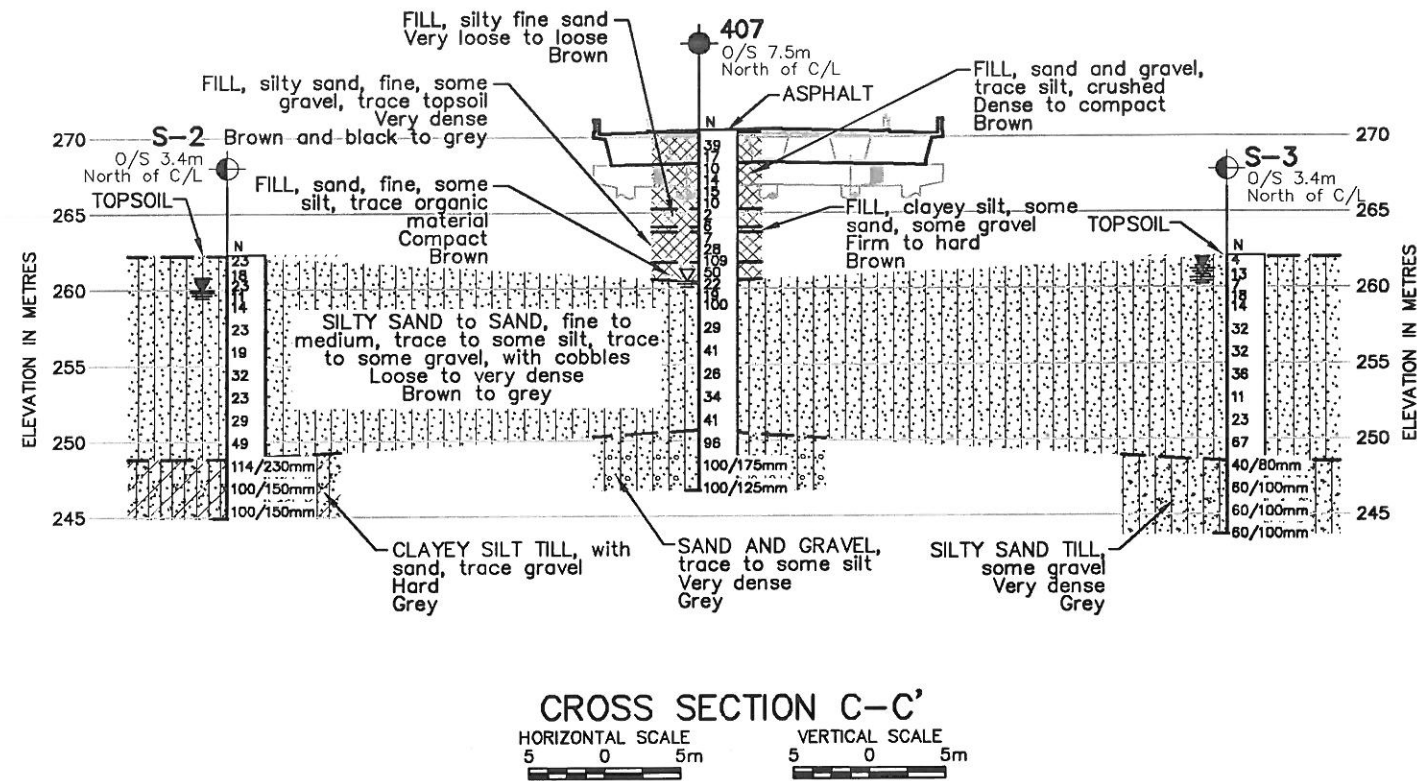
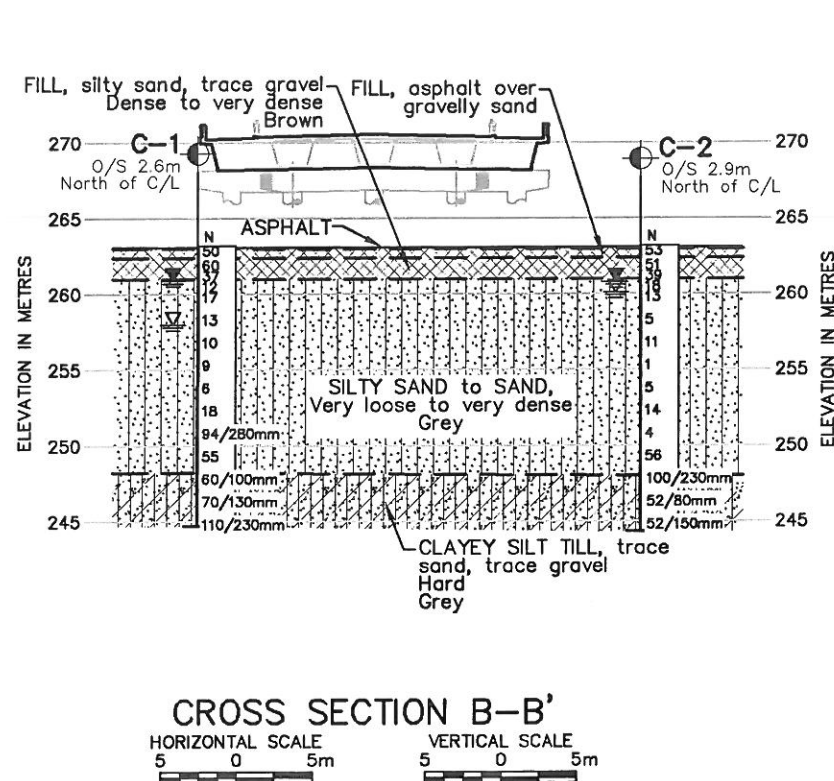
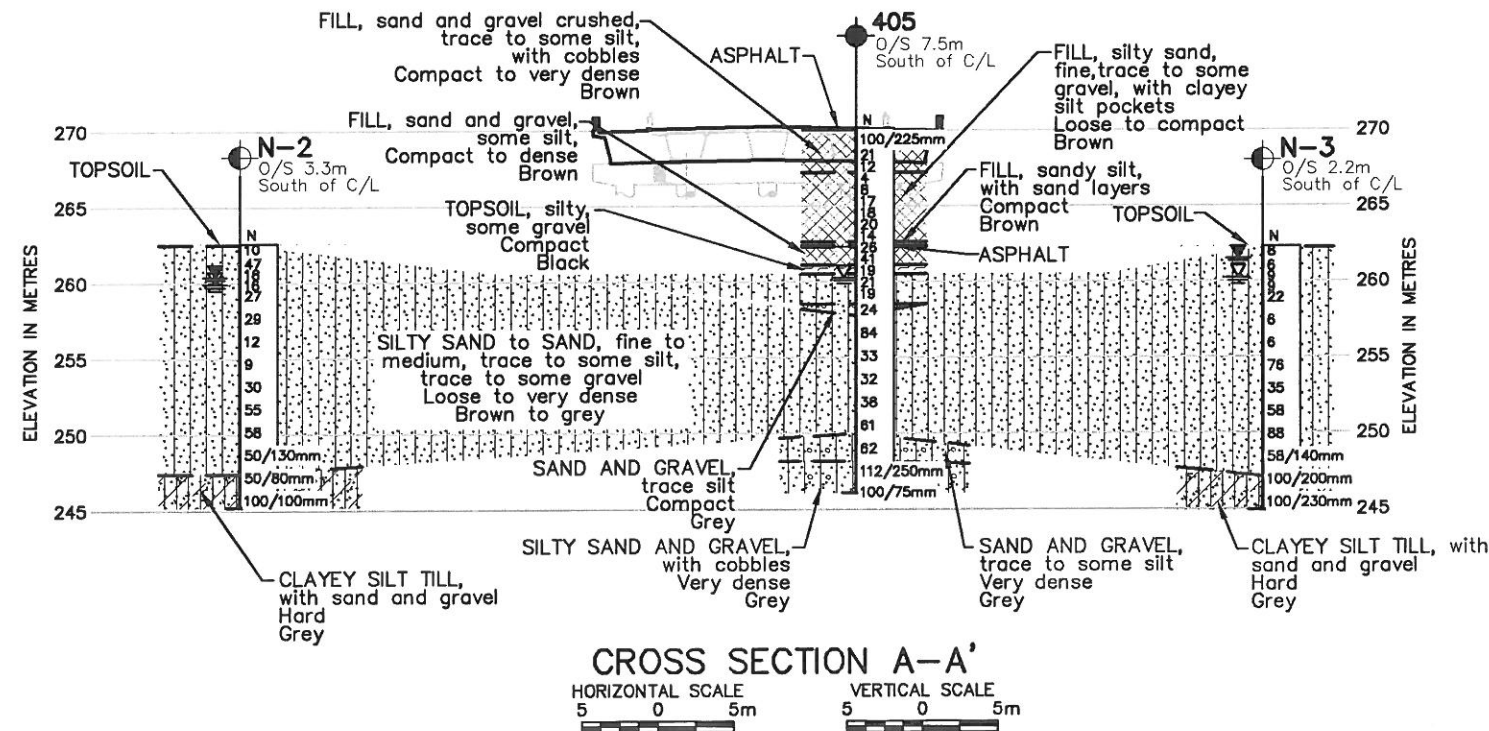
NO.	DATE	BY	REVISION
Geocres No. 40114-183			
HWY.	MIDDLESEX 73	PROJECT NO. 1788727	DIST.
SUBM'D. AC	CHKD. MB	DATE: July 13/18	SITE: 19-304
DRAWN: ZJB	CHKD. MB	APPD. MB	DWG. 1

METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 3153-16-00

MIDDLESEX ROAD 73 (ELGIN ROAD)
HIGHWAY 401 UNDERPASS REPLACEMENT
SOIL STRATA

SHEET



LEGEND

- Borehole (Previous Golder Investigation: 12-1132-0076-2001-R03)
- Borehole (Geocres 4014-143)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured
- WL encountered during drilling
- DRY Water level not established

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11)	
		NORTHING	EASTING
405	270.11	4 759 509.7	425 799.1
407	270.46	4 759 446.5	425 801.5
Geocres 4014-143			
C-1	263.2	4 759 478.0	425 787.7
C-2	263.2	4 759 485.0	425 816.1
N-2	262.6	4 759 504.6	425 758.5
N-3	262.3	4 759 521.1	425 824.0
S-2	262.3	4 759 435.9	425 771.9
S-3	262.1	4 759 449.8	425 836.4

NOTES

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

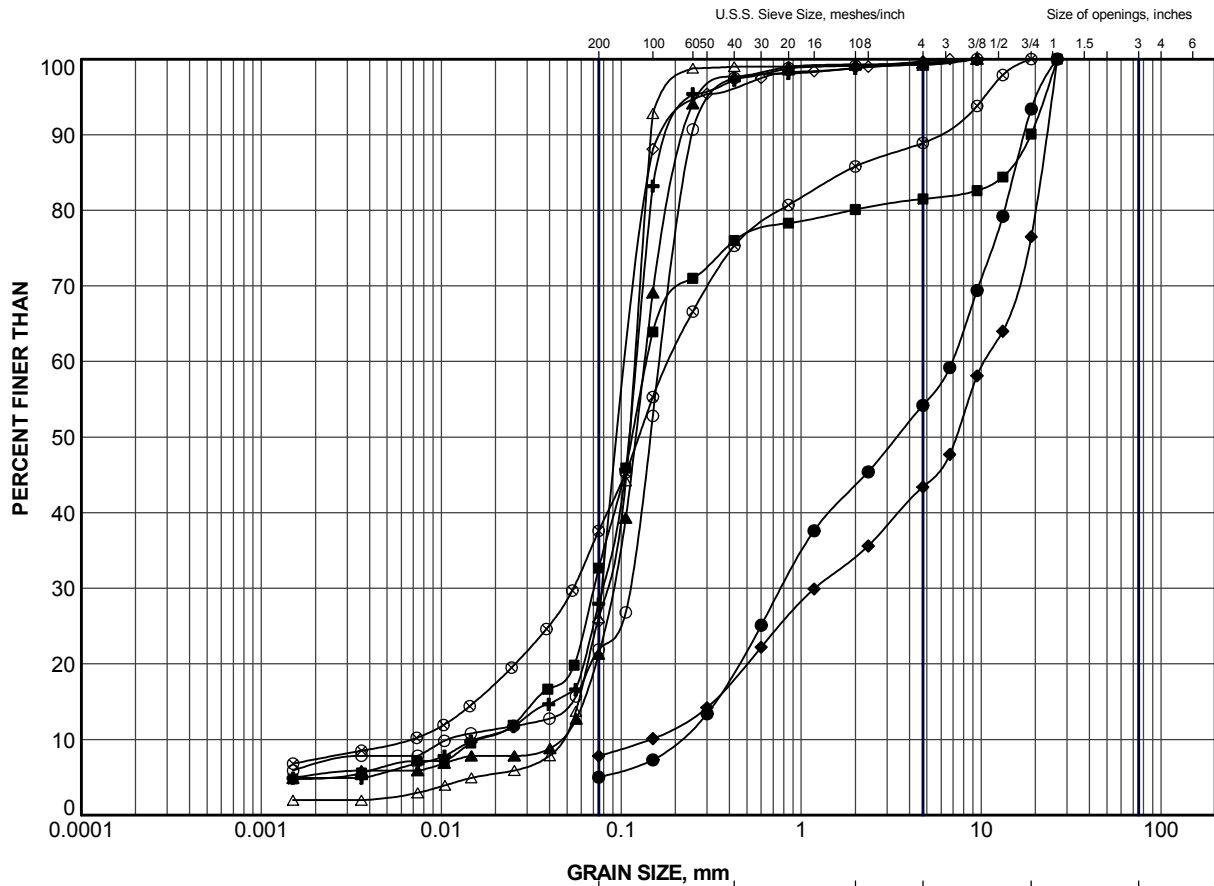
Base plans provided in digital format by Dillon Consulting.



NO.	DATE	BY	REVISION
Geocres No. 4014-183			
HWY.	MIDDLESEX 73	PROJECT NO. 1788727	DIST.
SUBM'D. AC	CHKD. MB	DATE: July 13/18	SITE: 19-304
DRAWN: ZJB	CHKD. MB	APPD. MB	DWG. 2

APPENDIX A

**Record of Boreholes and Laboratory Data –
Golder, GEOCRES No. 40I14-160**

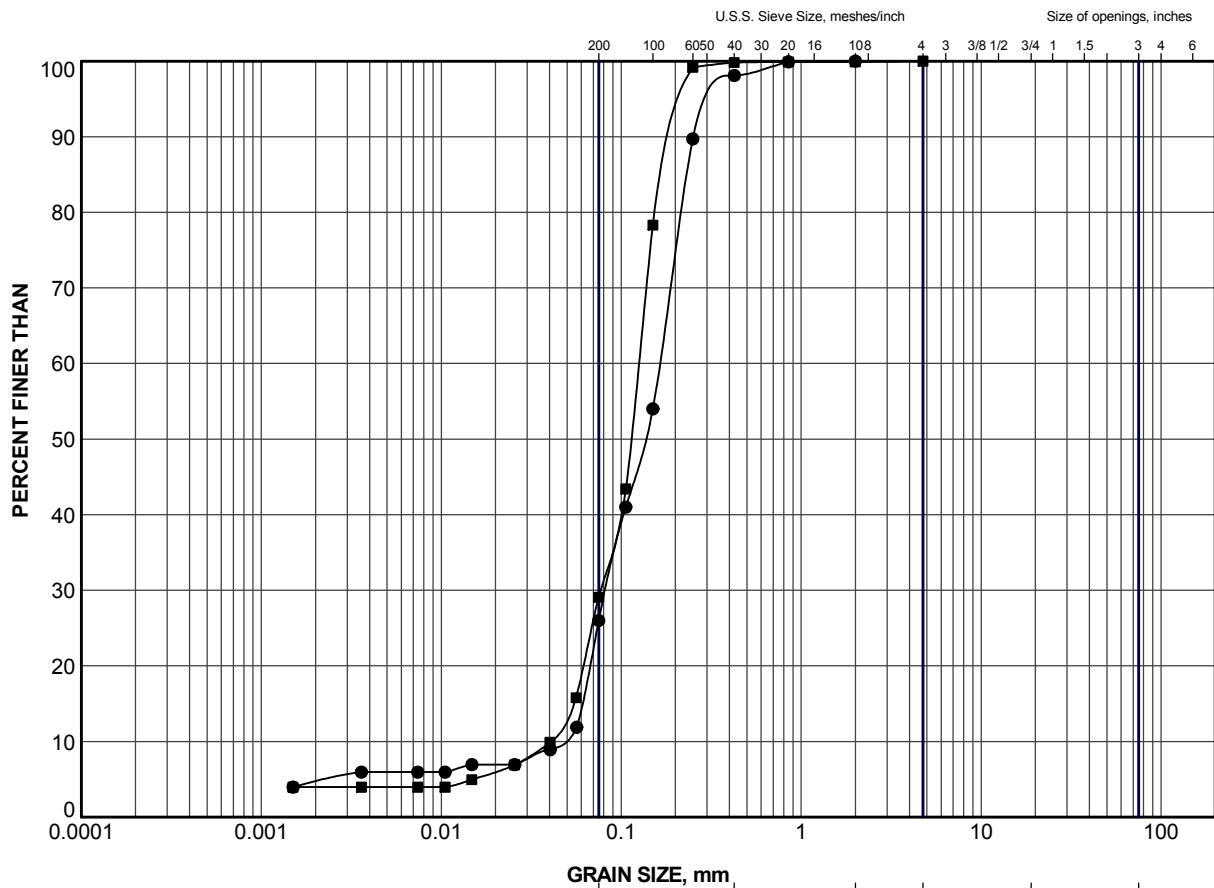


CLAY AND SILT						Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	405	2	268.4
■	405	6	265.3
▲	406	2	268.7
+	406	7	264.8
◆	407	3	267.9
◇	407	7	264.9
○	407	10	262.6
△	408	2	268.2
⊗	408	9	262.9

