



August 28, 2015

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**HIGH MAST LIGHT POLES  
FUTURE HIGHWAY 5 / HIGHWAY 6 INTERCHANGE AND  
ASSOCIATED MUNICIPAL ROADS, CITY OF HAMILTON  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 2112-05-00**

**Submitted to:**

IBI Group  
100 - 175 Galaxy Boulevard  
Toronto, Ontario  
M9W 0C9



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REPORT





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# **PART A**

**FOUNDATION INVESTIGATION REPORT  
HIGH MAST LIGHT POLES  
FUTURE HIGHWAY 5 / HIGHWAY 6 INTERCHANGE  
CITY OF HAMILTON  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 2112-05-00**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the proposed high mast light (HML) poles associated with the construction of a new interchange structure at the intersections of Highways 5 and 6, which is to replace the existing at-grade crossing. The proposed work is part of the overall future Highway 5 and Highway 6 interchange construction in the City of Hamilton, Ontario, which includes high fill embankments for the Highway 5 and Highway 6 re-alignments and interchange ramps, rock cut slope assessment, culvert extensions and replacements, retaining walls and overhead signs.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2010, which forms part of the Consultant's Assignment Number (Number 2008-E-0038) for this project. Golder's proposal for foundation engineering services associated with the Highway 5/Highway 6 Interchange structure is contained in Section 6.8 of IBI's Technical Proposal for this assignment and subsequent scope change dated December 9, 2013. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated September 10, 2012.

This report addresses the foundation investigation carried out for the proposed HML poles required for the proposed Highway 5/Highway 6 interchange.

## **2.0 SITE DESCRIPTION**

The compass orientations (i.e. north, south, east, west) used in this report have been referenced to the project north: Highway 5 is taken as being oriented west-east, and Highway 6 as being oriented north-south.

The proposed HML poles are to be located along the median of Highway 6 between the south and north project limits, and in the vicinity of the various proposed ramps for the proposed Highway 5 and Highway 6 interchange. The existing Highway 5 and Highway 6 intersection is located west of Waterdown and approximately 3 km north of the Highway 403/Highway 6 interchange at Clappison's Corners in the City of Hamilton, Ontario. The existing Highway 6 corridor south of Highway 5 was last widened in 2005.

The topography along and north of Highway 5 consists of relatively flat terrain which is generally at about Elevation 222 m. The ground surface slopes downward south of the intersection along Highway 6, down the Niagara Escarpment to about Elevation 195 at the south limit of the project site. Highway 6 generally traverses the escarpment in a cut up to 15 m deep through excavated bedrock as it approaches the intersection with Highway 5. North of the Highway 5-6 intersection, the Highway 6 grade slopes slightly downward to between about Elevation 220.5 m to 221 m.

Vegetation at the site is sparse, consisting of grass, small shrubs and isolated treed areas. Surplus material from the Queen Elizabeth Way (QEW) construction sites are stockpiled in the northwest quadrant of the intersection. Commercial facilities are present along the Highway 5 and Highway 6 corridors and residential properties are located along Highway 5 further to the west of the intersection.



### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Previous Investigation by Golder South of Site**

Golder carried out the foundation investigation for the widening of Highway 6 between Highway 403 and Highway 5 (G.W.P. 19-95-01), which is located south of the current site. Borehole OHS-2003-5 was advanced at the north end of that project site, which coincides with the south limit of the current project. The results of the investigation are included in report titled “Foundation Investigation Report, Overhead Signs, Highway 6 Widening Between Highways 403 and 5, G.W.P. 19-95-01” Report No. 001-1141F-8, dated August 2005. The location of the Borehole OHS-2003-5 is shown on Drawing 1 and the Record of Borehole OHS-2003-5 is included in Appendix A.

#### **3.2 Current Investigation**

The field work for the boreholes presented in this Foundation Investigation Report was carried out in September 2013, November 2013, and October-November 2014, during which time a total of 17 boreholes were advanced at the locations as shown on Drawing 1.

The borehole investigation was carried out using a track-mounted CME 55 drill rig and a truck-mounted CME 75 drill rig, supplied and operated by DBW Drilling Ltd. of Ajax, Ontario as well as a truck-mounted CME 75 drill rig, supplied and operated by Davis Drilling Ltd. of Milton, Ontario. The boreholes were advanced through the overburden using 102 mm and 150 mm outer diameter solid stem augers and 114 mm inside diameter hollow stem augers. Soil samples were obtained at ground surface or below the layer of asphalt where practical, and at intervals of depth of about 0.75 m to 1.5 m, using a 50 mm split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures<sup>1</sup>. Samples of the bedrock were obtained using an NQ-size rock core barrel and coring techniques.

The boreholes were advanced to auger and/or sampler refusal (i.e. inferred bedrock) and bedrock was confirmed by coring for approximately 3.0 m to 3.3 m in seven selected boreholes.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations. Piezometers were installed in Boreholes HML-3, HML-6, HML-7, H5-6, C2-2 and BC-4 to permit monitoring of the groundwater level at these locations. The installed piezometers consist of 37 mm (1-¼ inch) diameter PVC pipe, with a 1.5 m slotted screen sealed within a filter sand pack at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen and filter sand pack were backfilled to the ground surface with bentonite pellets. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendices A, B and C. All open boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by members of Golder’s engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling and sampling operations, logged the boreholes, and examined and cared for the soil and rock core samples. The soil and bedrock core samples were identified in the field, placed in appropriate containers, labelled and transported to Golder’s Mississauga geotechnical laboratory. In the laboratory the soil samples and rock core samples underwent further detailed visual examination and geotechnical testing (water content, Atterberg limits and grain size

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<sup>1</sup> ASTM D1586-08a – *Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soil.*



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distribution and rock core unconfined compression (uniaxial) strength testing) on selected samples. All of the laboratory tests were carried out to MTO LS and/or ASTM Standards, as appropriate. The results of the laboratory testing are noted on the Record of Borehole and Drillhole sheets and are presented on the laboratory test sheets which are included in Appendices A, B and C.

With the exception of Borehole OS-4 the as-drilled borehole locations and ground surface elevations for the boreholes listed below were surveyed by Callon Dietz, a licensed surveying company retained by Golder. The location of Borehole OS-4 was measured by Golder relative to existing site features, and plotted on the digital terrain model for the site, provided by IBI; the approximate ground surface elevation for this borehole was obtained from the topographic and contour maps also provided by IBI. The locations given in the Record of Borehole/Drillhole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

The borehole locations, ground surface elevations and drilled depths are summarized below.

Location	Borehole Number	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)		
South of Hwy 5, Along Hwy 6	HML-1	4796511.1	271399.8	194.4	10.7
	OS-2	4796767.7	271175.4	216.7	7.0
Along Hwy 5 at Hwy 6 Intersection	HML-2	4796929.5	271034.7	222.6	9.6**
	HML-3	4797072.3	271059.5	223.0	8.7**
	HML-4	4797029.0	270756.7	228.2	11.9
	HML-5	4797104.4	270843.8	222.2	9.2**
	C2-2	4796939.5	270861.0	222.3	6.6
	H5-6	4797086.5	270942.5	222.1	5.2
	H5-7	4797104.7	270959.6	222.6	5.3
	WS-1	4796977.4	270880.3	222.1	6.3
	WS-2	4796968.4	270932.5	222.5	6.3
	EN-1	4797131.6	270948.2	222.4	5.3
	EN-2	4797125.7	270923.8	222.2	5.3
North of Hwy 5 Along Hwy 6	HML-6	4797335.6	270608.9	221.6	7.5**
	HML-7	4797571.1	270371.8	221.2	6.1**
	OS-4	4797368.3	270547.7	220.5	6.4**
	BC-4	4797371.1	270573.8	220.7	3.9

\*\* Including between 3.0 m and 3.3 m of rock coring





## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

The study area is located on the Niagara Escarpment<sup>2</sup>, a topographic break that separates the two levels of the Niagara Peninsula, which is manifested in typically harder, resistant dolostone and limestone bedrock units forming vertical cliffs along the brow of the Escarpment, over the softer shale bedrock below. The Niagara Escarpment extends from the Niagara River to the northern tip of the Bruce Peninsula and is generally flanked by landscapes of glacial origin. Capping the Niagara Escarpment is the Lockport Formation consisting of white, grey and brown dolostone (Karrow, 1987)<sup>3</sup> at the crest underlain by the Rochester, Irondequoit, Reynales, Thorold, Grimsby and Cabot Head Formations consisting of grey to reddish brown shaley dolostone, limestone, siltstone and sandstone (Blair and McFarland, 1992)<sup>4</sup>.

The overburden within the study area is comprised primarily of glacial till, mapped in this area as the Halton Till, which extends as a sheet in the Hamilton area, terminating in the Waterdown Moraines east of the Niagara Escarpment. The Halton Till is generally considered a fine-grained diamicton with minor fine-grained lacustrine sediments incorporated within the body of the unit, likely from glacial reworking of underlying lacustrine sediments. The Halton Till also contains cobbles and boulders and in some areas, “boulder pavements” (Watt, 1955)<sup>5</sup> can be encountered where boulders are nested or concentrated within the till unit.

During the retreat of the last ice sheet, lakes were formed in depressions on the land surface in which were deposited sand, gravel, silt and clay materials. The last major meltwater system along the Escarpment occurred when the Waterdown Moraines were formed (to the east of this site). Several channels among the Waterdown Moraines functioned at various times, feeding meltwaters southwest toward glacial lakes to create lacustrine and outwash sand deposits.

### 4.2 Subsurface Conditions

The borehole location plan is presented on Drawing 1. The subsurface conditions at any given HML pole location may be interpreted based on the closest borehole location or, where an HML pole is located equidistant from two boreholes, by interpolation of the subsurface conditions between the two boreholes.

The detailed subsurface soil and groundwater conditions as encountered in the boreholes, including the results of the in situ tests and the results of the laboratory tests carried out on selected soil samples are presented on the borehole records in Appendix A, and on the geotechnical laboratory test figures in Appendix B. The results of the in situ field tests (i.e. SPT ‘N’-values) as presented on the borehole records and in this section are uncorrected. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress, the results of Standard Penetration Tests and interpretation of the

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<sup>2</sup> Chapman, L. J. and Putnam, D. F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000

<sup>3</sup> Karrow, P.F. 1987. *Quaternary Geology of the Hamilton-Cambridge Area, Southern Ontario*, Ontario Geological Survey, Report 255. Ministry of Northern Development and Mines, Ontario.

<sup>4</sup> Blair, R. and McFarland, S. 1993. *Regional Correlation of the Middle and Lower Silurian Stratigraphy of the Niagara Escarpment Area*, Proceedings of the 1992 Conference of the Canadian National Chapter, International Association of Hydrogeologists, Hamilton, Ontario, 659-696.

<sup>5</sup> Watt, A.K. 1955. *Pleistocene Geology and Groundwater Resources of the Township of North York*, York County, Ontario Department of Mines, Sixty Fourth Annual report, Volume LXIV, Part 7.





subsurface conditions. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In summary, the subsurface conditions at this site generally consist of the following, extending from ground surface to depth:

- asphalt and fill materials associated with the existing highways, and topsoil in boreholes located outside of the existing highways;
- a fill stockpile in the northwest quadrant of the Highway 5-6 intersection;
- thin deposits of clayey silt or sand and gravel at some borehole locations;
- a deposit of clayey silt till (the predominant native soil deposit in this area); and
- dolostone bedrock, except near Station 19+385, where shale bedrock is present below the Highway 6 grade, based on bedrock outcrop mapping (see Golder report titled “Rock Cut Assessment”, dated November 2013<sup>6</sup>) and the results from Boreholes OHS-2003-5 and HML-1.

A more detailed description of each subsurface unit is provided in the following sub-sections. However, as noted above, reference may be made to the closest borehole to each proposed HML pole location in order to interpret the subsurface conditions at any given HML pole. Such use and interpretation must take account of the grade change and bedrock cut along Highway 6 south of Highway 5 associated with the cut through the Niagara Escarpment; in this area, interpolation between boreholes should be based on depth, not elevation.

#### **4.2.1 Asphalt**

Boreholes HML-1, HML-5, HML-7, H5-6, H5-7, C2-2, OS-2, OS-4, WS-1 and WS-2 were advanced through the existing pavement structure of Highway 5 or 6, and encountered between approximately 100 mm and 200 mm of asphalt immediately below the ground surface.

#### **4.2.2 Topsoil**

In Boreholes EN-1 and EN-2, which were advanced outside of the existing pavement in the southeast quadrant of the Highway 5-6 intersection, approximately 200 mm to 300 mm of topsoil was encountered immediately below the ground surface.

#### **4.2.3 Fill – Stockpiled Material in Northwest Quadrant of Intersection**

A stockpile of fill material is present in the northwest quadrant of the Highway 5-6 intersection. It is understood that this represents surplus material from Queen Elizabeth Way (QEW) construction sites. Borehole HML-4 was advanced at a location near the crest of the stockpile, and encountered approximately 6.1 m of fill consisting of clayey silt with sand, trace to some gravel, extending to approximately Elevation 222.1 m. More detailed investigation of the stockpiled material was conducted as part of the pavement field investigation, and the results from that work are summarized in the Pavement Investigation and Design Report for this project; that investigation noted the presence of cobbles and boulders within the stockpiled material.

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<sup>6</sup> “Rock Cut Slope Assessment, Highway 5/Highway 6 Interchange (IC) and Associated Municipal Roads, City of Hamilton, Ontario, Ministry of Transportation, Ontario, GWP2112-05-00”, prepared by Golder Associates Ltd., November 2013.



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The Standard Penetration Test (SPT) “N”-values measured in Borehole HML-4 within the fill stockpile range from 6 blows to 16 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

A grain size distribution test was completed on one sample of the clayey silt fill material from the stockpile, and the result is shown on Figure B1 in Appendix B. Atterberg limits tests were completed on two samples of the clayey silt fill from the stockpile, and measured liquid limits of about 24 and 28 per cent, plastic limits of about 15 per cent, and plasticity indices of about 9 and 13 per cent. The result of the Atterberg limits tests are shown on a plasticity chart on Figure B2 in Appendix B and indicate that the stockpile material is classified as a clayey silt of low plasticity. The water content measured on three samples of the stockpile fill material range from about 7 to 13 per cent.

### 4.2.4 Fill

Fill material was encountered all boreholes at the site, except Borehole HML-2, as follows:

Site Area	Borehole No.	Depth (From – To) (m)	Elevation (From – To) (m)	Thickness (m)	Description of Fill Materials
Along Hwy 6, South of Hwy 5	OHS-2003-5	0.2 – 1.5	195.0 - 193.7	1.3	Very dense sand and gravel over very stiff clayey silt
	HML-1	0.2 – 0.8	194.2 – 193.6	0.6	Compact sand and gravel
	OS-2	0.2 – 2.0	216.5 – 213.7	1.8	Compact to very dense sand
Along Hwy 5, and in vicinity of Hwy 5/6 intersection	C2-2	0.2 – 2.3	222.1 – 220.0	2.1	Compact to very dense sand and gravel over stiff silty clay
	EN-1	0.3 – 1.4	222.1 – 221.0	1.1	Stiff clayey silt
	EN-2	0.2 – 1.4	222.0 – 220.8	1.2	Stiff clayey silt
	H5-6	0.1 – 1.4	222.0 – 220.7	1.3	Sand and gravel over stiff to very stiff clayey silt
	H5-7	0.1 – 1.4	222.5 – 221.2	1.3	Dense sand and gravel over stiff clayey silt
	HML-2	-	-	-	-
	HML-3	0.0 – 0.8	223.0 – 222.2	0.8	Firm clayey silt
	HML-4	0.0 – 6.1	228.2 – 222.1	6.1	See Section 4.2.3 regarding stockpiled fill materials
	HML-5	0.2 – 1.4	222.0 – 220.8	1.2	Very dense to compact sand and gravel
	WS-1	0.2 – 2.1	221.9 – 220.0	1.9	Compact sand and gravel to sandy silt over stiff clayey silt
	WS-2	0.2 – 1.4	222.3 – 221.1	1.2	Sand and gravel over firm clayey silt
Along Hwy 6, North of Hwy 5	BC-4	0.0 – 2.9	220.7 – 217.8	2.9	Compact silty sand and gravel over stiff clayey silt



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Site Area	Borehole No.	Depth (From – To) (m)	Elevation (From – To) (m)	Thickness (m)	Description of Fill Materials
	HML-6	0.0 – 2.2	221.6 – 219.4	2.2	Loose to compact sand and gravel over stiff silty clay
	HML-7	0.2 – 2.0	221.0 – 219.2	1.8	Very dense sand and gravel over stiff clayey silt
	OS-4	0.2 – 3.2	220.3 – 217.3	3.0	Dense to compact sand to sand and gravel over firm clayey silt

The SPT “N”-values measured within the non-cohesive fill material range from about 7 and 70 blows per 0.3 m of penetration, but are generally over 20 blows per 0.3 m of penetration, indicating a generally compact to very dense relative density. The SPT “N”-values measured within the cohesive fill range from about 5 to 18 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The results of grain size distribution tests completed on two samples of the sand to sand and gravel fill material, and four samples of the cohesive fill material, are shown on Figures B3 and B4, respectively, in Appendix B. Atterberg limits tests were carried out on five samples of the cohesive fill and measured liquid limits between about 26 and 38 percent, plastic limits between about 13 and 18 per cent, and plasticity indices between about 12 and 20 per cent. These results are shown on a plasticity chart on Figure B5 in Appendix B, and indicate that the tested cohesive fill material consists of clayey silt to silty clay of low to medium plasticity. The water contents measured on samples of the non-cohesive fill material are approximately 3 per cent to 5 per cent, while the water contents measured on samples of the cohesive fill are between approximately 12 and 28 per cent.

### 4.2.5 Clayey Silt

An approximately 0.1 m to 0.2 m thick layer of clayey silt was encountered below the fill material in Boreholes HML-1 and HML-7, and a 1.4 m thick layer of clayey silt was encountered immediately below the ground surface in Borehole HML-2. The deposit consists of clayey silt with sand to trace sand, trace to some gravel.

The SPT “N”-values of 10 and 14 blows per 0.3 m of penetration were measured in the clayey silt deposit, suggesting a stiff consistency. The natural water contents measured on two samples of the clayey silt deposit were 13 and 14 per cent.

### 4.2.6 Sand and Gravel

An approximately 0.4 m thick layer of sand and gravel was encountered underlying the fill in Borehole OS-2. The top of this layer was encountered at about Elevation 213.7 m.

An SPT “N”-value of 59 blows per 0.28 m of penetration was measured at the interface of this deposit and the underlying dolostone rock fragment layer, indicating a very dense relative density.

This layer consists of sand and gravel containing trace to some silt and trace clay. A grain size distribution was completed on one sample of the sand and gravel deposit and the result is presented on Figure B6 in Appendix B. The natural water content measured on a sample of this deposit is about 5 per cent.