PROJECT				MIDDLESEX ROAD 73 (ELGIN ROAD), SITE 19-304 HIGHWAY 401 UNDERPASS REPLACEMENT GWP 3153-16-00			
TITLE				GRAIN SIZE DISTRIBUTION FILL			
PROJECT No.		1788727		FILE No.		1788727-F010A1	
DRAWN		LMK/ZJB		SCALE		N/A	
CHECK		APR 19/18		REV.			
				FIGURE A-1			

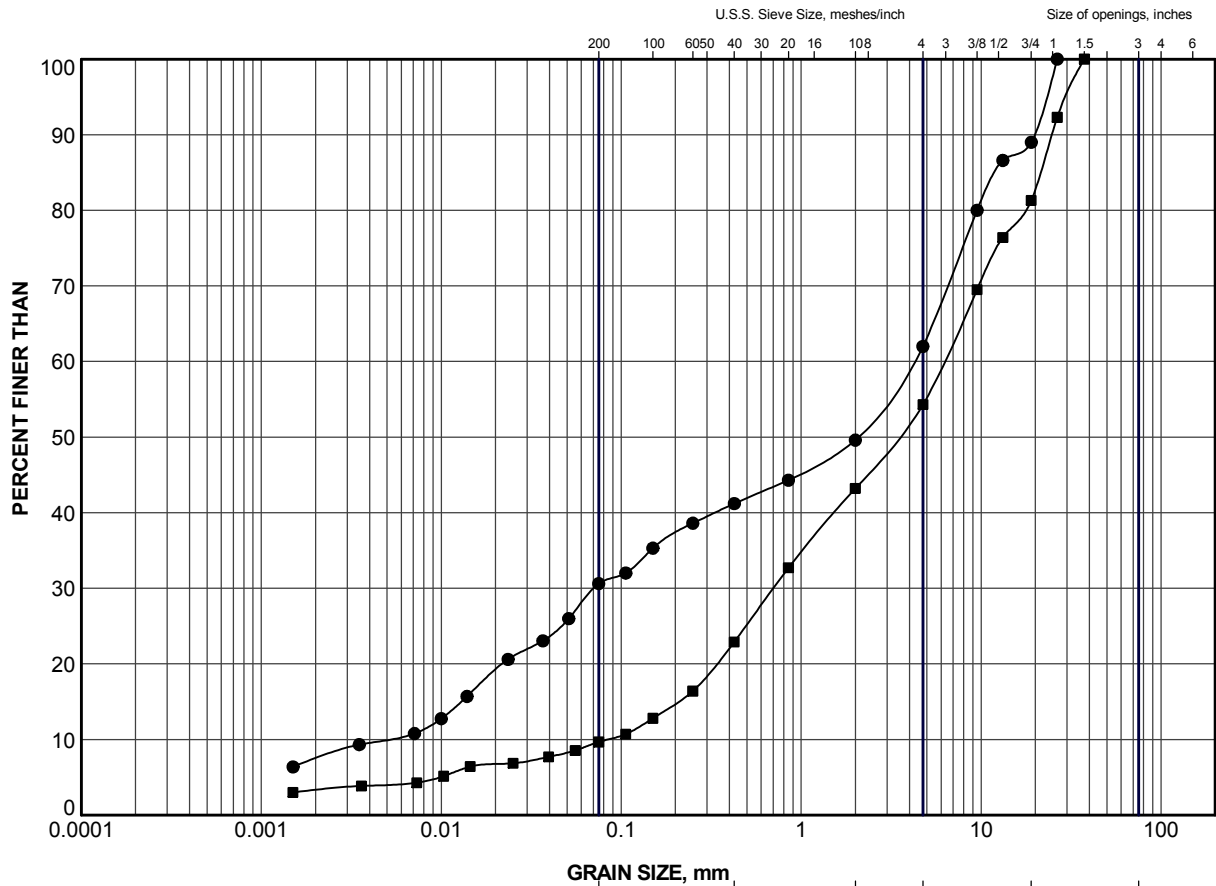


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	406	20	251.2
■	407	19	252.9

PROJECT				MIDDLESEX ROAD 73 (ELGIN ROAD), SITE 19-304 HIGHWAY 401 UNDERPASS REPLACEMENT GWP 3153-16-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY FINE SAND			
PROJECT No.		1788727		FILE No.		1788727-F010A3	
DRAWN		LMK/ZJB		SCALE		N/A	
CHECK		APR 19/18		REV.			
				FIGURE A-3			



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	405	22	247.5
■	407	21	249.8

PROJECT				MIDDLESEX ROAD 73 (ELGIN ROAD), SITE 19-304 HIGHWAY 401 UNDERPASS REPLACEMENT GWP 3153-16-00			
TITLE				GRAIN SIZE DISTRIBUTION SAND AND GRAVEL			
PROJECT No.		1788727		FILE No.		1788727-F010A4	
DRAWN		LMK/ZJB		SCALE		N/A	
CHECK		[Signature]		REV.		[Blank]	
GOLDER				FIGURE A-4			

RECORD OF BOREHOLE No 405

1 OF 2

METRIC

PROJECT 12-1132-0076
W.P. 3053-11-00 LOCATION N 4759509.7, E 425799.1 ORIGINATED BY MA
DIST HWY 401 BOREHOLE TYPE POWER AUGER, SOLID STEM, HOLLOW STEM / WASH BORING, CASED COMPILED BY WF/LK
DATUM GEODETIC DATE February 4, 2014 - February 11, 2014 CHECKED BY *WJ*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P W W _L								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)									
270.11	PAVEMENT SURFACE						20	40	60	80	100				GR	SA	SI	CL
0.00	ASPHALT																	
0.15	FILL, sand and gravel, crushed, trace silt																	
0.34	Brown FILL, sand and gravel, trace to some silt, with cobbles Compact to very dense Brown		1	SS	100/ 225mm													
			2	SS	21													
			3	SS	12													
267.21																		
2.90	FILL, silty fine sand, trace to some gravel, with clayey silt pockets Loose to compact Brown		4	SS	4													
			5	SS	8													
			6	SS	17													
			7	SS	18													
			8	SS	20													
			9	SS	14													
262.64																		
7.47	FILL, sandy silt, with sand layers Compact Brown		10	SS	26													
7.83	ASPHALT																	
	FILL, sand and gravel, some silt Compact to dense Brown		11	SS	41													
261.12																		
8.99	TOPSOIL, silty, some gravel Compact Black		12	SS	19													
260.51																		
9.60	SAND, fine to medium, trace silt Compact Grey		13	SS	21													
			14	SS	19													
258.53																		
11.58	SAND AND GRAVEL, trace silt Compact Grey		15	SS	24													
257.77																		
12.34	SAND, fine, some silt Very dense to dense Grey		16	SS	84													

Continued Next Page

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

PROJECT <u>12-1132-0076</u>		RECORD OF BOREHOLE No 405		2 OF 2		METRIC	
W.P. <u>3053-11-00</u>		LOCATION <u>N 4759509.7, E 425799.1</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER, SOLID STEM, HOLLOW STEM / WASH BORING, CASED</u>		COMPILED BY <u>WF/LK</u>			
DATUM <u>GEODETIC</u>		DATE <u>February 4, 2014 - February 11, 2014</u>		CHECKED BY <u>W</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			w _p	w	w _L		
								20 40 60 80 100							
254.41			17	SS	33		255								
15.70							254								
			18	SS	32										
							253								
			19	SS	38		252								
							251								
			20	SS	61										
249.99							250								
20.12															
			21	SS	62		249								
248.16							248								
21.95															
			22	SS	112/ 250mm										
							247								
246.09			23	SS	100/ 75mm										
24.02															