#### 4.2.7 Clayey Silt Till

A deposit of clayey silt till was encountered beneath the fill material or thin native soil layers in most of the boreholes at the site, overlying the bedrock, as summarized below:

Site Area	Borehole No.	Depth (From – To) (m)	Elevation (From – To) (m)	Thickness (m)
Along Hwy 6, South of Hwy 5	OHS-2003-5	1.5 – 2.0	193.7 – 193.2	0.5
	HML-1	-	-	-
	OS-2	-	-	-
Along Hwy 5, and in vicinity of Hwy 5/6 intersection	C2-2	2.3 – 6.6	220.0 – 215.7	4.3
	EN-1	1.4 – 5.3	221.0 – 217.1	3.9
	EN-2	1.4 – 5.3	220.8 – 216.9	3.9
	H5-6	1.4 – 5.2	220.7 – 216.9	3.8
	H5-7	1.4 – 5.3	221.2 – 217.3	3.9
	HML-2	1.4 – 6.3	221.2 – 216.3	4.9
	HML-3	0.8 – 5.5	222.2 – 217.5	4.7
	HML-4	6.1 – 11.9	222.1 – 216.3	5.8
	HML-5	1.4 – 6.2	220.8 – 216.0	4.8
	WS-1	2.1 – 6.3	220.0 – 215.8	4.2
	WS-2	1.4 – 6.3	221.1 – 216.2	4.9
Along Hwy 6, North of Hwy 5	BC-4	2.9 – 3.9	217.8 – 216.8	1.0
	HML-6	2.2 – 4.4	219.4 – 217.2	2.2
	HML-7	2.2 – 2.8	219.0 – 218.4	0.6
	OS-4	-	-	-

The SPT “N”-values measured within the till deposit range from 8 blows to 57 blows per 0.3 m of penetration, suggesting that the clayey silt till has a firm to hard consistency.

The till deposit is generally comprised of clayey silt with sand to some sand, trace gravel; seams or layers of water-bearing sands/silts were observed within the till in some boreholes, as noted on the borehole records in Appendix A. Bedrock fragments were also noted within some samples of the till deposit. Cobles and/or boulders were inferred from auger resistance in Borehole HML-2 at a depth of 5.2 m (Elevation 217.4 m). Although there was no direct evidence of obstructions in other boreholes, till deposits in southern Ontario typically contain cobbles and boulders and they should be expected within the till deposit at this site. Grain size distribution tests were completed on 18 selected samples of the clayey silt till deposit and the results are shown on Figures B7A to B7C in Appendix B.

Atterberg limits tests were completed on 22 selected samples of the till deposit and measured liquid limits between about 22 and 32 per cent, plastic limits between about 12 and 17 per cent, and plasticity indices between about 9 and 16 per cent. The results of the Atterberg limits tests are shown on a plasticity chart on Figures B8A to B8C in Appendix C, and confirm that the till material is classified as a clayey silt of low plasticity. The natural water content measured on selected samples of the clayey silt till ranges from about 12 to 20 per cent.



#### 4.2.8 Bedrock

South of the Highway 5 and 6 intersection, Highway 6 was constructed in a man-made rock cut and therefore at the south end of the project, the bedrock below the highway grade consists of shale. Further north, where the bedrock surface is at depth below the ground surface, the bedrock consists of dolostone.

Bedrock was encountered and core samples were recovered in Boreholes OHS-2003-5, OS-2, OS-4, HML-2, HML-3, HML-5, HML-6 and HML-7. Borehole HML-1 was able to be advanced through the shale bedrock using hollow stem augers and split-spoon sampling to a depth of 10.7 m (Elevation 183.7 m). Borehole OHS-2003-5 was advanced approximately 1.5 m below the bedrock surface with solid stem augers, prior to coring of the bedrock. In Boreholes OHS-2003-5 and HML-1 the split-spoon sampler was advanced for a distance of between 0.3 m and 0.6 m for each sample taken in the upper 1.5 m and 1.9 m below the bedrock surface, respectively, indicating that the bedrock within this zone is likely fractured, becoming more intact with depth. In the remaining boreholes, the dolostone bedrock surface has been inferred based on refusal to auger and split-spoon sampler penetration. The depth to bedrock or refusal and the corresponding bedrock surface or refusal elevation as encountered in the boreholes are summarized below:

Site Area	Borehole No.	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface/ Refusal Elevation (m)	Comments
Along Hwy 6, South of Hwy 5	OHS-2003-5	2.0	193.2	Shale bedrock cored.
	HML-1	0.9	193.5	Shale bedrock penetrated by augering and split-spoon sampling
	OS-2	3.4	212.8	Dolostone bedrock cored; note an approximately 0.5 m thick layer of dolostone fragments was encountered between the sand and gravel and the bedrock, below Elevation 213.3 m
Along Hwy 5, and in vicinity of Hwy 5/6 intersection	C2-2	6.6	215.7	Split-spoon refusal
	EN-1	5.3	217.1	Auger refusal
	EN-2	5.3	216.9	Auger refusal
	H5-6	5.2	216.9	Auger refusal
	H5-7	5.3	217.3	Auger refusal
	HML-2	6.3	216.3	Dolostone bedrock cored
	HML-3	5.5	217.5	Dolostone bedrock cored
	HML-4	11.9	216.3	Auger and split-spoon refusal
	HML-5	6.2	216.0	Dolostone bedrock cored
	WS-1	6.3	215.8	Auger and split-spoon refusal
Along Hwy 6, North of Hwy 5	WS-2	6.3	216.2	Auger and split-spoon refusal
	BC-4	3.9	216.8	Auger and split-spoon refusal
	HML-6	4.4	217.2	Dolostone bedrock cored
	HML-7	2.8	218.4	Dolostone bedrock cored
	OS-4	3.4	217.1	Dolostone bedrock cored; note an approximately 0.2 m thick layer of



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Site Area	Borehole No.	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface/ Refusal Elevation (m)	Comments
				dolostone fragments was encountered between the fill and bedrock, below Elevation 217.3 m

Based on the information provided on Record of Drillhole OHS-2003-5 and the split-spoon samples from Borehole HML-1, the bedrock at these two borehole locations consists of shale of the Thorold, Grimsby and Cabot Head Formation. In general, the bedrock samples are described as slightly weathered to fresh, grey to reddish brown, weak to medium strong shale containing limestone and dolostone seams and interlayers, as presented on the Record of Drillhole sheets in Appendix A.

Based on visual review of the bedrock core samples from the remaining boreholes the bedrock consists of dolostone of the Lockport Formation. In general, the bedrock samples are described as slightly weathered to fresh, thinly to medium bedded, fine-grained to medium crystalline, faintly to moderately porous, strong and grey, as presented on the Record of Drillhole sheets in Appendix A, and as shown on the photographs of the recovered core samples on Figures B9A-C in Appendix B. The degree of weathering of the bedrock core samples (i.e., fresh to slightly weathered – W1 to W2), and the strength classification of the intact rock mass based on field identification (i.e. strong to very strong – R4 to R5) are described in accordance with the International Society for Rock Mechanics (ISRM, 1985)<sup>6</sup> standard classification system.

The Total Core Recovery (TCR) and the Solid Core Recovery (SCR) of the shale core samples are between about 75 percent and 93 per cent. The Rock Quality Designation (RQD) measured on the shale core samples ranges from 40 per cent to 55 per cent, indicating a rock mass for the shale as poor to fair quality per Table 3.10 of CFEM (2006).<sup>7</sup>

The TCR and the SCR of the dolostone core samples are between about 84 and 100 per cent, and 72 and 100 per cent, respectively. The RQD measured on the core samples ranges from 60 per cent to 100 per cent, indicating a rock mass for the dolostone as fair to excellent quality per Table 3.10 of CFEM (2006).<sup>7</sup>

Unconfined compression testing (ASTM D7012) was carried out on seven dolostone bedrock core samples, and measured unconfined compressive strengths ranging from about 73 MPa to 106 MPa, as shown on the Record of Drillhole sheets in Appendix A, and in Table B1 and Figures B10 to B13 in Appendix B. In addition, point load strength index tests (ASTM D5731)<sup>7</sup> were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values ( $Is_{50}$ ) are shown on the drillhole records in Appendix A, and in Table B2 in Appendix B. Table B2 also presents estimated unconfined compressive strength values, based on a relationship between  $Is_{50}$  and UCS that is given by a correlation factor ( $K$ )<sup>9</sup> that varies depending on the size of the core sample and the site-specific strength of the rock as confirmed from the UCS testing.

Based on the result of the laboratory unconfined compressive strength tests and in accordance with Table 3.5 in CFEM (2006)<sup>7</sup>, the dolostone bedrock is classified as strong ( $R4$ ,  $50 \text{ MPa} < \text{UCS} < 100 \text{ MPa}$ ) to very strong ( $R5$ ,  $100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$ ).

<sup>7</sup> ASTM D5731 – Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification



#### 4.2.9 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the borehole records in Appendix A. A standpipe piezometer was installed in Boreholes BC-4, C2-2, H5-6, HML-3, HML-6 and HML-7 to monitor the groundwater level across the site; details of the piezometer installations are shown on the borehole records contained in Appendix A. The groundwater levels measured in the open boreholes and in the piezometers are summarized below:

Site Area	Borehole No.	Highest Groundwater Level During Drilling (Depth/Elevation)	Highest Groundwater Level in Piezometer (Depth/Elevation)	Date of Piezometer Reading
Along Hwy 6, South of Hwy 5	HML-1	5.5 m / 188.9 m	--	--
Along Hwy 5, and in vicinity of Hwy 5/6 intersection	C2-2	4.6 m / 217.7 m	2.7 m / 219.6 m	January 27, 2015
	EN-1	4.7 m / 217.7 m	--	--
	EN-2	4.8 m / 217.4 m	--	--
	H5-6	3.8 m / 218.3 m	1.8 m / 220.3 m	February 13, 2013
	H5-7	5.0 m / 217.6 m	--	--
	HML-2	Dry prior to rock coring	--	--
	HML-3	2.9 m / 220.1 m	1.4 m / 221.6 m	January 8, 2015
	HML-4	11.1 m / 217.1 m	--	--
	HML-5	4.1 m / 218.1 m	--	--
	WS-1	Dry	--	--
	WS-2	Dry	--	--
Along Hwy 6, North of Hwy 5	BC-4	Dry	3.7 m / 217.0 m	November 2, 2014
	HML-6	4.1 m / 217.5 m	3.6 m / 218.0 m	November 2, 2014
	HML-7	Dry prior to rock coring	2.9 m / 218.3 m	January 27, 2015

Based on the piezometers installed in the vicinity of the intersection of Highway 5 and Highway 6, it is anticipated that the groundwater level is at approximately Elevation 219.6 m to 221.6 m. The groundwater level will slope downward to the south, following the topography of the Highway 6 cut through the escarpment. It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.





## 5.0 CLOSURE

Mr. Alex Szot, an engineer-in-training with Golder supervised the field drilling program. This report was prepared by Ms. Sandra McGaghran, M.Eng., P.Eng a geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for this project and Principal with Golder, conducted an independent review and quality control audit of this report.

**GOLDER ASSOCIATES LTD.**



Sandra McGaghran, M.Eng., P.Eng.  
Geotechnical Engineer, Associate



Lisa Coyne, P.Eng.  
Designated MTO Foundations Contact, Principal

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# **PART B**

**FOUNDATION DESIGN REPORT  
HIGH MAST LIGHT POLES  
FUTURE HIGHWAY 5 / HIGHWAY 6 INTERCHANGE  
CITY OF HAMILTON  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 2112-05-00**



## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides geotechnical parameters and recommendations for the detail foundation design of nineteen proposed high mast light (HML) pole supports required in conjunction with the proposed interchange at Highway 5 and Highway 6 in the City of Hamilton, Ontario. The recommendations are based on interpretation of the factual data obtained from boreholes advanced during the subsurface investigation for this project. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the design of the proposed structure foundations.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on aspects related to construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### 6.2 Design of High Mast Light Pole Foundations

The HML pole foundations should be designed in accordance with MTO's *Guidelines for the Design of High Mast Pole Foundations*, dated May 2004. For the nineteen proposed HML poles, the location, existing and proposed ground surface elevation, and the top of footing elevation were provided by IBI in an email dated April 6, 2015, and these data are summarized in Table 1, following the text of this report. Table 1 also provides a summary of the selected relevant borehole for each HML pole location, and a summary of the subsurface conditions encountered in the borehole.

High mast light pole foundations typically consist of reinforced, cast-in-place concrete caissons constructed within the soil, nominally socketted into bedrock (where the overburden soils do not provide sufficient lateral resistance), or embedded into the bedrock (where bedrock is present at relatively shallow depth). As an alternative to embedding a caisson into the bedrock where bedrock is quite shallow, consideration could be given to supporting the HML pole on a spread footing anchored to the bedrock, or a caisson nominally socketted into the bedrock with dowels/anchors extending into the bedrock to achieve the required lateral/uplift resistance.

The anticipated foundation types for the proposed HML poles at this site are summarized as follows:

- At HML Poles P4 to P10 (inclusive), P17 and P18, the depth to bedrock varies from about 4.6 m to 7.5 m below the proposed finished ground surface elevation; it is anticipated that caissons socketted into bedrock will be the most practical and effective foundation solution at these locations.
- Spread footings or caissons anchored into bedrock could be considered as an alternative to caissons socketted deeper into bedrock at HML Poles P1, P2 and P3 (which are located in the south end of the project), and P11, P12 and P13 (which are located at the north end of the project), where the depth to bedrock below the proposed finished ground surface elevation varies from about 2.7 m to 3.9 m.
- At HML Poles P14, P15, P16 and P19, it is anticipated that the required lateral resistance may be able to be developed within the overburden, or with only nominal socketting into the bedrock. HML Pole P14 and P19 are proposed adjacent to Highway 5, where the proposed grade will be raised by about 4.9 m and 5.9 m respectively, and therefore these caissons may develop sufficient lateral resistance within the soil



(i.e., the proposed new fill material, existing fill material and native soils). The proposed HML Poles P15 and P16 are located in the vicinity of the existing stockpile material in the northwest quadrant of the intersection, and are adjacent to the proposed embankment along Ramp E-S and Ramp N-E/W, respectively. As recommended in Golder's Foundation Investigation and Design Report for High Fill Embankments (2014) for this project, the stockpiled material is required to be removed and replaced with engineered fill material; parameters for new fill are provided in Table 1. Since the proposed grade at HML Poles P15 and P16 will be about 5 m above the grade beyond the proposed ramps and clayey silt till extends about 5 m below the underside of the existing fill it is anticipated that sufficient lateral resistance will be developed in the soil.

It is noted that in the vicinity of HML Poles P1, P2, P3 and P4, the ground surface and the bedrock surface elevations change substantially as the grade increases to the north, through the Highway 6 cut in the escarpment, towards the intersection of Highways 5 and 6. The estimated bedrock surface elevations provided in Table 1 for HML Poles P1, P2 and P4 are based on interpolating the bedrock surface between Boreholes HML-1, OS-2 and HML-2, where the ground surface varies from Elevation 194.4 m to 222.6 and the bedrock surface varies from Elevation 193.5 m to 216.3 m as encountered in the boreholes. It is recommended that the Contractor be warned about the potential for variation between the estimated bedrock surface and the actual bedrock surface at these locations; an NSSP is included in Appendix C.

### 6.2.1 Caisson Foundation Design in Soil

The caisson foundation may be designed using the following equations to calculate the unfactored passive lateral earth pressure,  $P_p$  (kPa), distributed along the length of the caisson, based on the stratigraphy and geotechnical design parameters given in Table 1 following the text of this report.

$$P_p = K_p \gamma d + 2 c_u / K_p \quad \text{above the groundwater table}$$

$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) + 2 c_u / K_p \quad \text{below the groundwater table}$$

where:

- $K_p$  = passive earth pressure coefficient;
- $\gamma$  = bulk unit weight ( $\text{kN/m}^3$ );
- $\gamma'$  = effective unit weight below the groundwater level ( $\text{kN/m}^3$ );
- $d$  = depth below the ground surface (m); and
- $d_w$  = depth to the groundwater level (m).

In the design of the foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action. The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at Ultimate Limit States (ULS).

Where both undrained shear strength and effective stress parameters are provided for fill material, such as at HML Pole P4, the structural assessment should be completed for both cases, and the more conservative approach adopted. In this case, the lateral resistance for the length of the caisson within the cohesive soil should be calculated assuming an internal angle of friction,  $\Phi' = 0$  degrees, and an unfactored passive lateral



pressure distribution varying from  $2 S_u$  at 1.2 m below finished grade (i.e. frost penetration depth) to  $9 S_u$  at and below a depth equivalent to three caisson diameters, acting over the actual width/diameter of the caisson.

### **6.2.2 Caisson Foundation with Tip Nominally Socketted in Rock**

For some of the HML pole locations, the overburden thickness may not be sufficient to provide the required lateral resistance and a nominal socket into the bedrock may be needed. In this case, the socket depth into the rock must not be less than 0.5 times the caisson diameter. The horizontal bearing resistance of the strong to very strong dolostone bedrock at this site will be greater than the strength of the concrete; however, in accordance with MTO practice, the socket depth must be such that the resulting horizontal bearing pressure in the rock is less than the compressive strength of the concrete in the caisson.

### **6.2.3 Caisson Foundations Embedded in Rock**

Where the bedrock surface is relatively shallow, consideration could be given to embedding the caisson into rock. Such caissons are required to have a minimum embedment into sound bedrock of 2.5 m below the bottom of frost penetration. The horizontal bearing resistance of the strong to very strong dolostone bedrock at this site will be greater than the strength of the concrete; however in accordance with MTO practice, the socket depth must be such that the resulting horizontal bearing pressure in the rock is less than the compressive strength of the concrete in the caisson. The depth to “sound” bedrock is provided in Table 1, along with recommended values for  $f_{horiz}$  (the factored horizontal bearing capacity of sound rock at Ultimate Limit States, as defined in *Guidelines for the Design of High Mast Pole Foundations*).

It is noted that the dolostone bedrock at the site is generally strong to very strong, and coring, churn drilling or other appropriate techniques will be necessary to advance the socket into the bedrock. As an alternative to the minimum rock socket length of 2.5 m, caissons or spread footings anchored to the rock may be considered. Recommendations for the rock anchors are provided in the Section 6.2.4.

### **6.2.4 Foundations Anchored into Bedrock**

If anchoring is adopted, it is recommended that the concrete foundations (either caissons or spread footings) be embedded a minimum of 0.3 m into the bedrock. As per Section 6.2 of *Procedures for the Design of High Mast Pole Foundations*, a minimum concrete foundation length of 1.75 m is required to allow sufficient length for the anchorage assembly.

Since the compressive strength of the caisson concrete is lower than the compressive strength of the strong to very strong bedrock at the site, the vertical bearing resistance should be taken as limited by the compressive strength of the concrete in the caisson.

Based on the boreholes advanced at site it is expected that the bedrock at all HML pole locations, with the exception of P1, will consist of dolostone. The unfactored bond strength between the grout and dolostone bedrock may be taken as 1,400 kPa for design of rock anchors/dowels to support the HML pole foundations in tension. At the location of HML Pole P1, the bedrock consists of shale and the upper 2.0 m is of poor quality; if consideration is given to anchoring this caisson into the bedrock, it is recommended that the anchor bond zone be at least 2.0 m below the bedrock surface. The unfactored bond strength between the grout and shale bedrock (at a depth of at least 2.0 m below the bedrock surface) may be taken as 500 kPa for design of rock anchors/dowels to support the HML P1 pole foundation in tension.



If consideration is given to the use of anchors/dowels into the rock, Section 6.2 of the *Guidelines for the Design of High Mast Pole Foundations* requires that the anchors be a minimum of 1.75 m long for 25 m, 30 m and 35 m high poles. It is understood that P15 and P18 will be 30 m high poles and the remainder will be 25 m high poles. Taking into consideration the caisson diameter, the number of anchors and the diameter of the anchor hole as presented on Table 6 of the *Guidelines for the Design of High Mast Pole Foundations* for 25 m and 30 m high poles no reduction in ultimate bond strength between the grout and bedrock (shale or dolostone) is required. In addition, if consideration is given to supporting the pole with anchors into bedrock, a test program is recommended as part of construction to confirm the allowable bond stress, as recommended in *Guidelines for the Design of High Mast Pole Foundations* and the requirements of OPSS 942 (*Construction Specification for Prestressed Soil and Rock Anchors*).