LDN_MTO_06 12-1132-0076-2001.GPJ LDN_MTO.GDT 20/01/15

RECORD OF BOREHOLE No 406

1 OF 2

METRIC

PROJECT 12-1132-0076
W.P. 3053-11-00 LOCATION N 4759431.7, E 425804.6 ORIGINATED BY MA/NG
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM / WASH BORING, CASED COMPILED BY WF/LK
DATUM GEODETIC DATE February 7, 2014 - April 23, 2014 CHECKED BY *WJ*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV	DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _P	W	W _L		
270.40		PAVEMENT SURFACE						20	40	60	80	100					
0.00		ASPHALT															
0.15		FILL, sand and gravel, crushed, trace silt															
0.30		Brown															
269.33		FILL, sand and gravel, trace silt, with cobbles	1	SS	100/125mm												
1.07		Very dense															
		Brown															
		FILL, silty fine sand, trace gravel	2	SS	23												1 78 16 5
		Compact to very dense															
		Brown															
			3	SS	15												
			4	SS	16												
			5	SS	26												
			6	SS	25												
			7	SS	31												
			8	SS	44												
			9	SS	66												
262.93																	
7.47		FILL, clayey silt, some sand, some gravel	10	SS	55												
7.77		Hard															
		Brown															
261.87		FILL, sandy silt, some gravel	11	SS	71												
8.53		Very dense															
		Grey															
261.41		FILL, silty sand and gravel, trace topsoil	12	SS	13												
8.99		Very dense															
261.01		Grey															
9.39		FILL, sand, some gravel															
260.65		Compact															
9.75		Grey															
		SILT, some sand, trace clay, trace roots	13	SS	13												0 93 (7)
		Compact															
		Grey															
		SAND, fine, trace silt	14	SS	50												
		Compact to dense															
		Brown															
258.82																	
11.58		SAND, fine to medium, trace silt	15	SS	19												
		Compact															
		Brown															
257.66			16	SS	46												2 94 (4)
12.74		SANDY SILT, Dense															
257.20		Brown															
13.20		SAND AND GRAVEL, with cobbles															
13.41		Dense															
		Grey															
		SAND, fine to medium, trace to some silt, trace to some gravel	17	SS	27												
		Compact to dense															
		Grey															

Continued Next Page

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

RECORD OF BOREHOLE No 407

1 OF 2

METRIC

PROJECT 12-1132-0076
W.P. 3053-11-00 LOCATION N 4759446.5 , E 425801.5 ORIGINATED BY NG
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM / WASH BORING, CASED COMPILED BY WF/LK
DATUM GEODETIC DATE April 24, 2014 - April 25, 2014 CHECKED BY *LV*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40	60	80	100			20	40	60	80
270.46	PAVEMENT SURFACE																	
0.00	ASPHALT																	
0.20	FILL, sand and gravel, crushed, trace silt Dense Brown						270											
269.24			1	SS	39													
1.22	FILL, sand and gravel, trace silt Compact Brown						269											
			2	SS	17													
							268						o				57	35 (8)
			3	SS	10													
							267											
			4	SS	14													
							266											
			5	SS	15													
							265											
265.28			6	SS	10													
5.18	FILL, silty fine sand Very loose to loose Brown						264											
			7	SS	2									o			1	73 (26)
264.06			8	SS	6		264											
6.40	FILL, clayey silt Firm Brown						263											
263.75																		
6.71	FILL, silty fine sand Loose to compact Brown						262											
			9	SS	7													
							261											
			10	SS	28									o			1	77 15 7
262.23							260											
8.23	FILL, silty sand, some gravel, trace topsoil Very dense Brown and black						259											
261.77			11	SS	109													
8.69							258											
261.47	FILL, sand and gravel Very dense Grey						257											
8.99			12	SS	50									o				
	FILL, sand, fine, some silt, trace topsoil Compact to dense Brown						256											
260.46			13	SS	22									o				
10.00																		
259.94	SAND, fine, some silt, trace organic material Compact Grey																	
10.52																		
	SAND, fine to medium, trace silt, trace to some gravel, with cobbles Compact to very dense Grey																	
			14	SS	19													
			15	SS	100													
			16	SS	29													

Continued Next Page

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

PROJECT <u>12-1132-0076</u>		RECORD OF BOREHOLE No 407		2 OF 2	METRIC
W.P. <u>3053-11-00</u>	LOCATION <u>N 4759446.5 , E 425801.5</u>	ORIGINATED BY <u>NG</u>			
DIST <u> </u> HWY <u>401</u>	BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM / WASH BORING, CASED</u>	COMPILED BY <u>WF/LK</u>			
DATUM <u>GEODETIC</u>	DATE <u>April 24, 2014 - April 25, 2014</u>	CHECKED BY <u>LK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100	w _p		w	w _L			
								20	40	60	80	100	10	20	30						
253.70 16.76	SAND, fine to medium, trace silt, trace to some gravel, with cobbles Compact to very dense Grey																				
			18	SS	26																
250.65 19.81	SILTY FINE SAND Dense Grey																				
			19	SS	34										○			0	71	25	4
			20	SS	41																
246.71 23.75	SAND AND GRAVEL, trace to some silt Very dense Grey																				
			21	SS	96										○			46	44	6	4
			22	SS	100/ 175mm																

LDN_MTO_06 12-1132-0076-2001.GPJ LDN_MTO.GDT 20/01/15

METRIC

PROJECT 12-1132-0076

W.P. 3053-11-00

LOCATION N 4759524.6 . E 425796.1

ORIGINATED BY MA

DIST HWY 401

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY WF/LK

DATUM GEODETIC

DATE January 20, 2014 - February 3, 2014

CHECKED BY 11

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa									WATER CONTENT (%)		
269.99	PAVEMENT SURFACE																	
0.00	ASPHALT																	
0.24	FILL, sand and gravel, crushed Brown																	
	FILL, sand and gravel, trace silt, with cobbles Very dense Brown		1	SS	100													
268.71																		
1.28	FILL, silty fine sand Compact to dense Brown		2	SS	25													
			3	SS	22													
			4	SS	31													
			5	SS	33													
			6	SS	37													
			7	SS	38													
			8	SS	32													
263.28																		
6.71	FILL, silty sand, some gravel, trace topsoil Dense to very dense Brown		9	SS	41													
			10	SS	54													
261.76																		
8.23	FILL, sandy silt and gravel Compact Brown		11	SS	26													
261.00																		
8.99	FILL, sand, fine to medium, some silt, trace gravel Compact Brown		12	SS	10													
260.54																		
9.45	TOPSOIL, sandy Loose Dark brown		13	SS	10													
260.08																		
9.91	SAND, fine, trace to some silt Loose to very dense Brown		14	SS	9													
			15	SS	80													
			16	SS	7													
255.36																		
14.63																		

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

LDN_MTO_06 12-1132-0076-2001.GPJ LDN_MTO.GDT 20/01/15

PROJECT		12-1132-0076		RECORD OF BOREHOLE No 408		2 OF 2		METRIC											
W.P.		3053-11-00		LOCATION		N 4759524.6 , E 425796.1		ORIGINATED BY											
DIST		HWY 401		BOREHOLE TYPE		POWER AUGER, HOLLOW STEM		COMPILED BY											
DATUM		GEODETIC		DATE		January 20, 2014 - February 3, 2014		CHECKED BY											
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH		DESCRIPTION		STRAT PLOT		NUMBER		TYPE		"N" VALUES		SHEAR STRENGTH kPa		WATER CONTENT (%)		γ		GR SA SI CL	
250.18		SAND, fine to medium, trace silt Dense to very dense Brown		[Strat Plot]		17		SS		40		[Shear Strength Plot]		[Water Content Plot]		[Unit Weight Plot]		1 94 (5)	
19.81		END OF BOREHOLE		[Strat Plot]		20		SS		62		[Shear Strength Plot]		[Water Content Plot]		[Unit Weight Plot]			
		Groundwater encountered at about elev. 260.24m during drilling on January 20, 2014.		[Strat Plot]								[Shear Strength Plot]		[Water Content Plot]		[Unit Weight Plot]			

APPENDIX B

**Record of Borehole and Laboratory Data
- Peto MacCallum Ltd., GEOCREES 40I14-173**

RECORD OF BOREHOLE No C-1

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 478.0 N ; 425 787.7 E ORIGINATED BY S.A.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.07.07 LATITUDE 42.965489 LONGITUDE -81.016922 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
263.2	Ground Surface													
0.0	200 mm ASPHALT over gravelly sand		1	SS	50		263							
	Brown/grey													
262.4	(PAVEMENT FILL)													
0.8	SILTY SAND, with gravel		2	SS	60		262							
	Dense to very dense, Brown													
	(FILL)		3	SS	37									
261.0	SILTY SAND to SAND						261							
2.2	Loose to compact, Grey		4	SS	12									0 87 (13)
							260							
			5	SS	17									
							259							
			6	SS	13		258							
							257							
							256							
			8	SS	9		255							0 94 (6)
							254							
			9	SS	6									
							253							
			10	SS	18		252							
							251							17 75 (8)
			11	SS	94/28cm									
							250							
			12	SS	55		249							
248.2														

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C-1

2 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 478.0 N ; 425 787.7 E ORIGINATED BY S.A.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.07.07 LATITUDE 42.965489 LONGITUDE -81.016922 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80	100					○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL				
248.2 15.0	CLAYEY SILT, with sand, trace gravel Hard, Grey (TILL)		13	SS	60/10cm		248										3	32	53	12			
							247																
			14	SS	70/13cm		246																
							245																
244.7 18.5	END OF BOREHOLE		15	SS	110/23cm																		
<div><div></div><div>Water level observed during drilling</div></div> <div><div></div><div>Water level measured after completion of drilling</div></div> <div>NOTES:</div> <div>1. Borehole caved-in to 10.4 m depth upon completion of augering</div> <div>2. Auger refusal was encountered at 1.5 m depth. Moved 1.5 m West and continued.</div>																							

RECORD OF BOREHOLE No C-2

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 485.0 N ; 425 816.1 E ORIGINATED BY Mi.V.
DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
DATUM Geodetic DATE 2017.07.06 LATITUDE 42.965546 LONGITUDE -81.016572 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
263.2	Ground Surface						263							
0.0	200 mm ASPHALT over gravelly sand		1	SS	53									
	(PAVEMENT FILL)													
262.4	SILTY SAND, trace gravel		2	SS	51		262							
0.8	Dense, Brown, Wet													
	(FILL)		3	SS	39									
261.0	SILTY SAND to SAND						261							
2.2	Compact to very loose, Grey, Wet		4	SS	18									0 81 (19)
			5	SS	13		260							
			6	SS	5		259							
							258							
			7	SS	11		257							0 90 (10)
			8	SS	1		256							
							255							
			9	SS	5		254							
							253							
			10	SS	14		252							
							251							0 78 (22)
			11	SS	4									
							250							
			12	SS	56		249							
248.2														

Continued Next Page

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

METRIC

SOIL PROFILE				SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40						60
248.2															
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
								WATER CONTENT (%)							
								20	40	60	80	100	20	40	60
													kN/m ³	GR SA SI CL	

[illegible]

RECORD OF BOREHOLE No N-1

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 555.8 N ; 425 777.0 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.07.05 LATITUDE 42.966196 LONGITUDE -81.017042 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)			
						20	40	60	80	100	20	40	60		GR	SA	SI	CL		
269.8	Ground Surface																			
0.0	GRAVELLY SAND		1	SS	23															
	Compact to very dense, Brown, Moist																			
	asphalt debris		2	SS	57															
	SILTY SAND, trace gravel		3	SS	16															
	Compact, Brown, Moist		4	SS	10															
			5	SS	25															
			6	SS	16															
			7	SS	10															
	(FILL)		8	SS	10															
263.7	SILTY SAND to SAND		9	SS	20															
6.1	Compact to very dense, Brown, Moist																			
			10	SS	59															
	organics		11	SS	4															
			12	SS	9															
			13	SS	15															
			14	SS	10															
254.8																				
											</									

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


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

RECORD OF BOREHOLE No N-1

2 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 555.8 N ; 425 777.0 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.07.05 LATITUDE 42.966196 LONGITUDE -81.017042 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)			
254.8 15.0	SILTY SAND to SAND Loose to compact, Grey		15	SS	16		254	20	40	60	80	100		○				0	95	(5)
254.0 15.8	END OF BOREHOLE																			
	<div><div></div>Water level observed during drilling</div> <div><div></div>Water level measured after completion of drilling</div> <div>NOTE: Borehole caved-in to 13.4 m depth upon completion of augering</div>																			

RECORD OF BOREHOLE No N-2

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 504.6 N ; 425 758.5 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.06.27 LATITUDE 42.965739 LONGITUDE -81.017279 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
262.6 0.0	Ground Surface																						
262.5 0.1	TOPSOIL																						
	SILTY SAND to SAND		1	SS	10		262																
	trace gravel to 1.4 m depth																						
	Loose to compact, Grey, Wet		2	SS	47																		
			3	SS	18		261										0	97	(3)				
			4	SS	16		260										0	92	(8)				
			5	SS	27		259																
			6	SS	29		258																
							257																
			7	SS	12		256																
			8	SS	9		255																
							254																
			9	SS	30		253										1	96	(3)				
							252																
			10	SS	55		251																
							250										27	65	(8)				
			11	SS	58		249																
			12	SS	50/13cm		248																
247.6																							

Continued Next Page

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

RECORD OF BOREHOLE No N-2

2 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 504.6 N ; 425 758.5 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.06.27 LATITUDE 42.965739 LONGITUDE -81.017279 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L								
247.6 15.0	CLAYEY SILT. with sand and gravel Hard, Grey, Dry to moist (TILL)		13	SS	50/8cm																		
247.4 15.2																							
245.2 17.4			14	SS	100/10cm																		
End of borehole																							
<p> Water level observed during drilling Water level measured after drilling </p> <p>NOTE: Borehole caved-in to 15.8m depth</p> <p><u>Water Level Reading in Open Borehole</u></p> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>June 28/17</td> <td>3.1</td> <td>259.5</td> </tr> </tbody> </table>																		Date	Depth (m)	Elev.	June 28/17	3.1	259.5
Date	Depth (m)	Elev.																					
June 28/17	3.1	259.5																					

RECORD OF BOREHOLE No N-3

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 521.1 N ; 425 824.0 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.06.29 LATITUDE 42.965876 LONGITUDE -81.016474 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL
262.3	Ground Surface							20	40	60	80	100								
262.2	TOPSOIL		1	SS	8		262													
0.1	SILTY SAND to SAND																			
	Loose to compact, Brown/grey, Moist to wet		2	SS	6		261													
	organic inclusions																			
			3	SS	9		260													
			4	SS	9		259													
							258													
			6	SS	6		257													
							256													
			7	SS	6		255													
							254													
							253													
							252													
			10	SS	58		251													
							250													
							249													
			12	SS	58/14cm		248													

Continued Next Page

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

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
			NUMBER	TYPE	"N" VALUES
247.3					
247.1					
15.2	CLAYEY SILT, with sand and gravel Hard, Grey, Dry to moist		13	SS	100/20cm
	(TILL)		14	SS	100/23cm
244.9					
17.4	End of borehole				
<div> Water level observed during drilling</div> <div> Water level measured after drilling</div> <div>NOTE: Borehole caved-in to 3.8 m depth</div>					

RECORD OF BOREHOLE No S-1

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 408.3 N ; 425 820.1 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.06.26 LATITUDE 42.964862 LONGITUDE -81.016546 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
270.5	Ground Surface													
0.0	GRAVELLY SAND		1	SS	17		270							
	Compact to dense, Brown, Moist to dry		2	SS	56									
	SILTY SAND, trace gravel		3	SS	30		269							
	Compact to dense, Brown to grey, Moist		4	SS	26		268							
	(FILL)		5	SS	28		267							8 73 (19)
			6	SS	40		266							
			7	SS	29									
265.3	SILTY SAND to SAND, trace gravel		8	SS	30		265							1 65 (34)
5.2	Compact to dense, Brown to grey, Moist		9	SS	42		264							
			10	SS	37		263							
			11	SS	10		261							
			12	SS	15		260							0 91 (9)
			13	SS	10		258							
			14	SS	13		257							0 96 (4)
255.5							256							

Continued Next Page




+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No S-1

2 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 408.3 N ; 425 820.1 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.06.26 LATITUDE 42.964862 LONGITUDE -81.016546 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
255.5							20	40	60	80	100							
15.0	SILTY SAND to SAND																	
	Compact, Grey, Wet		15	SS	16		255										20.9	
254.7																		
15.8	End of borehole																	
	<div><div> Water level observed during drilling</div><div> Water level measured after drilling</div></div> <div>NOTE: Borehole caved-in to 14.0 m depth</div>																	

RECORD OF BOREHOLE No S-2

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 435.9 N ; 425 771.9 E ORIGINATED BY Mi.V.
DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
DATUM Geodetic DATE 2017.06.28 LATITUDE 42.965118 LONGITUDE -81.01713 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
262.3	Ground Surface													
262.2 0.1	TOPSOIL SILTY SAND to SAND Compact to dense, Brown, Moist to wet		1	SS	23		262							
			2	SS	18		261							
			3	SS	23		260							0 86 (14)
			4	SS	11		259							
			5	SS	14		258							
			6	SS	23		257							
			7	SS	19		256							
			8	SS	32		255							0 97 (3)
			9	SS	23		254							
			10	SS	29		253							0 75 (25)
			11	SS	49		252							
248.8 13.5	CLAYEY SILT, with sand, trace gravel Hard, Grey, Dry to moist		12	SS	114/23cm		251							8 35 44 13
247.3							250							