The horizontal resistance of dowels is dependent on the strength of the bedrock, grout and steel. At this site, the rock mass is stronger than concrete, and so the design of the dowels in the rock should be handled in the same way as the dowel embedment into the concrete, assuming that the unconfined compressive strength of the grout is similar to that of the concrete. The structural strength of the dowel and the compressive strength of the grout should not be exceeded.

As these are permanent rock anchors/dowels, they should be provided with suitable corrosion protection or sacrificial thickness of steel. Anchor installation, grouting and testing should be carried out in accordance with OPSS 942 (*Construction Specification for Pre-Stressed Soil and Rock Anchors*).

## **6.3 Construction Considerations**

Construction of the caissons for the HML poles should be in accordance with OPSS 903 (*Construction Specification for Deep Foundations*).

### **6.3.1 Control of Soil and Groundwater**

Water-bearing non-cohesive (sand to sand and gravel) layers within the fill and/or water-bearing non-cohesive (sand/silt) interlayers within the cohesive till deposit are expected to be present at the proposed HML pole locations. Depending on the period of the year, “perched” groundwater may also be encountered at the base of non-cohesive fill or native soils, atop the underlying, less permeable clayey silt fill or clayey silt till deposits. Wet non-cohesive soil deposits and pockets should be expected to run or flow into the drilled hole during or after augering for the HML pole foundations. Therefore, temporary or permanent caisson liners should be used during advancement of the caissons to minimize ground loss during drilling and concrete placement. It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of this condition; such an NSSP is provided in Appendix C.

The final grade surrounding the HML pole should be sloped to promote surface water drainage and pavement structure drainage away from the pavement and HML pole, to the adjacent ditches.

### **6.3.2 Foundations in Bedrock**

Caisson foundations at the HML pole locations will extend into the dolostone bedrock, which is generally strong to very strong below the fractured (fragments) zone; however, at HML Pole P1, weak to medium strong shale bedrock is present. Appropriate construction procedures and equipment (such as coring or churn drilling equipment) will be required to penetrate the bedrock. It is recommended that an NSSP be included in the Contract Documents to warn the Contractor of this condition; such an NSSP is provided in Appendix C. If



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dowelling is required for structural considerations, a Non-Standard Special Provision (NSSP) should be included in the Contract Documents to specify the installation, materials and testing of the dowels; this will be developed if this foundation type is selected for some of the HML poles at this site.

### 7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Sandra McGaghran, M.Eng., P.Eng., a geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and Principal with Golder, conducted an independent review and quality control audit of this report.

**GOLDER ASSOCIATES LTD.**



Sandra McGaghran, M.Eng., P.Eng.  
Geotechnical Engineer, Associate



Lisa Coyne, P.Eng.  
Designated MTO Foundations Contact, Principal

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### Ontario Provincial Standard Specifications (OPSS)

- OPSS 903                Construction Specification for Deep Foundations
- OPSS 942                Construction Specification for Pre-Stressed Soil and Rock Anchors

### Ontario Provincial Standard Drawings (OPSD)

- OPSD 3090.101        Foundation Frost Penetration Depths for Southern Ontario

### ASTM International

- ASTM D1586 – Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils.
- ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens.
- ASTM D5731 – Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification

### Ontario Water Resources Act:

- Ontario Regulation 903/90   Wells



TABLE 1 - GEOTECHNICAL DESIGN PARAMETERS FOR HIGH MAST LIGHT POLE FOUNDATIONS  
FOUNDED IN SOIL AND/OR SOCKETTED INTO BEDROCK

HML Pole No	Station	Borehole No./ Ground Surface at Borehole	Original Ground Elevation at HML Pole	Finished Ground Elevation at HML Pole	Top of Footing Elevation	Stratum	Depth <sup>1</sup> (m)	Elevation (m)	Design Parameters <sup>2,3</sup>							Design Groundwater Elevation (m)
									$S_u$ (kPa)	$\phi'$ (°)	$\gamma$ (kN/m <sup>3</sup> )	$\gamma'$ (kN/m <sup>3</sup> )	$K_p$	$n_h$ (kPa/m)	$f_{horiz}$ (kPa)	
P1	19+385	OHS-2003-5 (195.2) HML-1 (194.4)	202.3	202.6	203.6	Compact sand and gravel fill	0.0 – 0.9	202.6 – 201.7	--	30	20	10	3.0	6,600	--	201.0
						Shale Bedrock fragments	0.9 – 2.9	201.7 – 198.8	--	36	23	13	3.9	8,000	--	
						Shale Bedrock	Below 2.9	Below 198.8	--	40	23	13	--	--	1,500	
P2	19+500	HML-1 (194.4)	210.3	210.3	211.4	Compact sand and gravel fill	0.0 – 0.9	210.3 – 209.4	--	30	20	10	3.0	6,600	--	209.0
						Slightly weathered limestone/dolostone	Below 0.9	Below 209.4	--	40	23	13	--	--	5,000	
P3	19+615	OS-2 (216.7)	216.9	216.7	217.8	Compact to very dense sand fill	0.0 to 3.0	216.7 to 213.7	--	30	20	10	3.0	6,600	--	215.5
						Very dense sand and gravel	3.0 – 3.4	213.7 – 213.3	--	34	21	11	3.5	11,000	--	
						Dolostone fragments	3.4 – 3.9	213.3 – 212.8	--	40	23	13	4.5	11,000	--	
						Slightly weathered to fresh dolostone bedrock	Below 3.9	Below 212.8	--	40	23	13	--	--	5,000	
P4	19+725	OS-2 (216.7)	220.7	220.7	220.7	Compact to very dense sand fill	0.0 – 5.2	220.7 – 215.5	--	30	20	10	3.0	6,600	--	219.5
						Very dense sand and gravel	5.2 - 5.6	215.5 - 215.1	--	34	21	11	3.5	11,000	--	
						Dolostone fragments	5.6 - 6.1	215.1 - 214.6	--	40	23	13	4.5	11,000	--	
						Slightly weathered to fresh dolostone bedrock	Below 6.1	Below 214.6	--	40	23	13	--	--	5,000	
		HML-2 (222.6)	220.7	220.7	220.7	Stiff clayey silt	0.0 – 1.4	220.7 – 219.3	75	30	20	--	3.0	--	--	
						Very stiff to hard clayey silt till	1.4 – 6.1	219.3 – 214.6	150	34	21	11	3.5	--	--	
P5	19+830	HML-2 (222.6)	222.5	222.6	223.6	Slightly weathered dolostone bedrock	Below 6.1	Below 214.6	--	40	23	13	--	--	5,000	221.0
						Stiff clayey silt	0.0 – 1.4	222.6 – 221.2	75	30	20	--	3.0	--	--	
						Very stiff to hard clayey silt till	1.4 – 6.3	221.2 – 216.3	150	34	21	11	3.5	--	--	
P6	19+940	WS-2 (222.5)	222.0	222.4	223.4	Slightly weathered dolostone bedrock	Below 6.3	Below 216.3	--	40	23	13	--	--	5,000	220.5
						Firm to very stiff clayey silt fill	0.0 – 2.4	222.4 – 220.0	50	28	19	9	2.8	--	--	
						Stiff to hard clayey silt with sand till	2.4 – 6.2	220.0 – 216.2	150	34	21	11	3.5	--	--	
P7	20+085	HML-5 (222.2)	222.2	222.4	223.5	Slightly weathered dolostone bedrock	Below 6.2	Below 216.2	--	40	23	13	--	--	5,000	221.0
						Compact to very dense sand and gravel fill	0.0 – 1.7	222.4 – 220.8	--	30	20	--	3.0	6,600	--	
						Stiff to very stiff clayey silt till	1.7 – 6.4	220.8 – 216.0	100	32	20	--	3.3	--	--	
P8	20+195	HML-5 (222.2) HML-6 (221.6)	223.5	223.7	224.7	Slightly weathered dolostone bedrock	Below 6.4	Below 216.0	--	40	23	13	--	--	5,000	222.0
						Compact to very dense sand and gravel fill	0.0 – 4.3	223.7 – 219.4	--	30	20	10	3.0	6,600	--	
						Stiff to very stiff clayey silt till	4.3 – 7.7	219.4 – 216.0	100	32	20	10	3.3	--	--	
P9	20+305	HML-5 (222.2) HML-6 (221.6)	223.3	223.5	224.5	Slightly weathered to fresh dolostone bedrock	Below 7.7	Below 216.0	--	40	23	13	--	--	5,000	222.0
						Compact to very dense sand and gravel fill	0.0 – 4.1	223.5 – 219.4	--	30	20	10	3.0	6,600	--	
						Stiff to very stiff clayey silt till	4.1 – 7.5	219.4 – 216.0	100	32	20	10	3.3	--	--	
P10	20+415	HML-6 (221.6)	221.6	221.8	222.5	Slightly weathered to fresh dolostone bedrock	Below 7.5	Below 216.0	--	40	23	13	--	--	5,000	220.5
						Loose to compact sand and gravel fill	0.0 - 1.4	221.8 – 220.4	--	28	19	--	2.8	1,300	--	
						Stiff silty clay fill	1.4 – 2.4	220.4 – 219.4	50	28	19	9	2.8	--	--	
						Stiff to very stiff clayey silt till	2.4 – 4.6	219.4 – 217.2	100	32	20	10	3.3	--	--	
P10	20+415	HML-6 (221.6)	221.6	221.8	222.5	Slightly weathered to fresh dolostone bedrock	Below 4.6	Below 217.2	--	40	23	13	--	--	5,000	220.5
						Slightly weathered to fresh dolostone bedrock	Below 4.6	Below 217.2	--	40	23	13	--	--	5,000	



FOUNDATION REPORT – HIGH MAST LIGHTS  
FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE, GWP 2112-05-00

HML Pole No	Station	Borehole No./ Ground Surface at Borehole	Original Ground Elevation at HML Pole	Finished Ground Elevation at HML Pole	Top of Footing Elevation	Stratum	Depth <sup>1</sup> (m)	Elevation (m)	Design Parameters <sup>2,3</sup>							Design Groundwater Elevation (m)
									$S_u$ (kPa)	$\phi'$ (°)	$\gamma$ (kN/m <sup>3</sup> )	$\gamma'$ (kN/m <sup>3</sup> )	$K_p$	$n_h$ (kPa/m)	$f_{horiz}$ (kPa)	
P11	20+525	OS-4 (220.5)	220.4	220.5	221.5	Dense sand fill	0.0 - 0.8	220.5 – 219.7	--	30	20	--	3.0	6,600	--	217.0
						Compact sand and gravel fill	0.8 – 1.4	219.7 – 219.1	--	28	19	--	2.8	6,600	--	
						Firm clayey silt fill	1.4 – 3.2	219.1 – 217.3	50	28	19	9	2.8	--	--	
						Dolostone fragments	3.2 – 3.4	217.3 – 217.1	--	40	23	--	4.5	11,000	--	
						Slightly weathered to fresh dolostone bedrock	Below 3.4	Below 217.1	--	40	23	13	--	--	5,000	
P12	20+625	OS-4 (220.5) HML-7 (221.2)	220.6	220.6	221.6	Dense sand fill	0.0 - 0.9	220.6 – 219.7	--	30	20	--	3.0	6,600	--	218.0
						Compact sand and gravel fill	0.9 – 1.5	219.7 – 219.1	--	30	20	--	3.0	6,600	--	
						Firm clayey silt fill	1.5 – 3.3	219.1 – 217.3	50	28	19	--	2.8	--	--	
						Dolostone fragments	3.3 – 3.5	217.3 – 217.1	--	40	23	13	4.5	11,000	--	
						Slightly weathered dolostone bedrock	Below 3.5	Below 217.1	--	40	23	13	--	--	5,000	
P13	20+725	HML-7 (221.2)	221.1	221.1	222.2	Very dense sand and gravel fill	0.0 – 0.7	221.1 – 220.4	--	30	20	--	3.0	6,600	--	218.5
						Stiff clayey silt fill	0.7 – 1.9	220.4 – 219.2	50	28	19	--	2.8	--	--	
						Stiff clayey silt	1.9 – 2.1	219.2 – 219.0	75	30	20	--	3.0	--	--	
						Very stiff clayey silt till	2.1 – 2.7	219.0 – 218.4	150	34	21	--	3.5	--	--	
						Slightly weathered dolostone bedrock	Below 2.7	Below 218.4	--	40	23	13	--	--	5,000	
P14	29+906 (HWY 5)	WS-1 (222.1) C2-2 (222.3)	221.2	227.2	227.3	Fill (assumed – new firm clayey silt fill)	0.0 – 4.9	227.2 – 222.3	50	28	19	--	2.8	--	--	220.0
						Compact to very dense sand and gravel fill	4.9 – 6.3	222.3 – 220.9	--	30	20	--	3.0	6,600	--	
						Stiff silty clay fill	6.3 – 7.2	220.9 – 220.0	50	28	19	--	2.8	--	--	
						Very stiff to hard clayey silt till	7.2 – 11.5	220.0 – 215.7	150	34	21	11	3.5	--	--	
P15	10+114 (Ramp E-S)	HML-4 (228.2)	227.7	227.7	227.8	Fill (assumed – new firm clayey silt fill)	0.0 – 5.6	227.7 – 222.1	50	28	19	--	2.8	--	--	221.0
						Stiff to very stiff clayey silt till	5.6 – 11.4	222.1 – 216.3	100	32	20	10	3.3	--	--	
P16	10+215 (Ramp N-E/W)	HML-4 (228.2)	228.8	227.3	227.4	Fill (assumed – new firm clayey silt fill)	0.0 – 5.2	227.3 – 222.1	50	28	19	--	2.8	--	--	221.0
						Stiff to very stiff clayey silt till	5.2 – 11.0	222.1 – 216.3	100	32	20	10	3.3	--	--	
P17	10+114 (Ramp S-E/W)	HML-2 (222.6)	222.4	222.4	222.6	Stiff clayey silt	0.0 – 1.2	222.4 – 221.2	75	30	20	--	3.0	--	--	221.0
						Very stiff to hard clayey silt till	1.2 – 6.1	221.2 – 216.3	150	34	21	11	3.5	--	--	
						Slightly weathered dolostone bedrock	Below 6.1	Below 216.3	--	40	23	13	--	--	5,000	
P18	10+103 (Ramp W-N)	HML-3 (223.0)	223.0	223.0	223.1	Firm clayey silt fill	0.0 – 0.8	223.0 – 222.2	50	28	19	--	2.8	--	--	221.5
						Stiff to hard clayey silt till	0.8 – 5.5	222.2 – 217.5	150	34	21	11	3.5	--	--	
						Slightly weathered dolostone bedrock	Below 5.5	Below 217.5	--	40	23	13	--	--	5,000	
P19	30+063 (HWY 5)	EN-2 (222.2)	222.3	228.2	228.4	Fill (assumed – new firm clayey silt fill)	0.0 – 6.0	228.2 – 222.2	50	28	19	--	2.8	--	--	221.0
						Stiff clayey silt fill	6.0 – 7.4	222.2 – 220.8	50	28	19	--	2.8	--	--	
						Very stiff to hard clayey silt till	7.4 – 11.3	220.8 – 216.9	150	34	21	11	3.5	--	--	

Prepared By: SMM      Reviewed By: LCC

NOTES:

1. Depths are given relative to the ground surface elevation provided by IBI for each high mast light (HML) pole location. Should the location of the HML pole change, the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual HML pole foundation location, and the depths to various soil and bedrock strata adjusted accordingly.



2. Design parameters:
- $s_u$

= undrained shear strength (kPa);
- $\phi'$

= effective friction angle (degrees);
- $\gamma$

= bulk unit weight (kN/m<sup>3</sup>);
- $\gamma'$

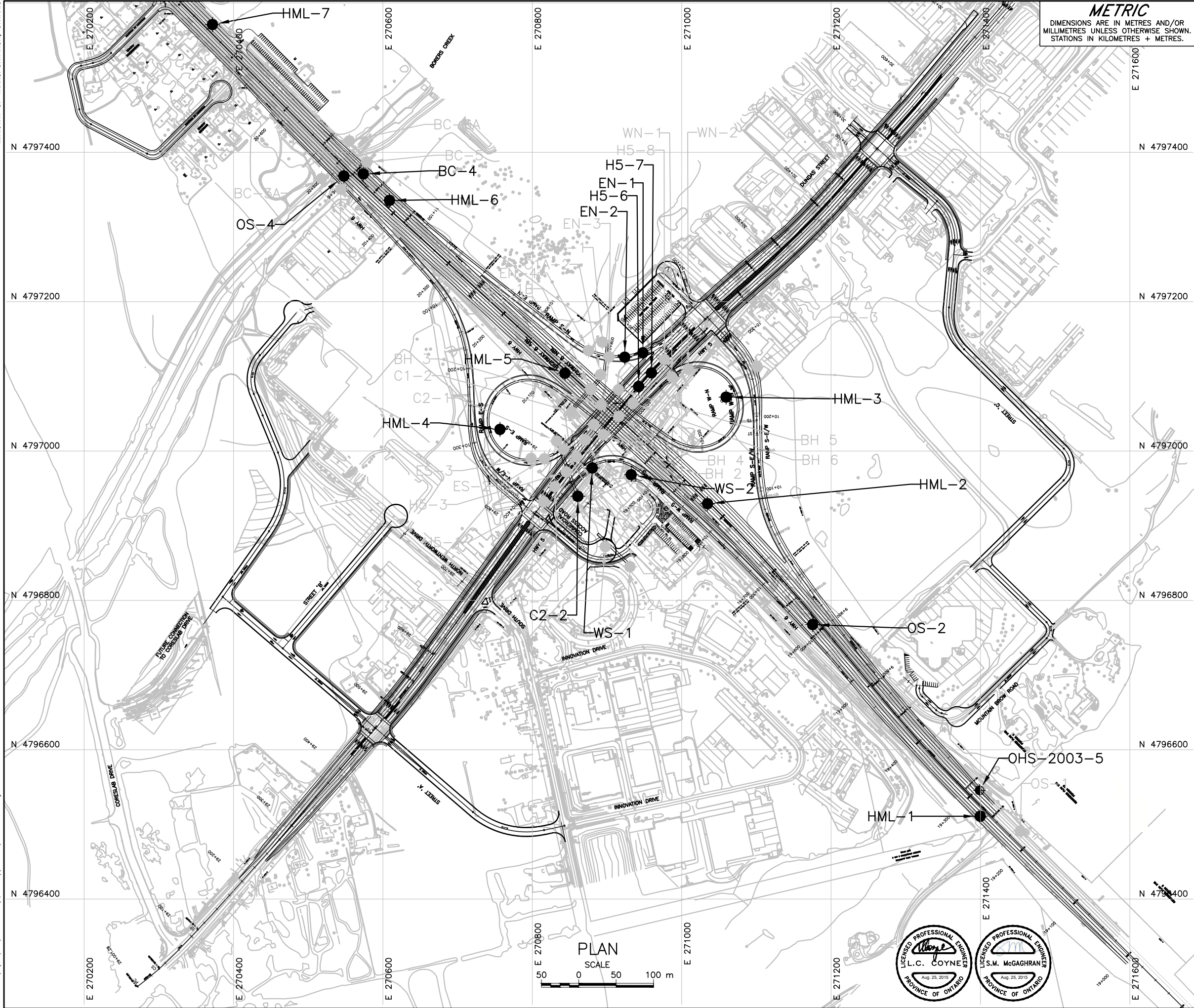
= effective unit weight below the groundwater level (kN/m<sup>3</sup>);
- $K_p$

= passive earth pressure coefficient;
- $n_h$

= constant of subgrade reaction (kPa/m) ; and
- $f_{horiz}$

= factored horizontal bearing capacity of “sound” rock at Ultimate Limit States (kPa).
3. For specific design purposes, the passive resistance in the upper 1.2 m is to be neglected to account for frost action,  $S_u$ ,  $\phi'$ ,  $K_p$  and  $n_h$  parameters are given for the soil and weathered shale bedrock, in the event that the ground surface elevation varies significantly between the existing borehole and the actual HML pole location.
4. “Sound” bedrock means fresh to slightly weathered bedrock, as recorded on the Record of Borehole/Drillhole sheets.

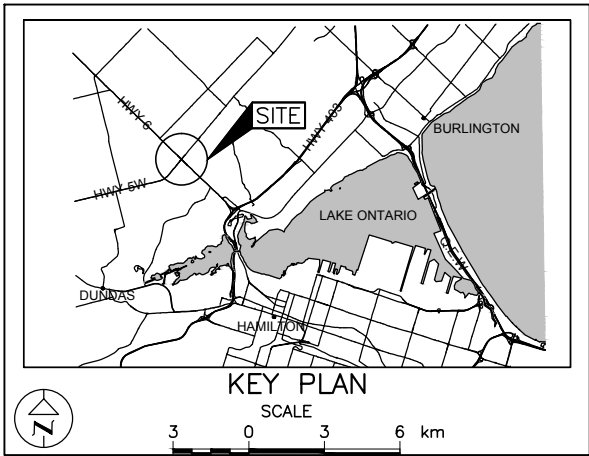




**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2112-05-00

HIGHWAY 5/6 INTERCHANGE  
HIGH MAST LIGHT POLES  
BOREHOLE LOCATIONS



**LEGEND**

- Borehole - Current Investigation (solid black circle)
- Borehole - Current Investigation (grey circle)
- Borehole - Previous Investigation (30M5-249) (circle with crosshair)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BC-4	220.7	4797371.1	270573.8
C2-2	222.3	4796939.5	270861.0
EN-1	222.4	4797131.6	270948.2
EN-2	222.2	4797125.7	270923.8
H5-6	222.1	4797086.5	270942.5
H5-7	222.6	4797104.7	270959.6
HML-1	194.4	4796511.1	271399.8
HML-2	222.6	4796929.5	271034.7
HML-3	223.0	4797072.3	271059.5
HML-4	228.2	4797029.0	270756.7
HML-5	222.2	4797104.4	270843.8
HML-6	221.6	4797335.6	270608.9
HML-7	221.2	4797571.1	270371.8
OHS-2003-5	195.2	4796545.5	271399.0
OS-2	216.7	4796767.7	271175.4
OS-4	220.5	4797368.3	270547.7
WS-1	222.1	4796977.4	270880.3
WS-2	222.5	4796968.4	270932.5

**NOTES**

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

**REFERENCE**

Base plans provided in digital format by IBI, drawing file nos. Highway 5&6 Plan.dwg, modified January 30, 2015 and 4272 HM Layout.dwg, modified April 9, 2015.

Geocres No. 30M5-317		PROJECT NO. 10-1184-0016		DIST. .	
HWY. 5 & 6	SUBM'D. AJS	CHKD. SMM	DATE: July 2015	SITE: .	
DRAWN: JFC	CHKD. SMM	APPD. LCC	DWG. 1		





# APPENDIX A

## Borehole and Drillhole Records





## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

$\pi$	3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

### (a) Index Properties (continued)

w	water content
$w_l$ or LL	liquid limit
$w_p$ or PL	plastic limit
$I_p$ or PI	plasticity index = $(w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index = $(w - w_p) / I_p$
$I_C$	consistency index = $(w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$





## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

#### Dynamic Cone Penetration Resistance; $N_d$ :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils Consistency

	$C_u, S_u$	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
$SO_4$	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

**Note:** 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

### V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

### CORE CONDITION

#### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

#### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

#### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

### DISCONTINUITY DATA

#### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

#### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

#### Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT		10-1184-0016		RECORD OF BOREHOLE No BC-4		SHEET 1 OF 1		METRIC															
G.W.P.		2112-05-00		LOCATION		N 4797371.1 ; E 270573.8		ORIGINATED BY															
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY															
DATUM		Geodetic		DATE		October 28, 2014		CHECKED BY															
								SMM															
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ						
220.7	0.0	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W <sub>p</sub> — W — W <sub>L</sub> 10 20 30			kN/m <sup>3</sup>			GR SA SI CL			
		Silty sand and gravel (FILL) Compact Brown Moist		1	SS	26		220															
				2A																			
219.5	1.2	Clayey silt with sand, trace gravel (FILL) Stiff Grey-brown Moist		2B	SS	14		219															
				3	SS	8																	
				4A																			
217.8	2.9	CLAYEY SILT, trace to some sand, trace gravel (TILL) Very stiff Brown Moist		4B	SS	8		218															
				5	SS	21																	
216.8	3.9	END OF BOREHOLE AUGER AND SPOON REFUSAL INFERRED BEDROCK		6A	SS	10000		217															
				6B																			
NOTES:																							
1. Open borehole dry upon completion of drilling.																							
2. Water level readings in piezometer:																							
	Date	Depth (m)	Elev. (m)																				
	11/02/14	3.7	217.0																				

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT		10-1184-0016		RECORD OF BOREHOLE No EN-1		SHEET 1 OF 1		METRIC								
G.W.P.		2112-05-00		LOCATION		N 4797131.6 ; E 270948.2		ORIGINATED BY								
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY								
DATUM		Geodetic		DATE		November 14, 2012		CHECKED BY								
								TVA								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
222.4	GROUND SURFACE															
0.0	TOPSOIL		1	SS	9											
0.3	Clayey silt with sand, trace gravel (FILL) Stiff Brown Moist		2	SS	10											1 23 59 17
221.0																
1.4	CLAYEY SILT with sand, containing sand layers between depths of 2.3 m and 3.5 m (TILL) Very stiff to hard Brown Moist		3	SS	27											
			4	SS	32											0 34 46 20
			5	SS	28											
			6	SS	25											
			7	SS	20											
217.1	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK															
5.3	NOTE: 1. Water level in open borehole measured at a depth of 4.7 m below ground surface (Elev. 217.7 m) upon completion of drilling.															



PROJECT		10-1184-0016		RECORD OF BOREHOLE No EN-2		SHEET 1 OF 1		METRIC						
G.W.P.		2112-05-00		LOCATION		N 4797125.7 ; E 270923.8		ORIGINATED BY						
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY						
DATUM		Geodetic		DATE		November 14, 2012		CHECKED BY						
								TVA						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
222.2	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30				
0.0	TOPSOIL													
0.2	Clayey silt with sand, trace gravel (FILL) Stiff Brown Moist		1	SS	11									
			2	SS	9									
220.8														
1.4	CLAYEY SILT, trace to some sand, trace gravel (TILL) Very stiff to hard Brown Moist		3	SS	19									3 17 54 26
			4	SS	31									
			5	SS	28									
			6	SS	40									
			7A 7B	SS	48									0 6 63 31
216.9	-----Wet													
5.3	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK													
NOTE: 1. Water level in open borehole measured at a depth of 4.8 m below ground surface (Elev. 217.4 m) upon completion of drilling.														

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT		10-1184-0016		RECORD OF BOREHOLE No H5-7		SHEET 1 OF 1		METRIC								
G.W.P.		2112-05-00		LOCATION		N 4797104.7 ; E 270959.6		ORIGINATED BY								
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY								
DATUM		Geodetic		DATE		November 15, 2012		CHECKED BY								
								TVA								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
222.6	GROUND SURFACE															
0.0	ASPHALT		1	SS	42											
221.9	Sand and gravel, trace to some silt, containing pieces of concrete (FILL)		2	SS	9											
0.7	Dense Grey to brown Moist															
221.2	Clayey silt, some sand, trace to some gravel (FILL)		3	SS	24											
1.4	Stiff Brown Moist															
	CLAYEY SILT with sand to some sand, trace gravel (TILL)		4	SS	57											
	Very stiff to hard Brown to grey Moist to wet		5	SS	20											
			6	SS	27											
	----- Wet		7	SS	22											
217.3	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK															
5.3	NOTE: 1. Water level in open borehole measured at a depth of 5.0 m below ground surface (Elev. 217.6 m) upon completion of drilling.															

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT		10-1184-0016		RECORD OF BOREHOLE No HML-2		SHEET 1 OF 1		METRIC										
G.W.P.		2112-05-00		LOCATION		N 4796929.5 ; E 271034.7		ORIGINATED BY										
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY										
DATUM		Geodetic		DATE		October 16, 2014		CHECKED BY										
								SMM										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
222.6	GROUND SURFACE							20	40	60	80	100						
0.0	CLAYEY SILT, some sand, trace to some gravel, containing rootlets and organics Stiff Brown Moist		1	SS	10													
			2	SS	14													
221.2																		
1.4	CLAYEY SILT with sand, trace gravel, containing bedrock fragments (TILL) Very stiff to hard Brown Moist		3	SS	27													
			4	SS	24													
			5	SS	51													
	----- Becoming grey below 3.8 m		6	SS	25													
			7	SS	26													
	----- Auger grinding at 5.2 m																	
216.3	DOLOSTONE (BEDROCK)		8	SS	100/0.0													
6.3	Bedrock cored from depths of 6.6 m to 9.6 m  For bedrock coring details, refer to Record of Drillhole HML-2.																	
			1	RC	REC 98%													
			2	RC	REC 93%													
213.0	END OF BOREHOLE																	
9.6	NOTES:  1. Spoon bouncing and auger refusal at a depth of 6.3 m below ground surface (Elev. 216.3 m).  2. Open borehole dry upon completion of drilling and prior to rock coring.																	

PROJECT: 10-1184-0016

## RECORD OF DRILLHOLE: HML-2

SHEET 1 OF 1

LOCATION: N 4796929.5 ; E 271034.7

DRILLING DATE: October 16, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES
		Continued from Record of Borehole HML-2		215.99									
7		Slightly weathered, thinly to medium bedded, grey, fine grained, faintly porous, strong, nodular DOLOSTONE (Lockport Formation, Goat Island Member)		6.60	1								10.7 MPa 8.5 MPa (Axial) UC=75.7 MPa
8	NORC NW Casing Rock Coring												
9					2								
		END OF DRILLHOLE		212.99									
10				9.60									
11													
12													
13													
14													
15													
16													

DEPTH SCALE

1 : 50



LOGGED: AJS

CHECKED: SMM

GTA-RCK 018 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 8/25/15 DD

PROJECT		10-1184-0016		RECORD OF BOREHOLE No HML-3		SHEET 1 OF 1		METRIC													
G.W.P.		2112-05-00		LOCATION		N 4797072.3 ; E 271059.5		ORIGINATED BY													
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY													
DATUM		Geodetic		DATE		October 15, 2014		CHECKED BY													
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)								
223.0	GROUND SURFACE						20	40	60	80	100	20	40	60	80	100	10	20	30		
0.0	Clayey silt, trace to some sand, trace to some gravel (FILL) Firm Brown Moist		1	SS	5																
222.2	CLAYEY SILT, trace to some sand, trace gravel (TILL) Stiff to hard Brown Moist to wet		2	SS	11																
0.8			3	SS	31																
			4	SS	34																
			5A	SS	32																
			5B	SS																	
			6A	SS	15																
			6B	SS																	
			7	SS	19																
			8	SS	100/0.0																
217.5	DOLOSTONE (BEDROCK)																				
5.5	Bedrock cored from depths of 5.5 m to 8.7 m  For bedrock coring details, refer to Record of Drillhole HML-3.		1	RC	REC 88%															RQD = 60%	
			2	RC	REC 93%															RQD = 83%	
			3	RC	REC 95%															RQD = 95%	
			4	RC	REC 100%															RQD = 100%	
214.3	END OF BOREHOLE																				
8.7	NOTE:  1. Wet split-spoon encountered below 3.8 m below ground surface (Elev. 219.8 m).  2. Spoon bouncing and auger refusal at a depth of 5.2 m below ground surface (Elev. 217.8 m).  3. Water level in open borehole measured at a depth of 2.9 m below ground surface (Elev. 220.1 m) upon completion of drilling and prior to rock coring.  4. Water level readings in piezometer:  Date      Depth (m)      Elev. (m) 10/02/14      2.4      220.6 01/08/15      1.4      221.6																				

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016 GPJ GAL-GTA.GDT 8/25/15 DD

PROJECT: 10-1184-0016

## RECORD OF DRILLHOLE: HML-3

SHEET 1 OF 1

LOCATION: N 4797072.3 ; E 271059.5

DRILLING DATE: October 16, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES
		Continued from Record of Borehole HML-3		217.47									
6	NORC NW Casing Rock Coring	Slightly weathered, thinly to medium bedded, grey, fine-grained, faintly porous, strong, nodular DOLOSTONE (Lockport Formation, Goat Island Member)		5.50	1								
7					2								
8					3								
					4								
9		END OF DRILLHOLE		214.27									
10				8.70									
11													
12													
13													
14													
15													

DEPTH SCALE



1 : 50



LOGGED: AJS

CHECKED: SMM

GTA-RCK 018 T:\PROJECTS\201010-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 8/25/15 DD

PROJECT		10-1184-0016		RECORD OF BOREHOLE No HML-4		SHEET 1 OF 1		METRIC							
G.W.P.		2112-05-00		LOCATION		N 4797029.0 ; E 270756.7		ORIGINATED BY							
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY							
DATUM		Geodetic		DATE		October 15, 2014		CHECKED BY							
								SMM							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
228.2 0.0	GROUND SURFACE Clayey silt with sand, trace to some gravel, containing organics and rootlets to a depth of 0.6 m (FILL) Firm to very stiff Brown to red to grey Moist  Containing organics and rootlets between depths of 4.6 m and 5.2 m		1	SS	15		228								18 35 36 11
	2		SS	16	227										
	3		SS	10	226										
	4		SS	6	225										
	5		SS	16	224										
	6		SS	10	223										
	7		SS	10	222										
222.1 6.1	CLAYEY SILT with sand, trace gravel (TILL) Brown Stiff to very stiff Moist  ----- Becoming grey below 9.1 m		8	SS	25		222							4 23 51 22	
	9		SS	25	221										
	10		SS	23	220										
	11		SS	14	219										
	12		SS	100/0.0	218										
216.3 11.9	END OF BOREHOLE AUGER AND SPOON REFUSAL  NOTE: 1. Water level in open borehole measured at a depth of 11.1 m below ground surface (Elev. 217.1 m) upon completion of drilling.						217								

PROJECT		RECORD OF BOREHOLE No HML-5				SHEET 1 OF 1		METRIC									
G.W.P. 2112-05-00		LOCATION N 4797104.4 ; E 270843.8				ORIGINATED BY AJS											
DIST Central HWY 5 & 6		BOREHOLE TYPE 102 mm O.D. Continuous Flight Solid Stem Augers				COMPILED BY PKS											
DATUM Geodetic		DATE October 26, 2014				CHECKED BY SMM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
222.2	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT																
0.2	Sand and gravel (FILL) Very dense to compact Brown Dry		1	SS	70												
			2	SS	20												
220.8																	
1.4	CLAYEY SILT with sand, trace gravel (TILL) Stiff to very stiff Brown Moist to wet		3	SS	8												
			4	SS	19												
			5	SS	22												
			6	SS	14												
	----- Becoming grey below 4.6 m																
216.0																	
6.2	DOLOSTONE (BEDROCK)		7	SS	100/0.10												
	Bedrock cored from depths of 6.2 m to 9.2 m		1	RC	REC 91%												
	For bedrock coring details, refer to Record of Drillhole HML-5.																
			2	RC	REC 95%												
213.0																	
9.2	END OF BOREHOLE																
	NOTES: 1. Wet split-spoon encountered below 6.1 m below ground surface (Elev. 216.1 m). 2. Spoon bouncing and auger refusal at a depth of 6.2 m below ground surface (Elev. 216.0 m) 3. Water level in open borehole measured at a depth of 4.1 m below ground surface (Elev. 218.1 m) upon completion of drilling and prior to rock coring.																



PROJECT: 10-1184-0016

## RECORD OF DRILLHOLE: HML-5

SHEET 1 OF 1

LOCATION: N 4797104.4 ;E 270843.8

DRILLING DATE: October 19, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES
		Continued from Record of Borehole HML-5		216.02									
7		Slightly weathered, thinly to medium bedded, grey, fine to medium grained, slightly porous, strong, nodular DOLOSTONE (Lockport Formation, Goat Island Member)		6.20	1								
8	NORC NW Casing Rock Coring	Infill with clay seam (4 mm)			2								
9				213.02									
10		END OF DRILLHOLE		9.20									
11													
12													
13													
14													
15													
16													

DEPTH SCALE

1 : 50



LOGGED: AJS

CHECKED: SMM

GTA-RCK 018 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 8/25/15 DD

PROJECT		10-1184-0016		RECORD OF BOREHOLE No HML-6		SHEET 1 OF 1		METRIC					
G.W.P.		2112-05-00		LOCATION		N 4797335.6 ; E 270608.9		ORIGINATED BY					
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY					
DATUM		Geodetic		DATE		October 27, 2014		CHECKED BY					
								SMM					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS				
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL
221.6	0.0	GROUND SURFACE Sand and gravel (FILL) Loose to Compact Brown Moist		1	SS	24		221					
220.4	1.2	Silty clay, trace to some sand, trace to some gravel, containing organics (FILL) Stiff Brown and grey Moist		2	SS	7		220					
219.4	2.2	CLAYEY SILT, trace to some sand, trace gravel, containing organics to a depth of 2.9 m (TILL) Stiff to very stiff Brown and grey Moist to wet		3	SS	9		219					
				4	SS	18		218					
				5	SS	29		217					
				6	SS	14		216					
217.2	4.4	DOLOSTONE (BEDROCK)  Bedrock cored from depths of 4.4 m to 7.5 m  For bedrock coring details, refer to Record of Drillhole HML-6.		7	SS	100/0.0		215					
				1	RC	REC 92%							RQD = 92%
				2	RC	REC 100%							RQD = 93%
214.1	7.5	END OF BOREHOLE  NOTES:  1. Spoon bouncing and auger refusal at a depth of 4.4 m below ground surface (Elev. 217.2 m).  2. Water level in open borehole measured at a depth of 4.1 m below ground surface (Elev. 217.5 m) upon completion of drilling and prior to rock coring.  3. Water level readings in piezometer:  Date Depth (m) Elev. (m) 11/02/14 3.6 218.0											

PROJECT: 10-1184-0016

## RECORD OF DRILLHOLE: HML-6

SHEET 1 OF 1

LOCATION: N 4797335.6 ;E 270608.9

DRILLING DATE: October 27, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES
		Continued from Record of Borehole HML-6		217.11									
5		Slightly weathered, thinly to medium bedded, grey to brownish grey, fine grained, faintly porous, strong, nodular DOLOSTONE (Lockport Formation, Goat Island Member)		4.50	1								
6	NORC NW Casing Rock Coring												
7		Fresh, thinly to thickly bedded, grey, medium grained, moderately porous, medium strong to strong, DOLOSTONE (Lockport Formation, Gasport Member)		215.01 6.60	2								
		END OF DRILLHOLE		214.11 7.50									
8													
9													
10													
11													
12													
13													
14													