Continued Next Page

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

RECORD OF BOREHOLE No S-2

2 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 435.9 N ; 425 771.9 E ORIGINATED BY Mi.V.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.06.28 LATITUDE 42.965118 LONGITUDE -81.01713 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
							20	40	60	80	100	W _p	W	W _L				
247.3 15.0	CLAYEY SILT, with sand, trace gravel Hard, Grey, Dry to moist		13	SS	100/15cm													
244.9 17.4	(TILL)		14	SS	100/15cm													
	End of borehole																	
	<div> Water level observed during drilling Water level measured after drilling </div> <p>NOTE: Borehole caved-in to 6.7 m depth</p>																	

RECORD OF BOREHOLE No S-3

1 OF 2

METRIC

G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 449.8 N ; 425 836.4 E ORIGINATED BY S.A.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.07.05 LATITUDE 42.965232 LONGITUDE -81.016336 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	+ FIELD VANE							
								● QUICK TRIAXIAL	× LAB VANE							
262.1 0.0	Ground Surface						20	40	60	80	100					
262.0 0.1	TOPSOIL						20	40	60	80	100					
	SILTY SAND to SAND, trace gravel		1	SS	4											
	Loose to dense, Brown, Wet															
			2	SS	13											
			3	SS	7											
			4	SS	18											1 93 (6)
			5	SS	14											
			6	SS	32											0 61 37 2
			7	SS	32											
			8	SS	36											
			9	SS	11											0 93 (7)
			10	SS	23											
			11	SS	67											1 94 (5)
248.5 13.6	SILTY SAND, some gravel		12	SS	40/8cm											
	Very dense, Grey, Wet															
	(TILL)															
247.1																

Continued Next Page

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

RECORD OF BOREHOLE No S-3

2 OF 2

METRIC

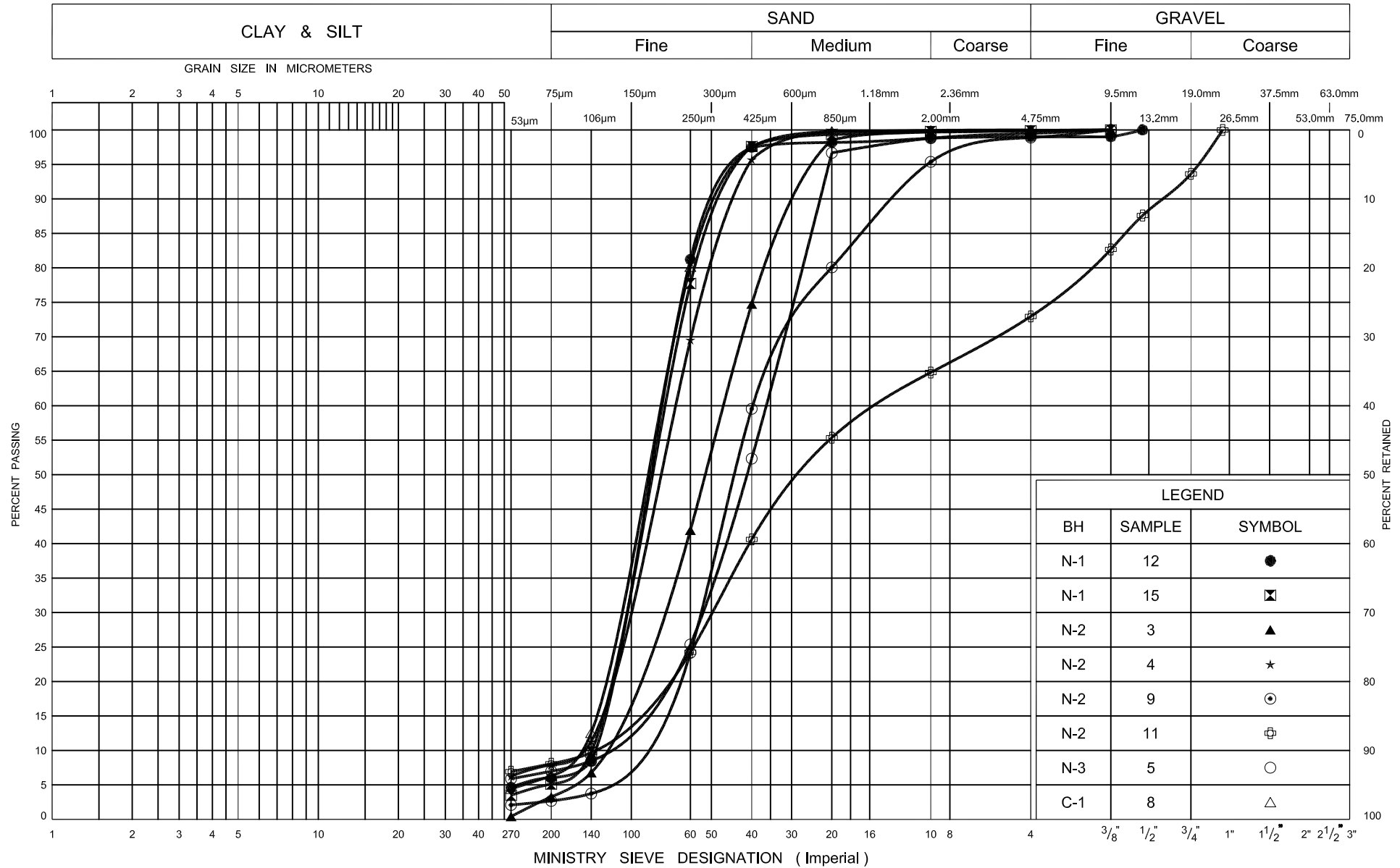
G.W.P. 3153-16-00 LOCATION Co-ords: 4 759 449.8 N ; 425 836.4 E ORIGINATED BY S.A.
 DIST London HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2017.07.05 LATITUDE 42.965232 LONGITUDE -81.016336 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L			
247.1	SILTY SAND, some gravel Very dense, Grey, Wet (TILL)		13	SS	60/10cm													
246																		
245			14	SS	60/10cm													
244																		
243.7	END OF BOREHOLE		15	SS	60/10cm													
18.4	Water level observed during drilling Water level measured after completion of drilling NOTE: Borehole caved-in to 3.2 m depth upon completion of augering																	



FIG No.	GS-1
HWY	401
G.W.P. No.	3153-16-00

UNIFIED SOIL CLASSIFICATION SYSTEM



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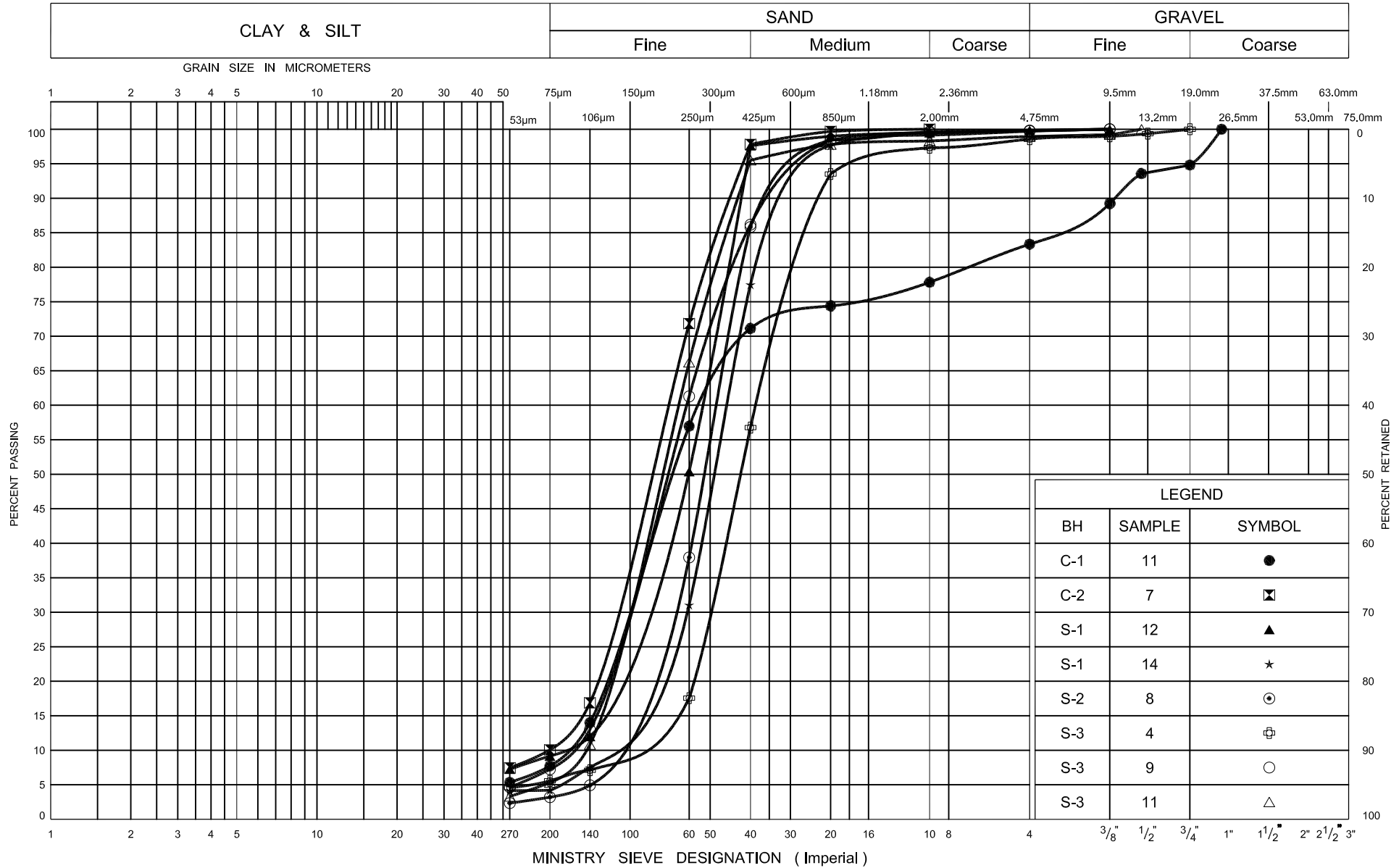
GRAIN SIZE DISTRIBUTION
SAND, trace silt, trace to with gravel
(FILL)