DEPTH SCALE

1 : 50



LOGGED: AJS

CHECKED: SMM

GTA-RCK 018 T:\PROJECTS\201010-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 8/25/15 DD

PROJECT		10-1184-0016		RECORD OF BOREHOLE No HML-7		SHEET 1 OF 1		METRIC											
G.W.P.		2112-05-00		LOCATION		N 4797571.1 ; E 270371.8		ORIGINATED BY											
DIST		Central HWY 5 & 6		BOREHOLE TYPE		102 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY											
DATUM		Geodetic		DATE		October 24, 2014		CHECKED BY											
								SMM											
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL	
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30						
221.2	0.0	GROUND SURFACE																	
0.2		Asphalt																	
220.4	0.8	Sand and gravel, trace silt (FILL) Very dense Brown Moist		1	SS	58		221											
				2A	SS	12		220											
				2B															
				3A	SS	10													
				3B															
219.2		CLAYEY SILT with sand Stiff Brown Moist		4A	SS	25		219											
218.4	2.8	CLAYEY SILT, some sand, trace to some gravel (TILL) Very stiff Brown Wet		4B	SS	100/0.0													
				5	SS														
				1	RC	REC 84%		218										RQD = 84%	
		DOLOSTONE (BEDROCK)																	
		Bedrock cored from depths of 3.1 m to 6.1 m		2	RC	REC 95%		217										RQD = 95%	
		For bedrock coring details, refer to Record of Drillhole HML-7.																	
				3	RC	REC 97%		216										RQD = 97%	
215.1	6.1	END OF BOREHOLE		4	RC	REC 100%												RQD = 100%	
NOTES:																			
1. Spoon bouncing and auger refusal at a depth of 3.0 m below ground surface (Elev. 218.2 m)																			
2. Open borehole dry upon completion of drilling and prior to rock coring.																			
3. Water level readings in piezometer:																			
	Date	Depth (m)	Elev. (m)																
	10/02/14	2.8	218.4																
	01/08/15	2.9	218.3																
	01/27/15	2.9	218.3																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: DBW Drilling

STA-RCK 018 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 8/25/15 DD

CHECKED: SMM

PROJECT		10-1184-0016		RECORD OF BOREHOLE No OS-2		SHEET 1 OF 1		METRIC										
G.W.P.		2112-05-00		LOCATION		N 4796767.7 ; E 271175.4		ORIGINATED BY										
DIST		Central HWY 5 & 6		BOREHOLE TYPE		150 mm O.D. Continuous Flight Solid Stem Augers and NQ Casing		COMPILED BY										
DATUM		Geodetic		DATE		September 3, 2013		CHECKED BY										
								SMM										
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30	kN/m <sup>3</sup>				
216.7	0.0	GROUND SURFACE																
0.2		ASPHALT (150 mm)																
		Sand, trace to some silt, trace to some gravel, trace clay (FILL)		1	SS	66		216										
		Compact to very dense		2	SS	66												
		Grey																
		Moist																
				3	SS	63		215									14 72 10 4	
				4	SS	29		214										
213.7																		
		SAND and GRAVEL, trace to some silt, trace clay		5A	SS	59/0.28		213									39 47 10 4	
213.3	3.4	Very dense		5B														
		Grey																
		Moist																
212.8	3.9	DOLOSTONE fragments																
		Grey																
		DOLOSTONE (BEDROCK)		1	RC	REC 100%		212									RQD = 67%	
		Bedrock cored from depths of 3.9 m to 7.0 m																
		For bedrock coring details, refer to Record of Drillhole OS-2.		2	RC	REC 100%		211									RQD = 100%	
								210										
209.7	7.0	END OF BOREHOLE																
		NOTES:																
		1. Split spoon bouncing and auger grinding at a depth of 3.3 m (Elev. 213.4 m).																
		2. Water level in open borehole not recorded as water was introduced for bedrock coring.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: DBW Drilling

CHECKED: SMM

PROJECT		10-1184-0016		RECORD OF BOREHOLE No OS-4		SHEET 1 OF 1		METRIC										
G.W.P.		2112-05-00		LOCATION		N 4797368.3 ; E 270547.7		ORIGINATED BY										
DIST		Central HWY 5 & 6		BOREHOLE TYPE		150 mm O.D. Continuous Flight Solid Stem Augers and NQ Casing		COMPILED BY										
DATUM		Geodetic		DATE		September 3, 2013		CHECKED BY										
								SMM										
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30	kN/m <sup>3</sup>				
220.5	0.0	GROUND SURFACE																
219.7	0.2	ASPHALT (150 mm)																
219.7	0.8	Sand, trace to some gravel, trace silt (FILL) Dense Brown Moist		1	SS	33		220										
219.1	1.4	Sand and gravel, trace to some silt, trace clay (FILL) Compact Brown Moist		2	SS	16		219										
217.3	3.4	Clayey silt, trace to some sand, trace gravel, trace organics, containing rootlets (FILL) Firm Mottled brown and grey Wet		3	SS	8		218										
				4	SS	7		217										
				5A	SS	50/0.05		216										
				5B	SS			215										
		DOLOSTONE fragments Grey																
		DOLOSTONE (BEDROCK)																
		Bedrock cored from depths of 3.4 m to 6.4 m.		1	RC	REC 94%												
		For bedrock coring details, refer to Record of Drillhole OS-4.		2	RC	REC 100%												
214.1	6.4	END OF BOREHOLE																
		NOTES:																
		1. Split spoon bouncing and auger grinding at a depth of 3.2 m (Elev. 214.3 m).																
		2. Water level in open borehole not recorded as water was introduced for bedrock coring.																



SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: DBW Drilling

CHECKED: SMM

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 10-1184-0016			RECORD OF BOREHOLE No WS-2			SHEET 1 OF 1			METRIC															
G.W.P. 2112-05-00			LOCATION N 4796968.4 ; E 270932.5			ORIGINATED BY JBH																		
DIST Central HWY 5 & 6			BOREHOLE TYPE 102 mm O.D. Continuous Flight Solid Stem Augers			COMPILED BY BM																		
DATUM Geodetic			DATE November 21, 2012			CHECKED BY TVA																		
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																			
222.5	GROUND SURFACE																							
0.0	ASPHALT																							
0.2	Sand and gravel, trace silt (FILL)																							
221.7	Brown Moist																							
0.8	Clayey silt, trace sand (FILL)		1	SS	6																			
221.1	Firm Brown Moist																							
1.4	CLAYEY SILT with sand, trace gravel, containing sand seams to a depth of 2.7 m (TILL)		2	SS	19																			
	Stiff to hard Brown Moist																							
			3	SS	25																			
			4	SS	33																			
			5	SS	28																			
			6	SS	13																			
	-----with SAND		7	SS	11																			
			8	SS	5/0.08																			
216.2	END OF BOREHOLE SPOON BOUNCING AND AUGER REFUSAL INFERRED BEDROCK																							
6.3	NOTE: 1. Borehole dry upon completion of drilling.																							



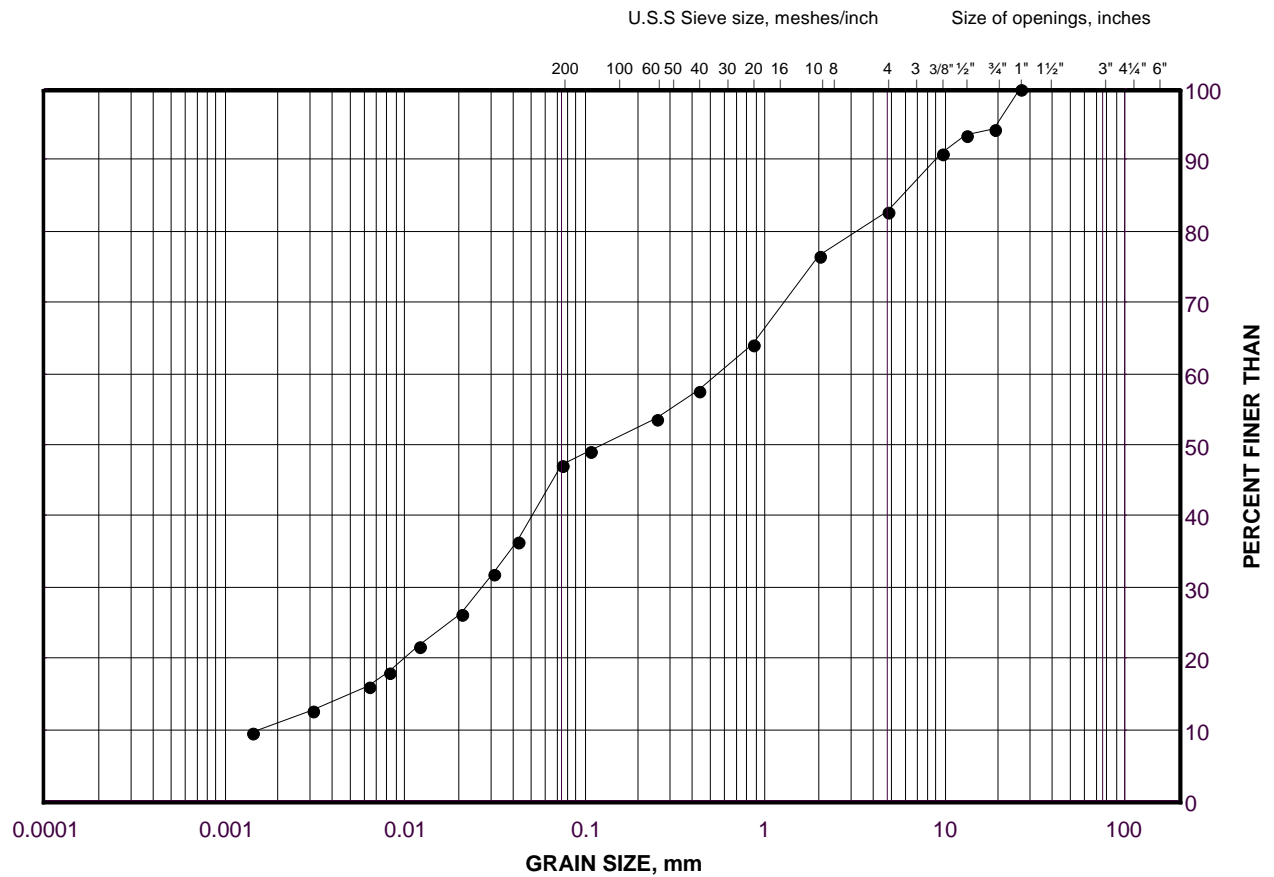
# **APPENDIX B**

## **Geotechnical Laboratory Test Results**

# GRAIN SIZE DISTRIBUTION

Stockpile Fill Material

FIGURE B1



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

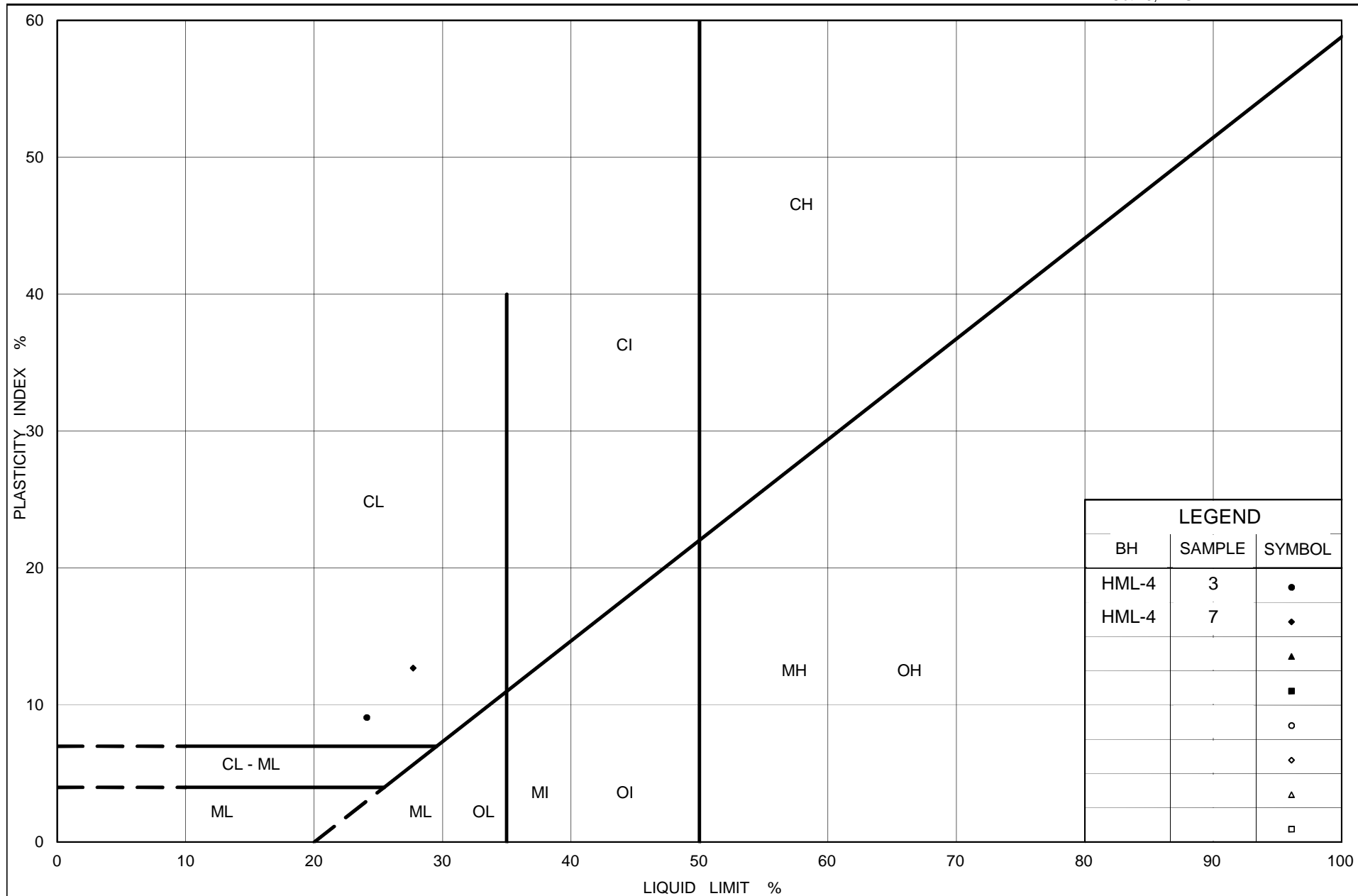
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	HML-4	3	226.3

Project Number: 10-1184-0016

Checked By: SMM

**Golder Associates**

Date: 23-Apr-15



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Stockpile Fill Material

Figure No. B2

Project No. 10-1184-0016

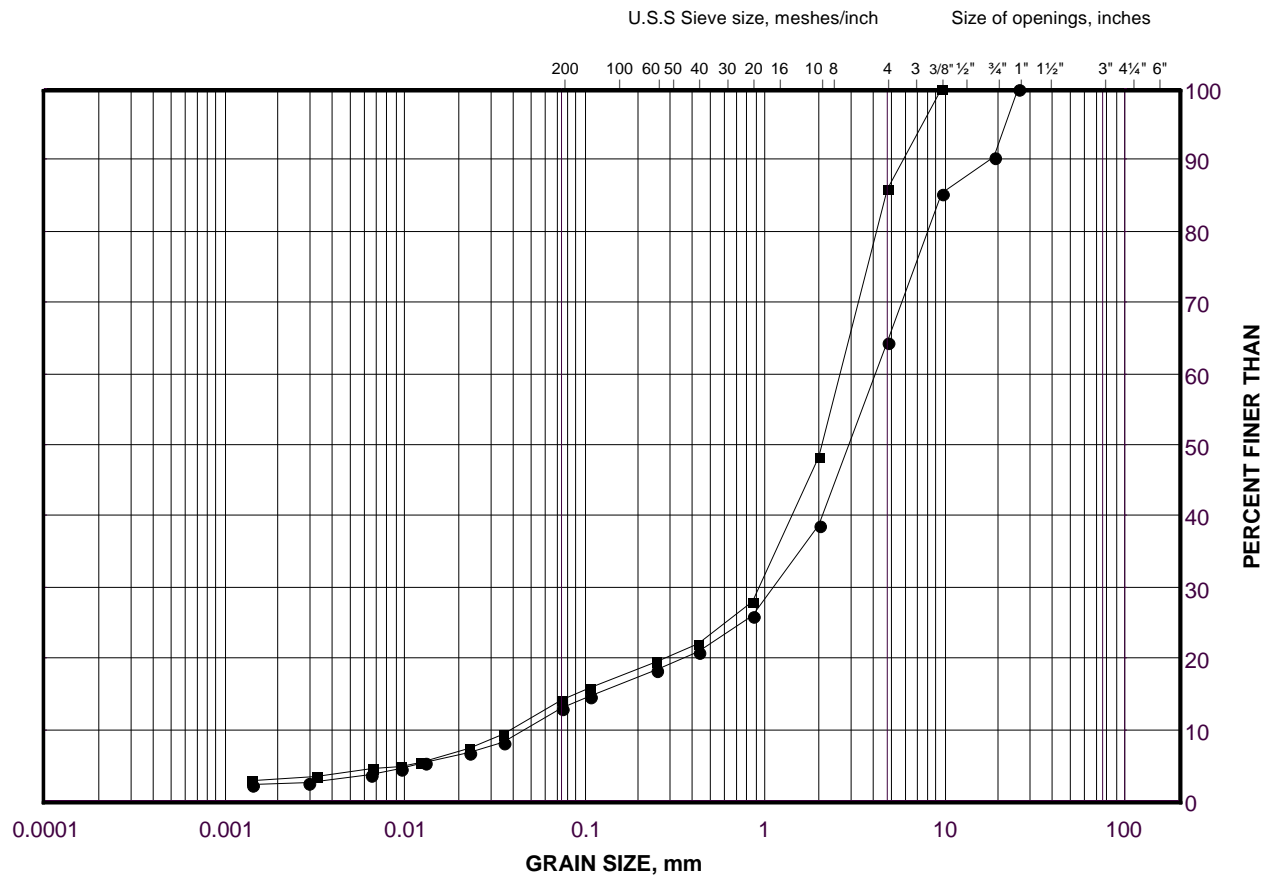
Checked By: SMM



# GRAIN SIZE DISTRIBUTION

Sand to Sand and Gravel Fill

FIGURE B3



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	OS-4	2	219.5
■	OS-2	3	214.9

Project Number: 10-1184-0016

Checked By: SMM

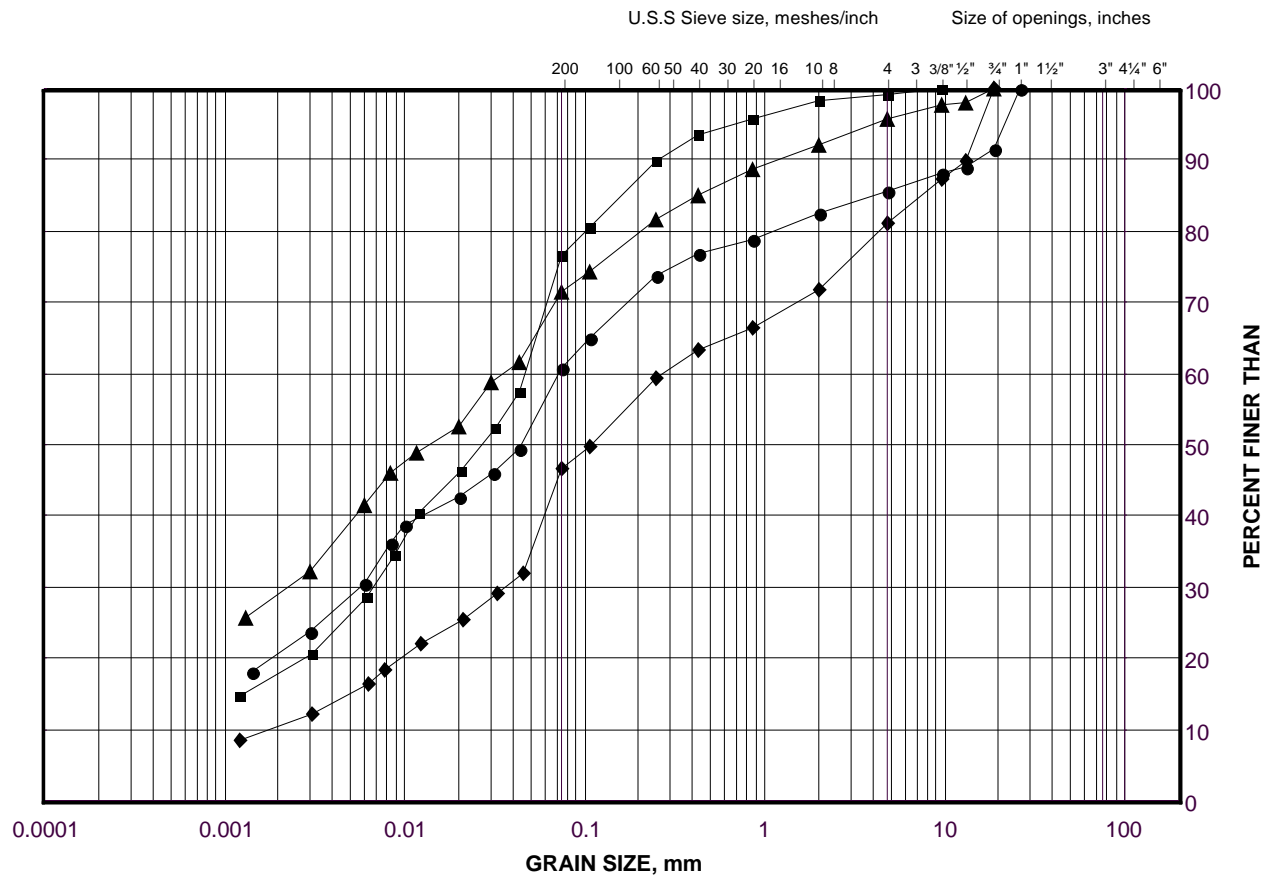
**Golder Associates**

Date: 01-Jun-15

# GRAIN SIZE DISTRIBUTION

Clayey Silt Fill

FIGURE B4



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

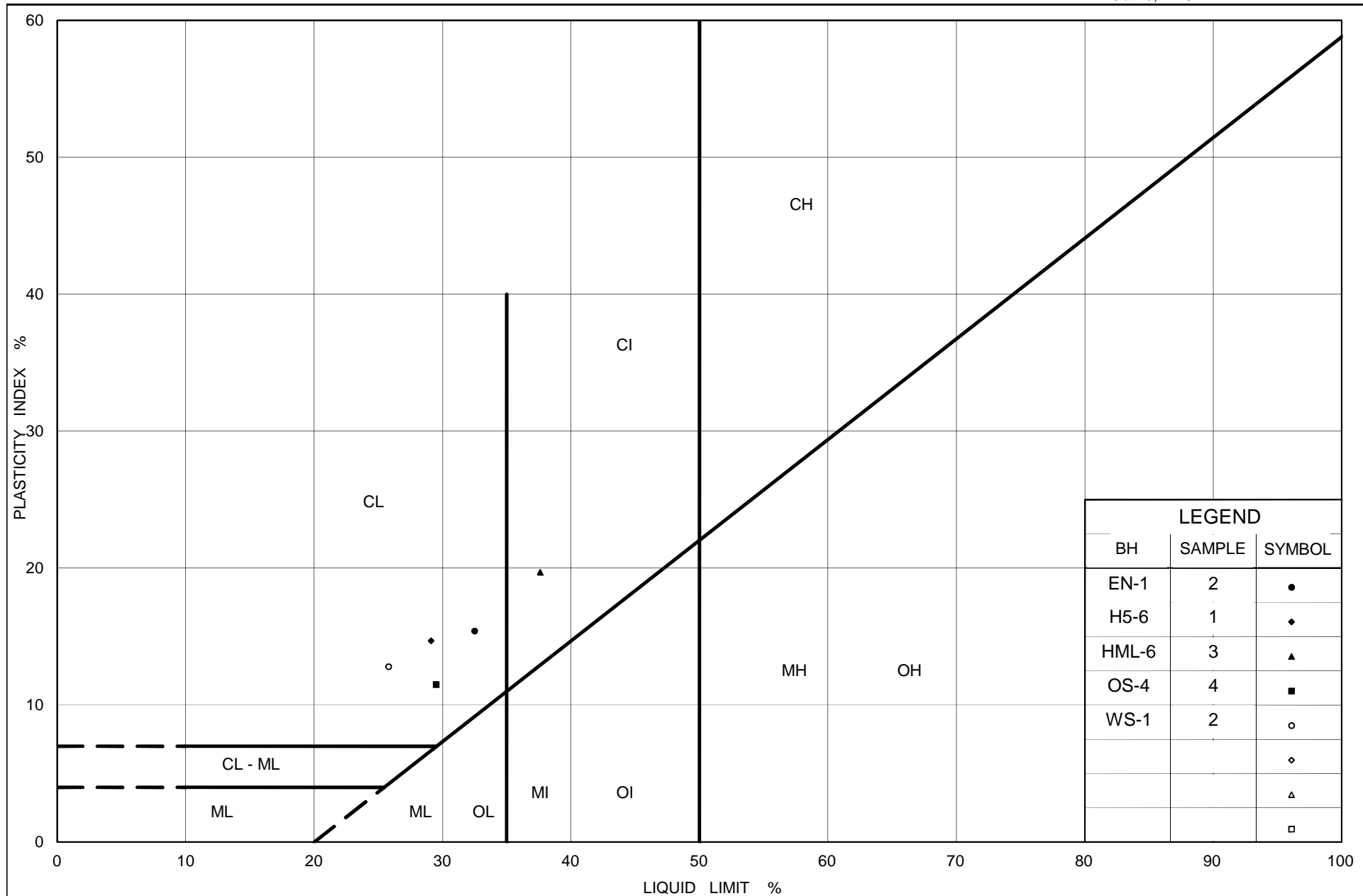
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WS-1	2	220.4
■	EN-1	2	221.4
◆	H5-6	2	221.1
▲	BC-4	3	218.8

Project Number: 10-1184-0016

Checked By: SMM

**Golder Associates**

Date: 01-Jun-15



Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt to Silty Clay Fill

Figure No. B5

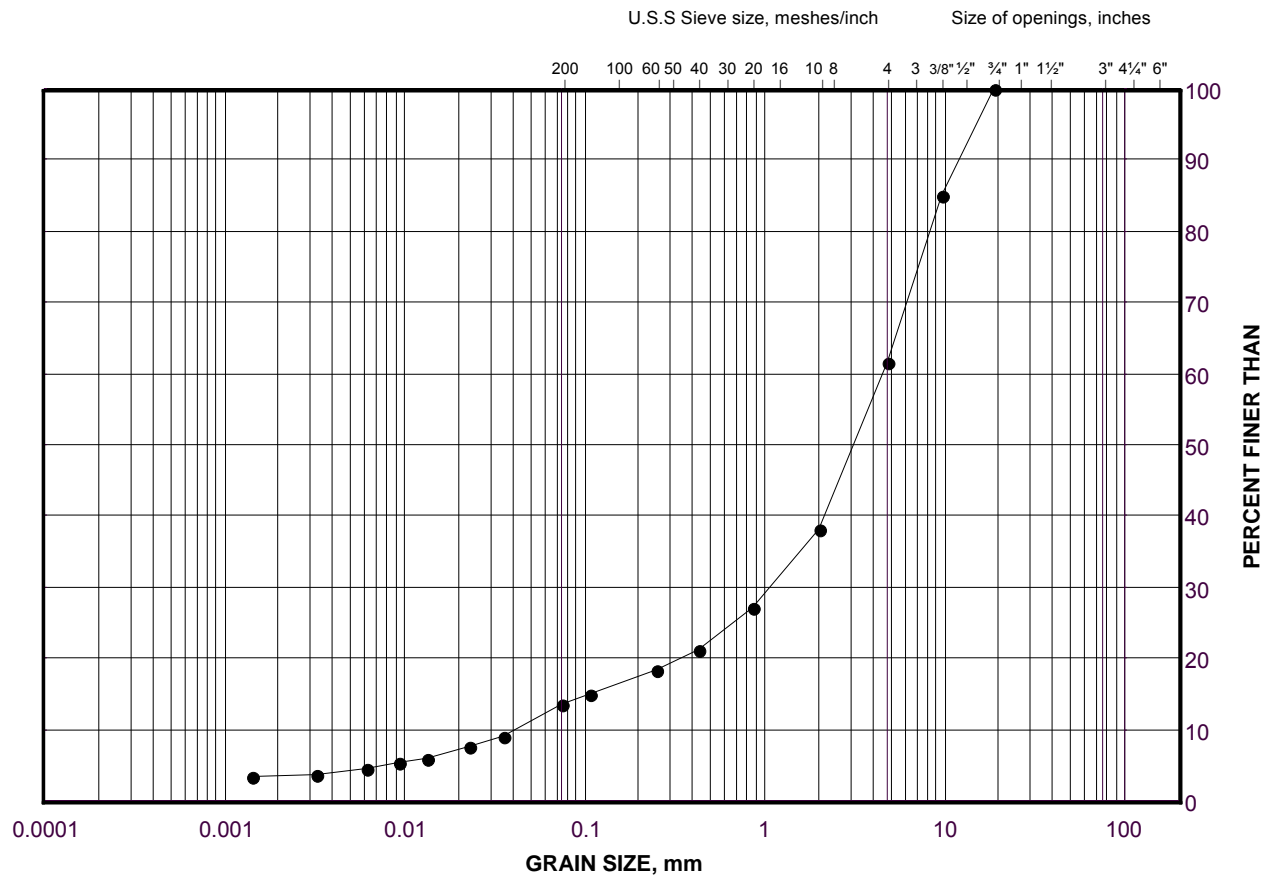
Project No. 10-1184-0016

Checked By: SMM

# GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B6



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	OS-2	5A	213.5

Project Number: 10-1184-0016

Checked By: SMM

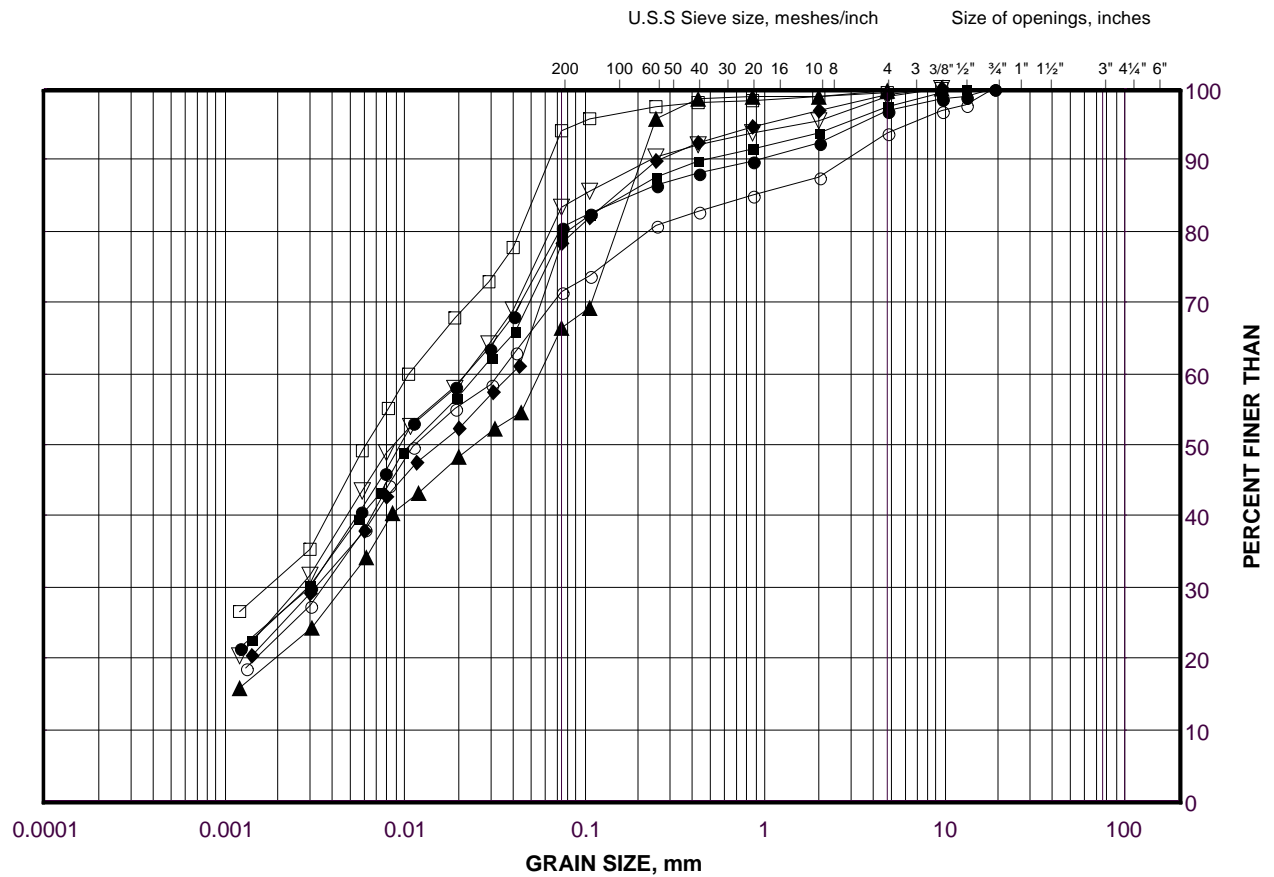
**Golder Associates**

Date: 28-Mar-14

# GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B7A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	EN-2	3	220.5
■	H5-7	3	220.8
◆	HML-2	4	220.0
▲	EN-1	4	219.8
▽	H5-6	4	219.6
○	H5-7	7	217.8
□	EN-2	7A	217.5

Project Number: 10-1184-0016

Checked By: SMM

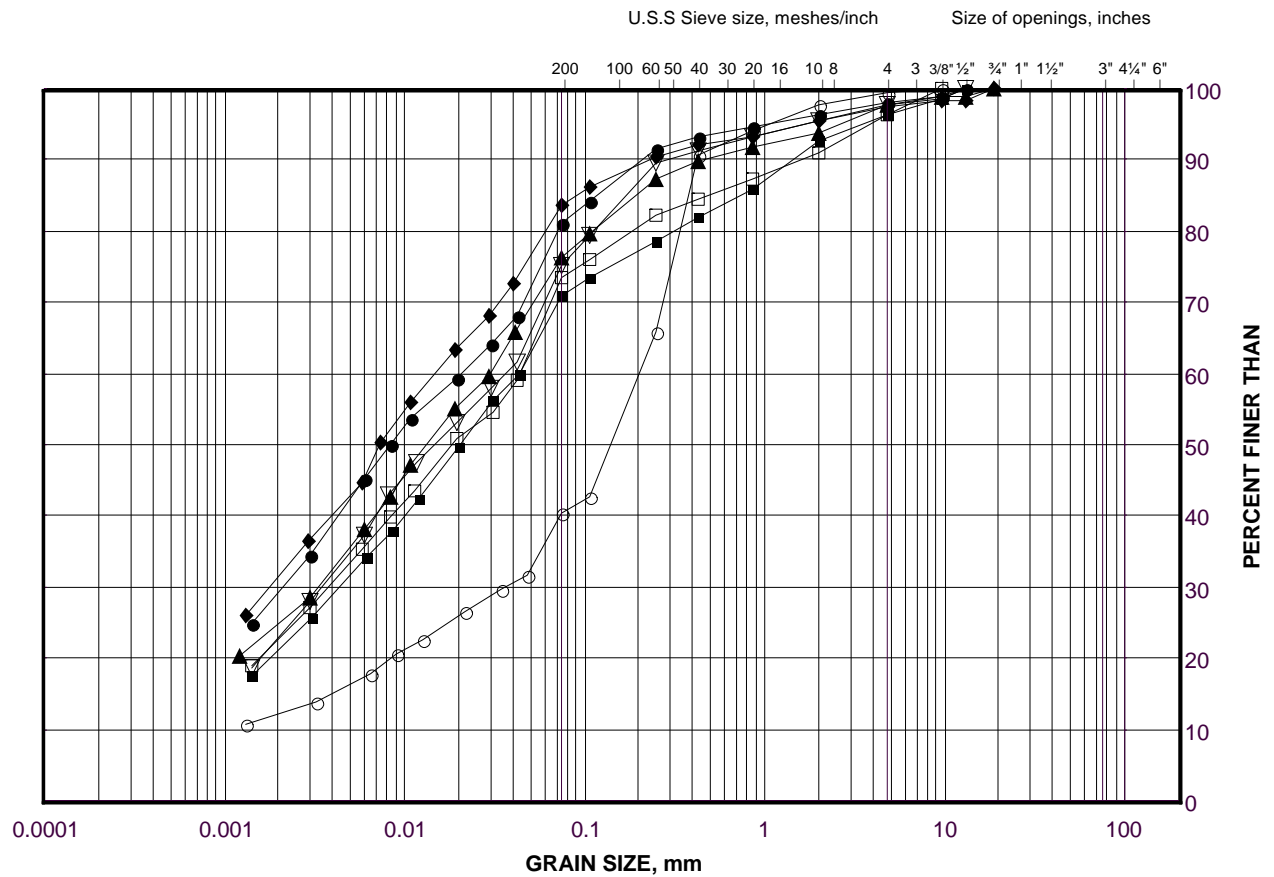
**Golder Associates**

Date: 23-Apr-15

# GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B7B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	HML-3	3	221.2
■	HML-5	4	219.7
◆	WS-1	4	218.8
▲	WS-2	5	218.5
▽	HML-2	6	218.4
○	HML-3	6A	218.1
□	HML-4	9	220.2