FIG No. GS-2A

HWY 401

G.W.P. No. 3153-16-00

UNIFIED SOIL CLASSIFICATION SYSTEM



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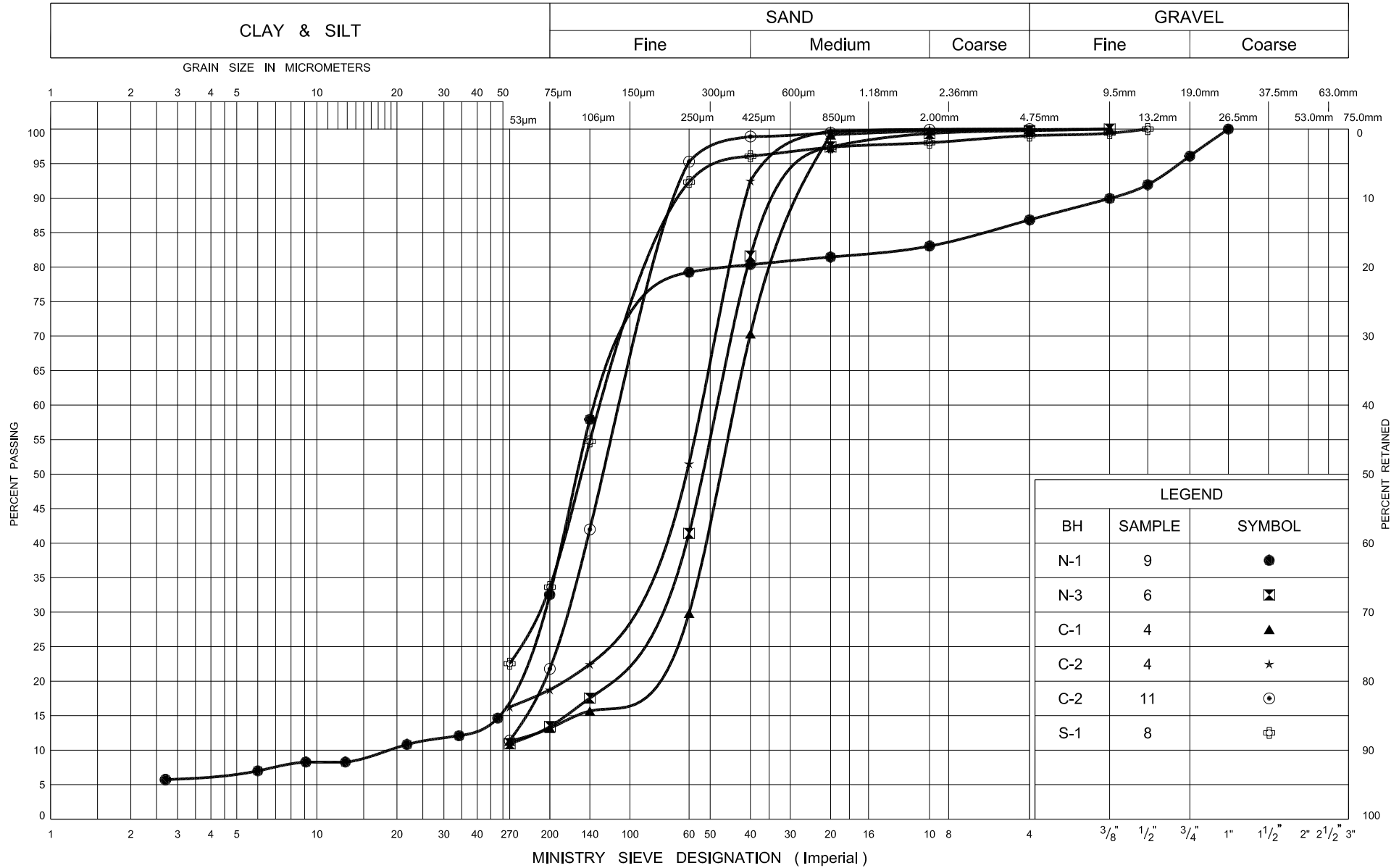
GRAIN SIZE DISTRIBUTION
SAND, trace silt, trace to with gravel
(FILL)

FIG No. GS-2B

HWY 401

G.W.P. No. 3153-16-00

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GRAIN SIZE DISTRIBUTION

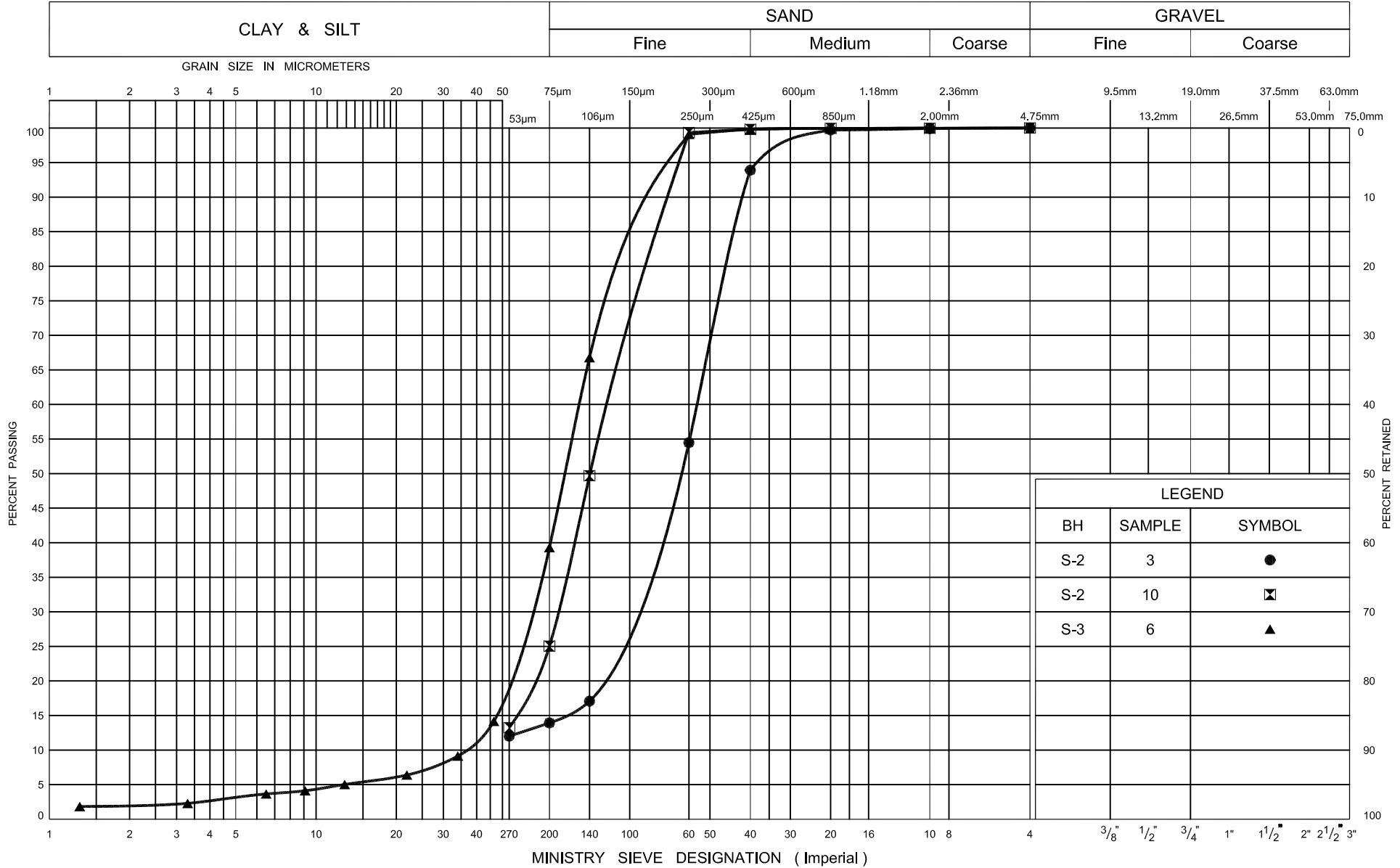
SILTY SAND, trace to some gravel, trace clay