Project Number: 10-1184-0016

Checked By: SMM

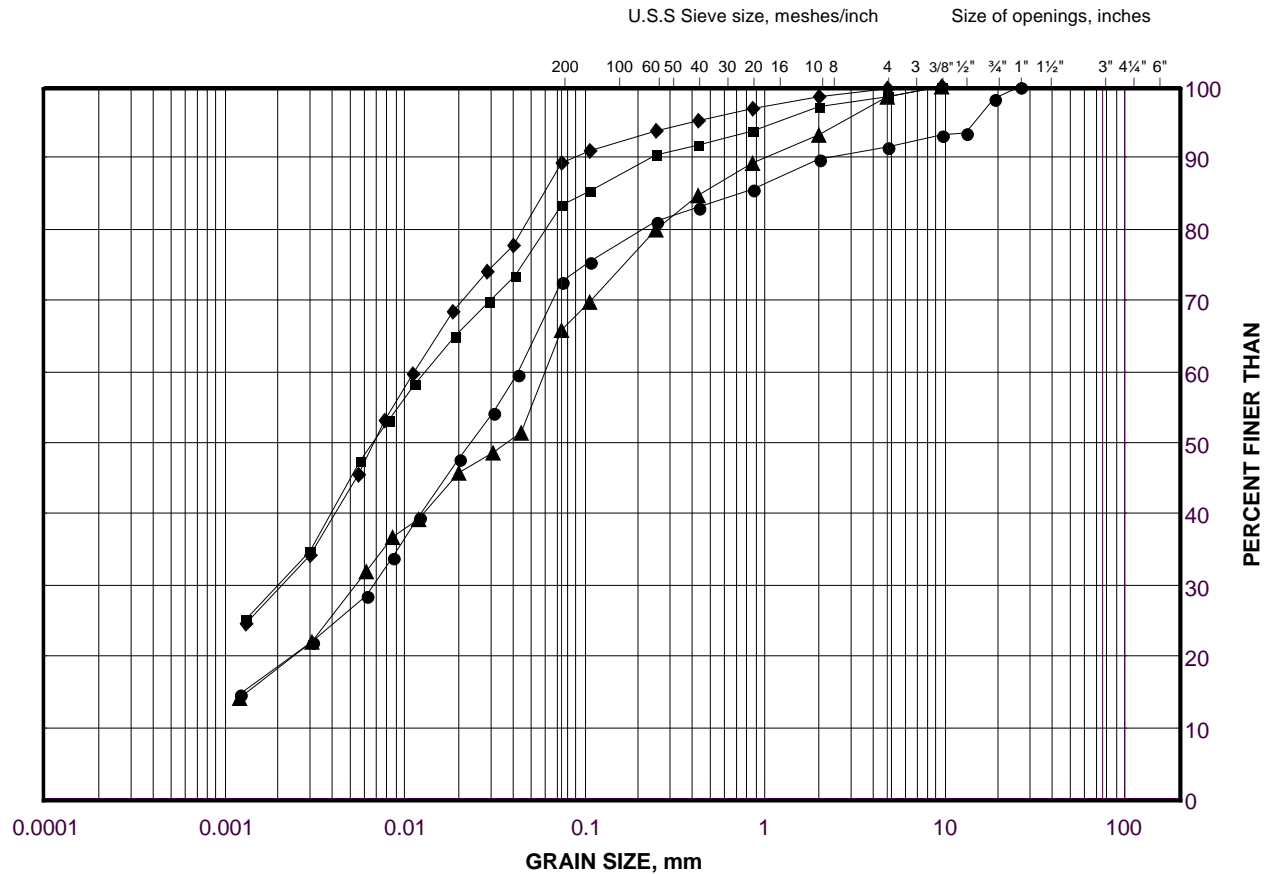
**Golder Associates**

Date: 23-Apr-15

# GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B7C



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

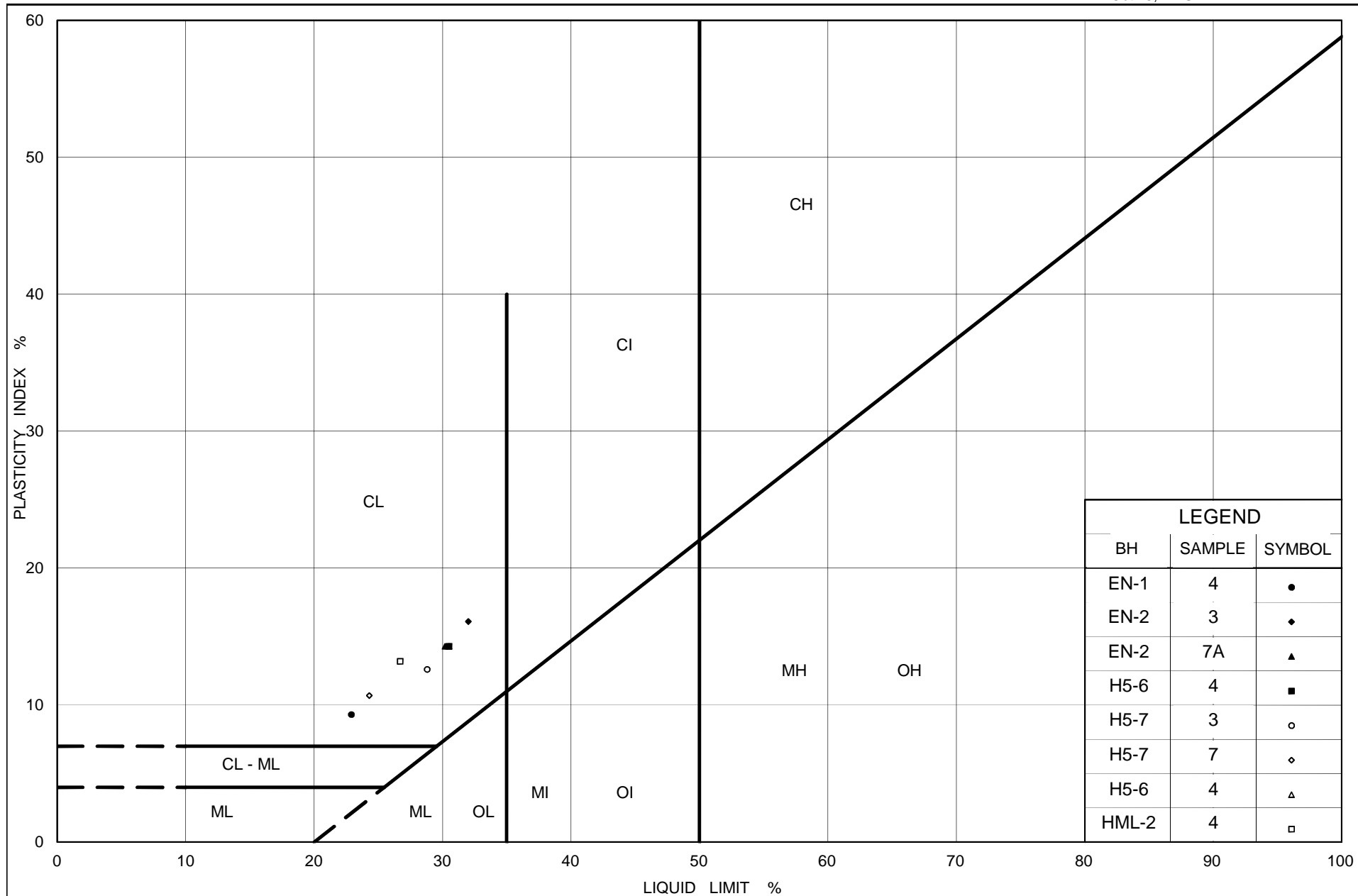
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	HML-7	4A	218.8
■	HML-6	5	218.2
◆	BC-4	5	217.4
▲	WS-2	7	216.9

Project Number: 10-1184-0016

Checked By: SMM

**Golder Associates**

Date: 01-Jun-15



Ministry of Transportation

Ontario

## PLASTICITY CHART

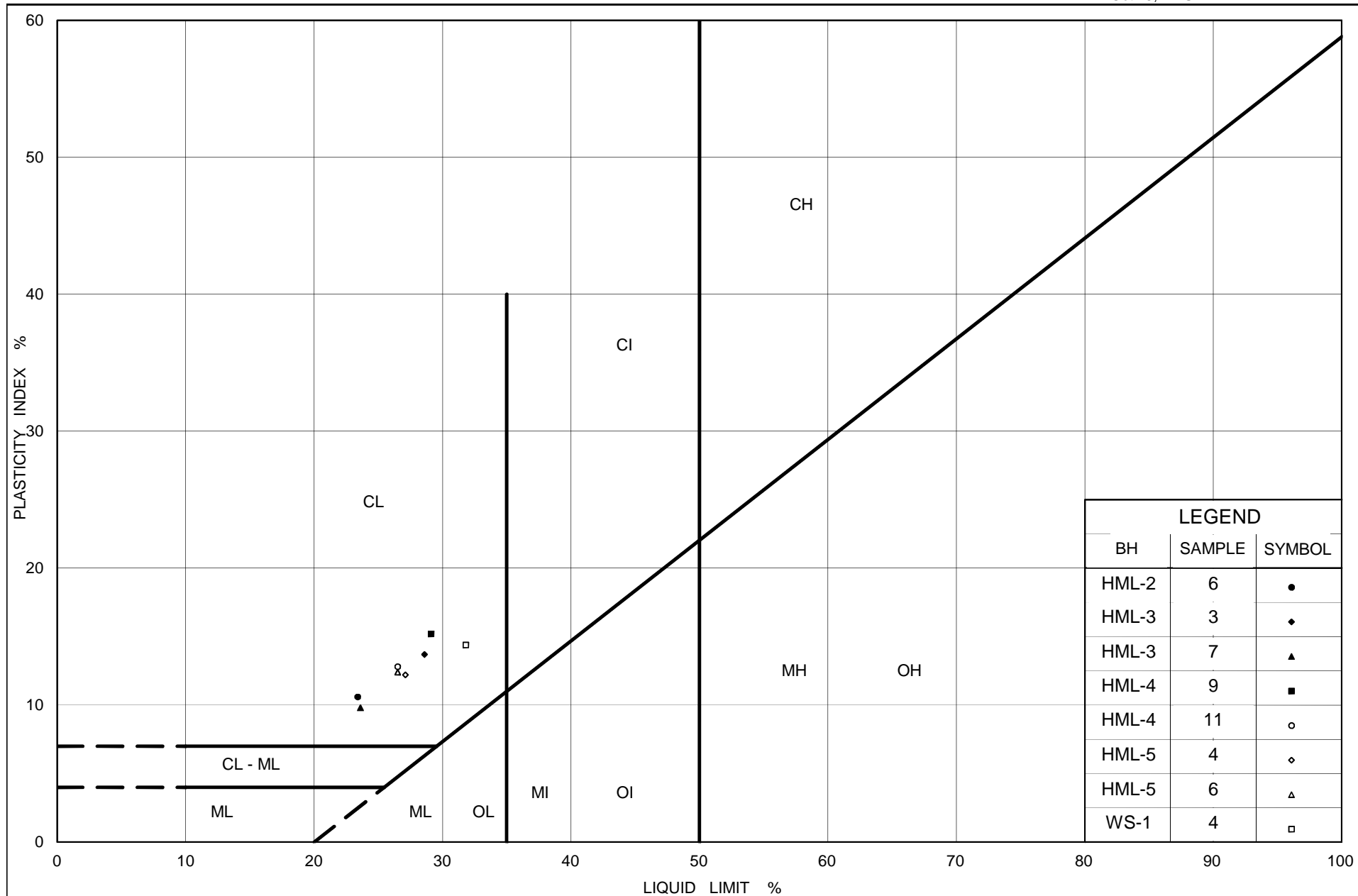
### Clayey Silt Till

Figure No. B8A

Project No. 10-1184-0016

Checked By: SMM





Ministry of Transportation

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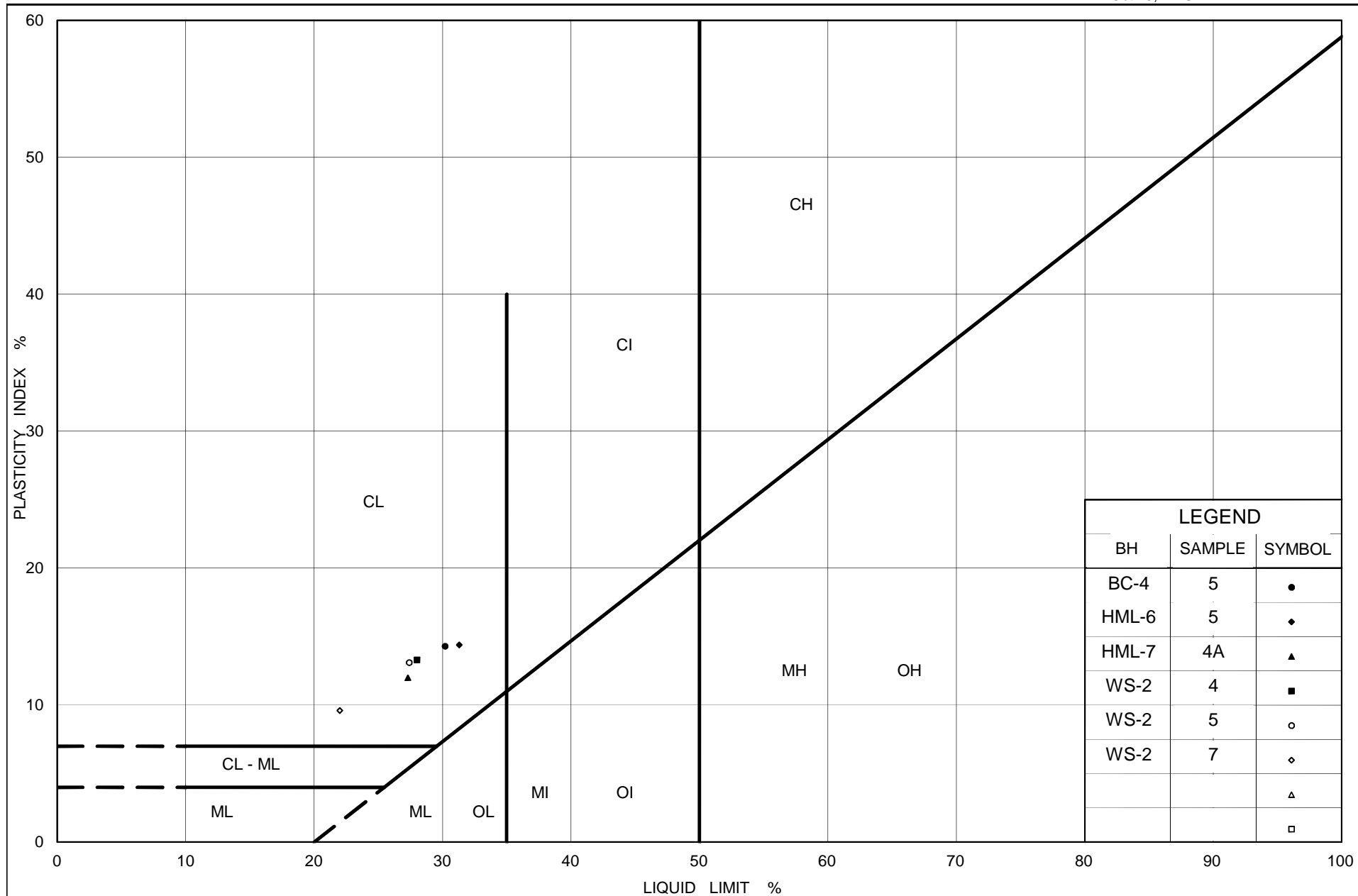
## PLASTICITY CHART

### Clayey Silt Till

Figure No. B8B

Project No. 10-1184-0016

Checked By: SMM



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Clayey Silt Till

Figure No. B8C

Project No. 10-1184-0016

Checked By: SMM




BH HML-2: Box 1 of 1: 6.6 m to 9.6 m



BH HML-3: Box 1 of 1: 5.5 m to 8.7 m



BH HML-5: Box 1 of 1: 6.2 m to 9.2 m

PROJECT		HIGH MAST LIGHT POLES-HIGHWAY 5 AND HIGHWAY 6 CITY OF HAMILTON, MINISTRY OF TRANSPORTATION, ONTARIO GWP 2112-05-00					
TITLE		Bedrock Core Photograph – Borehole HML-2, HML-3 and HML-5					
	PROJECT No.:		10-1184-0016		FILE No.	----	
	DESIGN	MP	NOVEMBER 2014		SCALE	AS SHOWN	REV.
	CADD	--					
	CHECK	SMM	JULY 2015		FIGURE B9A		
	REVIEW	LCC	JULY 2015				




BH HML-6: Box 1 of 1: 4.5 m to 7.5 m



BH HML-7: Box 1 of 1: 3.1 m to 6.1 m




BH OS-4: Box 1 of 1: 3.35 m to 6.40 m

PROJECT		HIGH MAST LIGHT POLES-HIGHWAY 5 AND HIGHWAY 6 CITY OF HAMILTON, MINISTRY OF TRANSPORTATION, ONTARIO GWP 2112-05-00			
TITLE		Bedrock Core Photograph Borehole HML-6 , HML-7 and OS-4			
		PROJECT No.: 10-1184-0016		FILE No. ----	
		DESIGN	MP	NOVEMBER 2014	SCALE AS SHOWN
		CADD	--		REV.
		CHECK	SMM	JULY 2015	FIGURE B9B
		REVIEW	LCC	JULY 2015	





BH OS-2: Box 1 of 1: 3.91 m – 6.99 m

PROJECT		HIGH MAST LIGHT POLES-HIGHWAY 5 AND HIGHWAY 6 CITY OF HAMILTON, MINISTRY OF TRANSPORTATION, ONTARIO GWP 2112-05-00			
TITLE		Bedrock Core Photograph OS-2			
		PROJECT No.: 10-1184-0016		FILE No. ----	
		DESIGN	MP	NOVEMBER 2014	SCALE AS SHOWN
		CADD	--		REV.
		CHECK	SMM	JULY 2015	FIGURE B9C
		REVIEW	LCC	JULY 2015	

**UNCONFINED COMPRESSION TEST (UC)**  
**ASTM D 7012**

**Figure B10**  
**Sheet 1 of 2**

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**SAMPLE IDENTIFICATION**

PROJECT NUMBER	10-1184-0016	SAMPLE NUMBER	-
BOREHOLE NUMBER	HML-2	SAMPLE DEPTH, m	6.86-7.01

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**TEST CONDITIONS**

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.41

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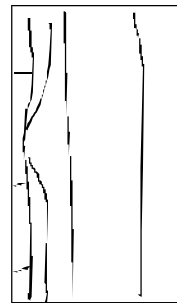
**SPECIMEN INFORMATION**

SAMPLE HEIGHT, cm	11.40	WATER CONTENT, (specimen) %	0.14
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m <sup>3</sup>	25.87
SAMPLE AREA, cm <sup>2</sup>	17.62	DRY UNIT WT., kN/m <sup>3</sup>	25.83
SAMPLE VOLUME, cm <sup>3</sup>	200.86	SPECIFIC GRAVITY	-
WET WEIGHT, g	529.99	VOID RATIO	-
DRY WEIGHT, g	529.25		

---

**VISUAL INSPECTION**

**FAILURE SKETCH**



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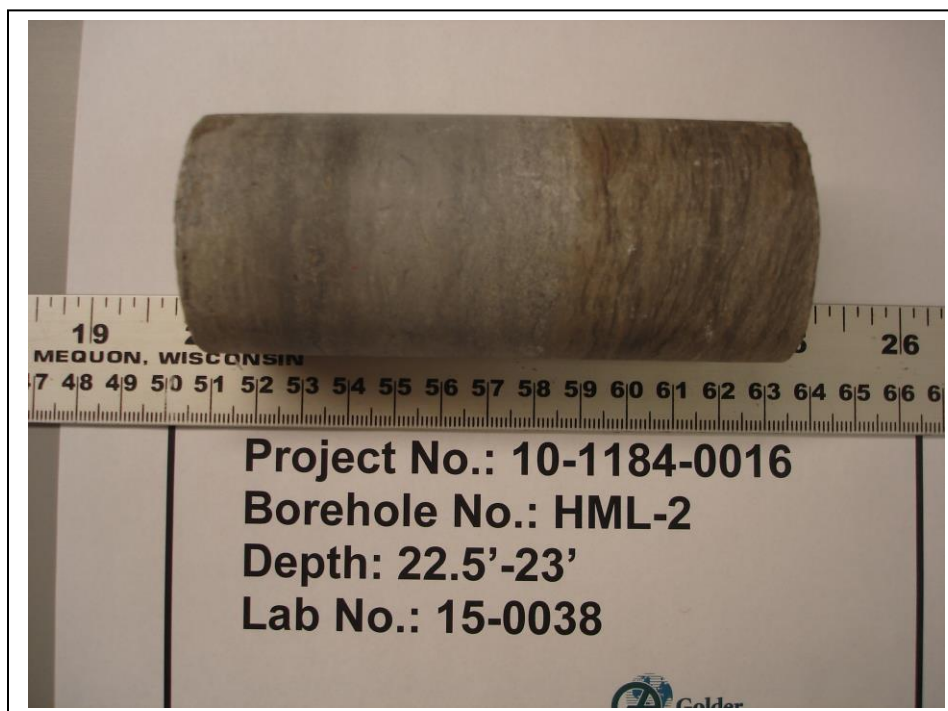
**TEST RESULTS**

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	75.7
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REMARKS:	DATE:	1/15/2014
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Checked By: SMM

**Golder Associates**



BEFORE COMPRESSION



AFTER COMPRESSION

Date Jan. 16, 2015  
Project 10-1184-0016

**Golder Associates**

Drawn Frank  
Chkd. SMM

**UNCONFINED COMPRESSION TEST (UC)****ASTM D 7012****Figure B11****Sheet 1 of 2****SAMPLE IDENTIFICATION**

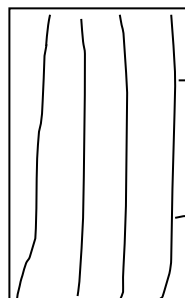
PROJECT NUMBER	10-1184-0016	SAMPLE NUMBER	-
BOREHOLE NUMBER	HML-3	SAMPLE DEPTH, m	6.15-6.31

**TEST CONDITIONS**

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.43

**SPECIMEN INFORMATION**

SAMPLE HEIGHT, cm	11.50	WATER CONTENT, (specimen) %	0.13
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m <sup>3</sup>	25.86
SAMPLE AREA, cm <sup>2</sup>	17.62	DRY UNIT WT., kN/m <sup>3</sup>	25.83
SAMPLE VOLUME, cm <sup>3</sup>	202.66	SPECIFIC GRAVITY	-
WET WEIGHT, g	534.65	VOID RATIO	-
DRY WEIGHT, g	533.96		

**VISUAL INSPECTION****FAILURE SKETCH****TEST RESULTS**

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	106.0
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REMARKS:

DATE:

1/15/2014

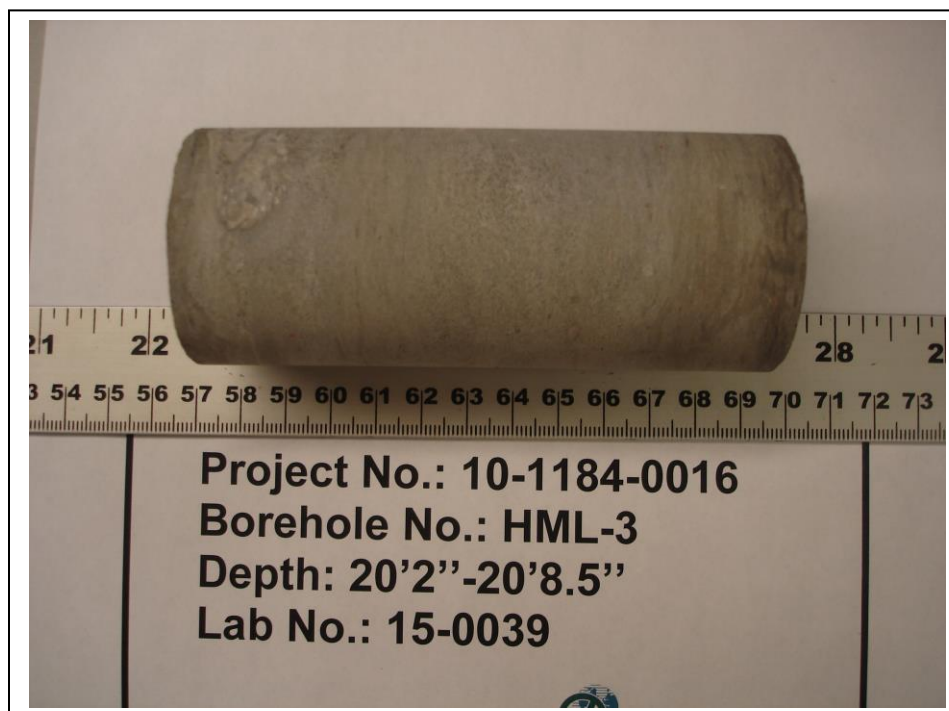
Checked By: SMM

**Golder Associates**

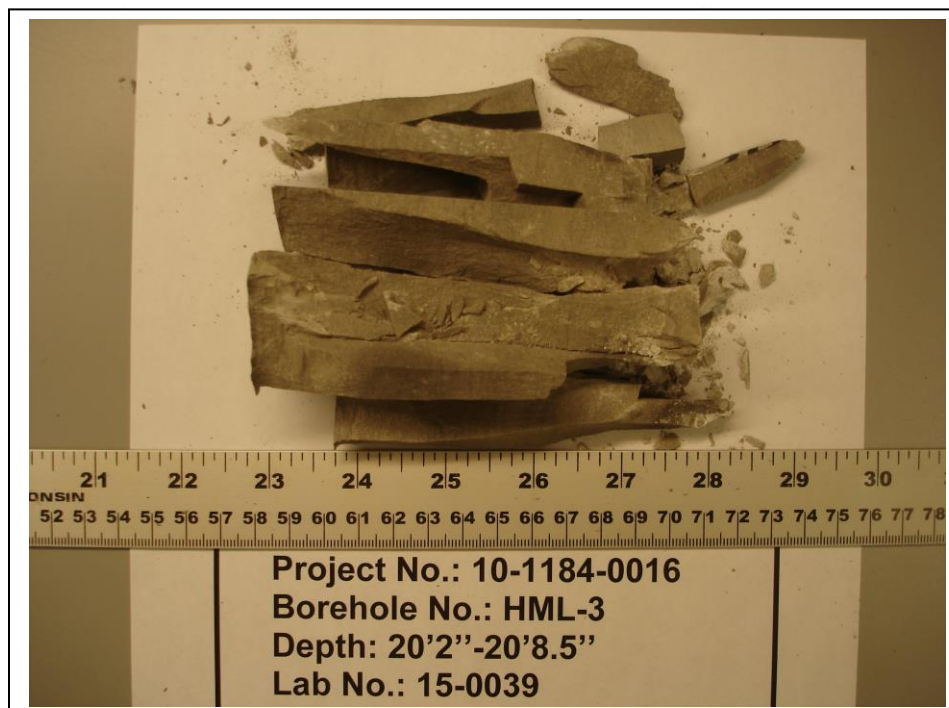


UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS  
ASTM D7012

Figure B11  
Sheet 2 of 2



BEFORE COMPRESSION



AFTER COMPRESSION

Date Jan. 16, 2015  
Project 10-1184-0016

**Golder Associates**

Drawn Frank  
Chkd. SMM

**UNCONFINED COMPRESSION TEST (UC)****ASTM D 7012****Figure B12****Sheet 1 of 2****SAMPLE IDENTIFICATION**

PROJECT NUMBER	10-1184-0016	SAMPLE NUMBER	-
BOREHOLE NUMBER	HML-7	SAMPLE DEPTH, m	3.13-3.26

**TEST CONDITIONS**

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.38

**SPECIMEN INFORMATION**

SAMPLE HEIGHT, cm	11.27	WATER CONTENT, (specimen) %	0.23
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m <sup>3</sup>	25.17
SAMPLE AREA, cm <sup>2</sup>	17.63	DRY UNIT WT., kN/m <sup>3</sup>	25.11
SAMPLE VOLUME, cm <sup>3</sup>	198.69	SPECIFIC GRAVITY	-
WET WEIGHT, g	510.14	VOID RATIO	-
DRY WEIGHT, g	508.97		

**VISUAL INSPECTION****FAILURE SKETCH****TEST RESULTS**

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	73.2
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REMARKS:

DATE:

1/15/2014

Checked By: SMM

**Golder Associates**



BEFORE COMPRESSION



AFTER COMPRESSION

Date Jan. 16, 2015  
Project 10-1184-0016

**Golder Associates**

Drawn Frank  
Chkd. SMM

**UNCONFINED COMPRESSION TEST (UC)****ASTM D 7012****Figure B13****Sheet 1 of 2****SAMPLE IDENTIFICATION**

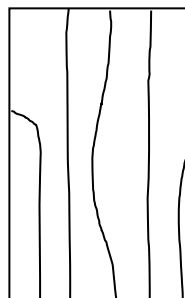
PROJECT NUMBER	10-1184-0016	SAMPLE NUMBER	1
BOREHOLE NUMBER	OS-2	SAMPLE DEPTH, m	5.22-5.34

**TEST CONDITIONS**

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.19

**SPECIMEN INFORMATION**

SAMPLE HEIGHT, cm	10.33	WATER CONTENT, (specimen) %	0.09
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m <sup>3</sup>	26.19
SAMPLE AREA, cm <sup>2</sup>	17.56	DRY UNIT WT., kN/m <sup>3</sup>	26.17
SAMPLE VOLUME, cm <sup>3</sup>	181.40	SPECIFIC GRAVITY	-
WET WEIGHT, g	484.65	VOID RATIO	-
DRY WEIGHT, g	484.21		

**VISUAL INSPECTION****FAILURE SKETCH****TEST RESULTS**

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	78.5
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REMARKS:

DATE:

10/23/2013

Checked By: SMM

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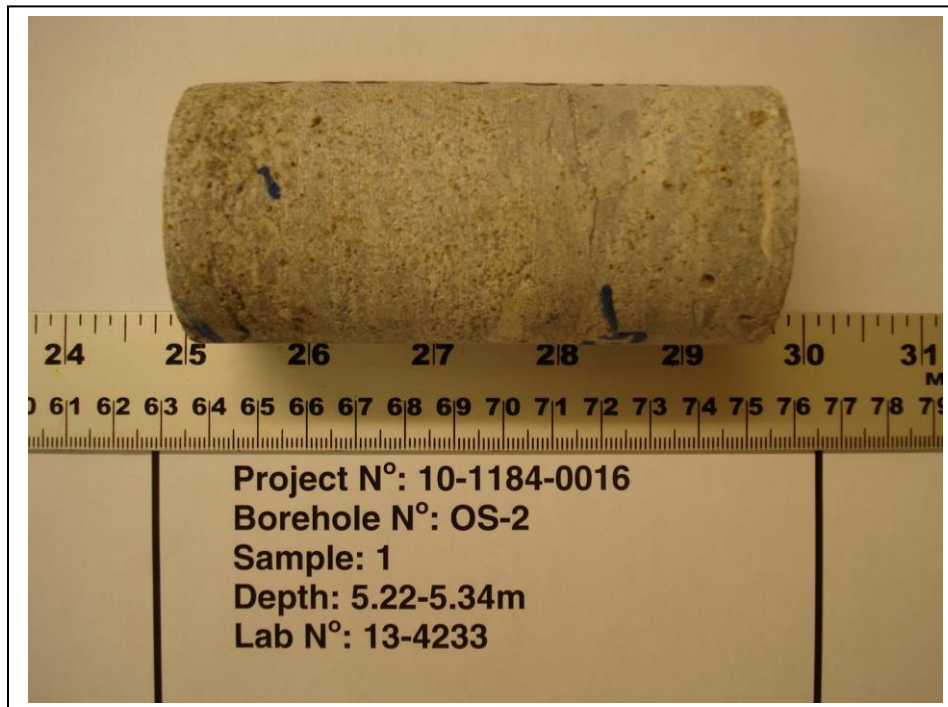


# UNCONFINED COMPRESSION TEST

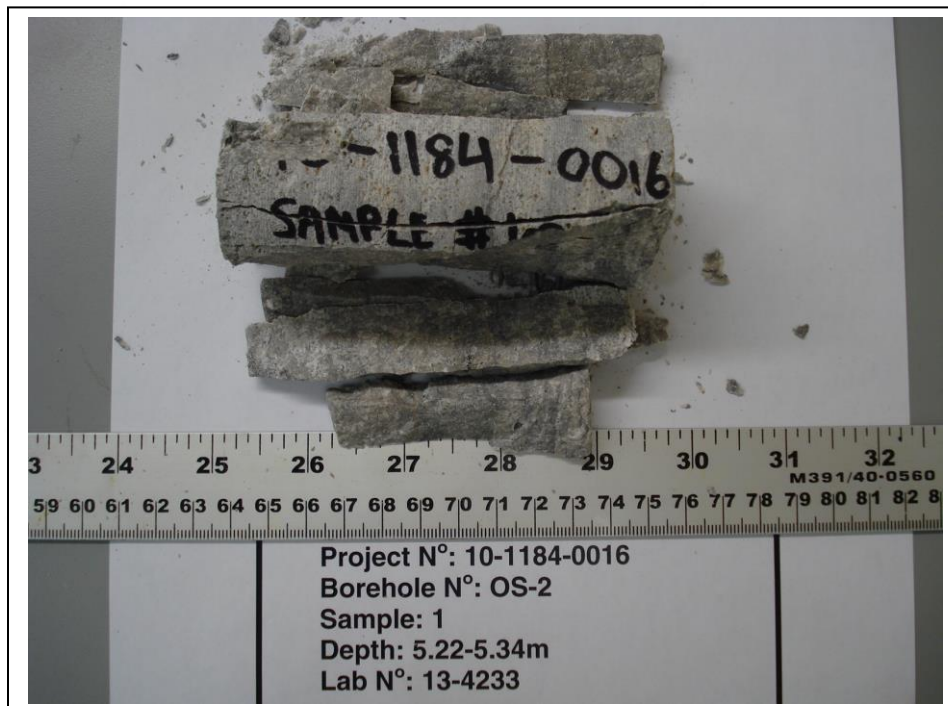
ASTM D7012-07

Figure B13

Sheet 2 of 2



BEFORE COMPRESSION



AFTER COMPRESSION

Date 11/4/2013  
Project 10-1184-0016

**Golder Associates**

Drawn Frank  
Chkd. SMM

**TABLE B1**  
**SUMMARY OF UNCONFINED COMPRESSIVE STRENGTH TEST RESULTS**  
**HIGH MAST LIGHT POLES**  
**HIGHWAY 5 / 6 INTERCHANGE, HAMILTON, ONTARIO**

<b>Borehole Number (Core Run)</b>	<b>Sample Depth (m)</b>	<b>Sample Elevation (m)</b>	<b>Rock Type</b>	<b>Core Diameter (mm)</b>	<b>Uniaxial Compressive Strength (MPa)</b>
OS-2 (1)	5.3	211.4	Dolostone	4.73	78
HML-2 (2)	6.9	215.7	Dolostone	4.74	76
HML-3 (2)	6.2	216.8	Dolostone	4.74	106
HML-7 / (3)	3.2	218.8	Dolostone	4.74	73
OS-4 / (2)	5.2	215.4	Dolostone	4.73	96

Compiled By: AJSReviewed By: SMM

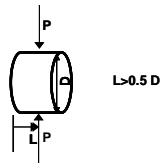
**TABLE B2**  
**SUMMARY OF POINT LOAD TEST RESULTS ON ROCK SAMPLES**  
**HIGH MAST LIGHT POLES**  
**HIGHWAY 5/6 INTERCHANGE, HAMILTON, ONTARIO**

Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Is (50mm) (MPa)	Approx. UCS Value <sup>(1)</sup> (MPa)
OS-2	1	5.18	211.5	Dolostone	Axial	17.0	94
OS-2	1	5.34	211.4	Dolostone	Diametral	12.8	71
OS-2	2	6.22	210.5	Dolostone	Axial	11.5	63
OS-2	2	6.26	210.4	Dolostone	Diametral	1.6	9
HML-2	1	6.6	216.0	Dolostone	Diametral	10.7	136
HML-2	1	6.7	215.9	Dolostone	Axial	8.5	108
HML-3	3	8.0	215.0	Dolostone	Axial	3.2	40
HML-3	3	7.8	215.2	Dolostone	Diametral	9.0	114
HML-5	1	7.2	215.0	Dolostone	Axial	9.6	121
HML-6	1	5.1	216.5	Dolostone	Axial	8.8	76
HML-6	1	5.7	215.9	Dolostone	Diametral	9.2	80
HML-7	2	4.7	216.5	Dolostone	Diametral	10.0	87
HML-7	2	3.9	217.3	Dolostone	Axial	10.4	90
OS-4	1	3.8	216.7	Dolostone	Diametral	17.3	151
OS-4	1	3.9	216.6	Dolostone	Axial	16.0	140
OS-4	2	5.0	215.5	Dolostone	Axial	3.5	30
OS-4	2	5.3	215.2	Dolostone	Diametral	18.3	159

<sup>(1)</sup>  $I_{s50} \times K$  (actual value could be confirmed by UCS testing) from ISRM. This range has been given based on  $K = 8.7$ , calculated from  $I_{s50}$  Average of nine tests on Axial Orientations and five UCS test.  
Refer to "Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int.J.Rock. Mech. Min.Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, PP 51-60.

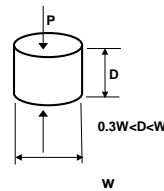
#### DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis  
(planar planes of weakness)



#### AXIAL SPECIMEN SHAPE REQUIREMENTS

note: Axial tests are parallel to core axis  
(planar planes of weakness)



Compiled By: AJS  
Checked By: SMM  
Reviewed By: LCC



# **APPENDIX C**

## **Non-Standard Special Provisions**





**CAISSON FOUNDATIONS FOR HML POLE FOUNDATIONS - Item No.**

Special Provision

Where OPSS 903 is called up by OPSS 915, OPSS 903 is amended by the following. Where conflict occurs, this NSSP shall take precedence.

The Contractor shall construct HML pole foundations in conformance with the design and at the locations indicated in the Contract Documents.

The Contractor shall construct the HML pole foundations against undisturbed bases and sides of excavations. The bases of caisson excavations shall be cleaned of loosened and/or softened materials prior to pouring concrete for the foundation. The construction methods and techniques shall be the responsibility of the Contractor, but consideration could be given to using temporary liners or tremie concreting techniques where conditions warrant.

The Contractor is advised that variable subsurface conditions and bedrock surface elevations may be encountered at HML caisson locations where included in the contract. For bidding purposes, the Contractor shall assume that the overburden has zones of non-cohesive soil and contains cobbles and boulders, and that the groundwater levels are near the surface. The Contractor is advised that non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head. As a lower priority than the above-noted instruction, the Contractor shall assume that the subsurface conditions at HML caisson locations are generally similar to the closest of the boreholes, as illustrated in the Foundation Investigation Report.

The Contractor is also alerted to the variable bedrock surface in the south of Highway 5. Where the HML pole foundations extend into the dolostone bedrock, the Contractor is alerted that the bedrock is strong to very strong; the shale bedrock in the vicinity of HML Pole P1 is weak to medium strong, and should be expected to contain stronger interlayers of limestone and/or dolostone. Appropriate construction procedures and equipment will be required to penetrate the bedrock to form the HML pole foundation.

**Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

**END OF SECTION**

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

[solutions@golder.com](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**6925 Century Avenue, Suite #100**  
**Mississauga, Ontario, L5N 7K2**  
**Canada**  
**T: +1 (905) 567 4444**