FIG No. GS-3A

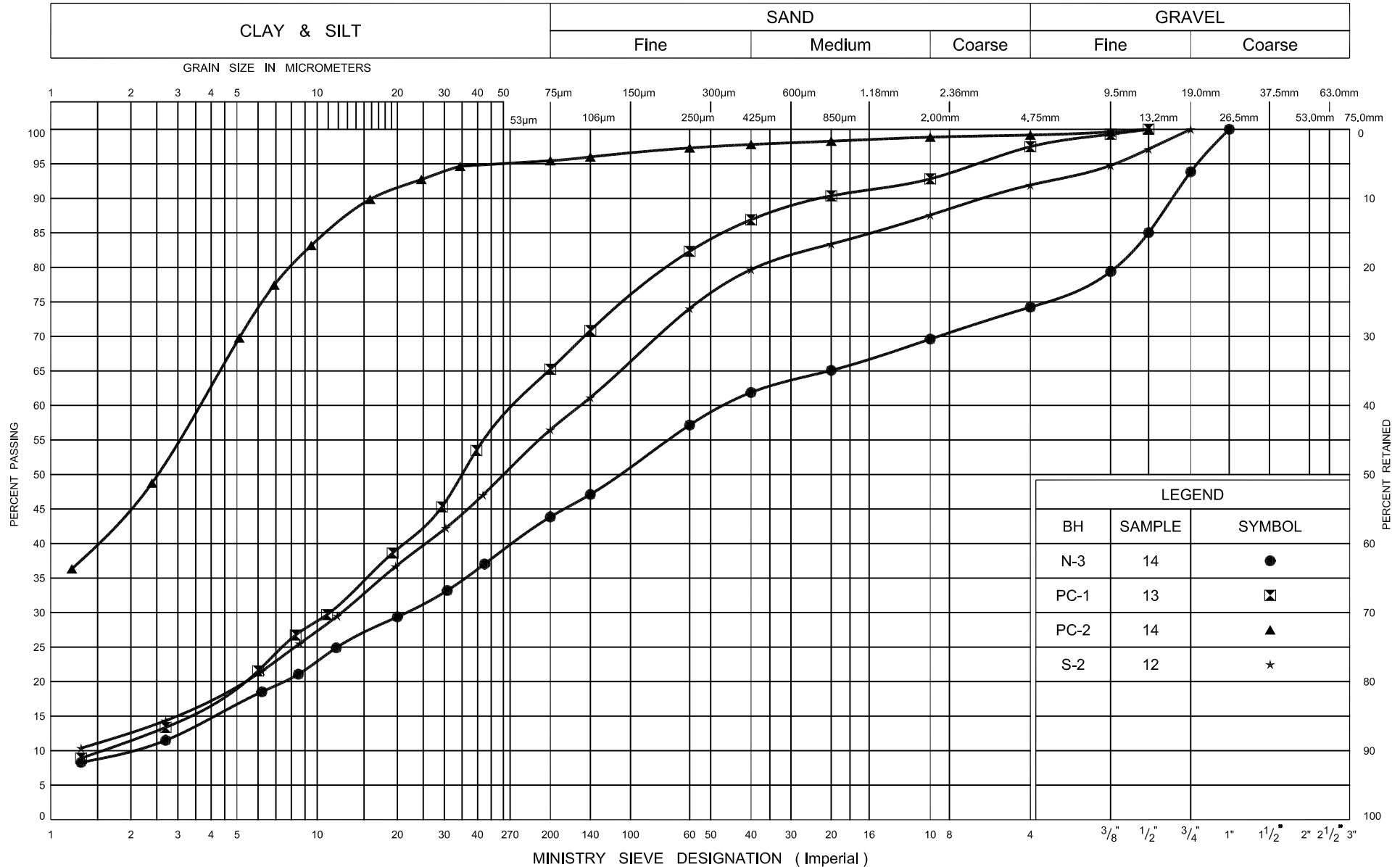
HWY 401

G.W.P. No. 3153-16-00

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM

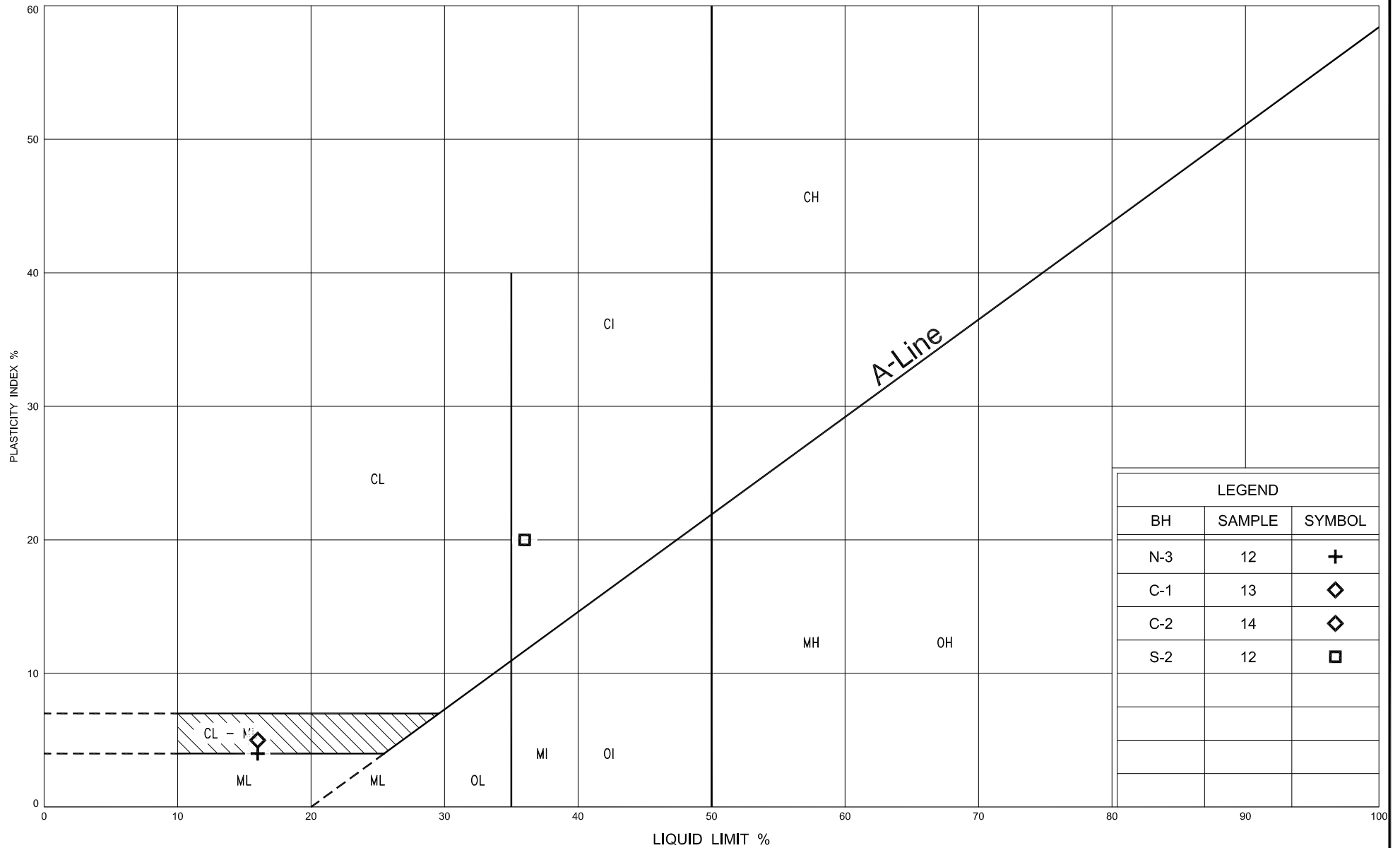


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Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, trace to with sand, trace to some gravel
(TILL)

FIG No.	GS-4
HWY	401
G.W.P. No.	3153-16-00



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Transportation

PLASTICITY CHART

SILTY SAND TO SANDY SILT, trace clay, trace gravel

FIG No. PC-1

HWY 401

PML Ref. 16TF028



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