

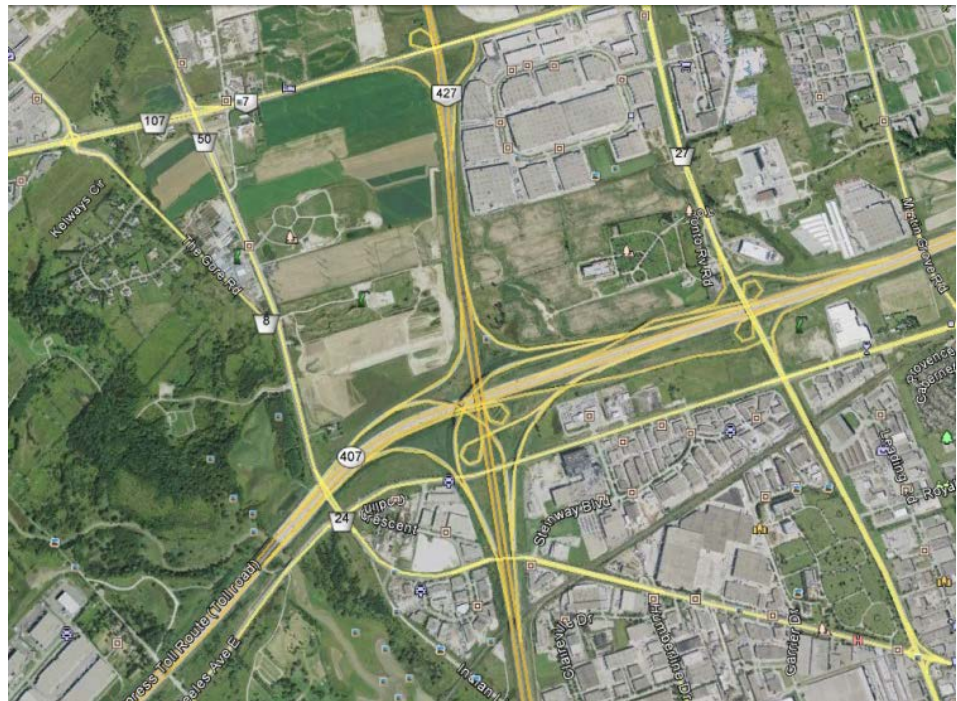


January 13, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

High Mast Light Poles and Overhead Signs Highway 427 Widening from Albion Road to Highway 7, City of Vaughan and Regional Municipality of York G.W.P. 2229-09-00(f)

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REPORT





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PART A

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGH MAST LIGHT POLES AND OVERHEAD SIGNS
HIGHWAY 427 WIDENING FROM ALBION ROAD TO HIGHWAY 7,
CITY OF VAUGHAN, THE REGIONAL MUNICIPALITY OF YORK
G.W.P. 2229-09-00(f)**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin, a member of MMM Group Ltd. (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the future widening of the Highway 427 from Albion Road to Highway 7 (approximately 2.3 km) in the City of Vaughan and the City of Toronto in the Regional Municipality of York, Ontario. As part of the future widening work, 5 new overhead sign (OHS) supports and 11 high mast light (HML) poles will be constructed requiring foundation engineering services. The overhead signs will be constructed at the following locations (referenced to the stationing along the Highway 427 alignment):

- Highway 427 Southbound Lanes, Station 10+912
- Highway 427 Northbound Lanes, Station 11+247
- Highway 427 S – Highway 407 E/W Ramp, Station 11+691
- Highway 427 Northbound Lanes, Station 13+161
- Highway 427 Northbound Lanes, Station 13+531

The high mast light poles will be constructed at the following locations (referenced to the stationing along the Highway 427 alignment):

- Highway 427 East of Northbound Lanes, Station 12+526
- Highway 427 Median, Station 12+638
- Highway 427 Median, Station 12+810
- Highway 427 Median, Station 12+971
- Highway 427 Median, Station 13+151
- Highway 427 Median, Station 13+319
- Highway 427 Median, Station 13+458
- Highway 427 Median, Station 13+601
- Highway 427 Median, Station 13+743
- Highway 427 East of Northbound Lanes, Station 13+869
- Highway 427 West of Southbound Lanes, Station 13+927

This report presents a summary of the interpreted subsurface conditions throughout the project area based on boreholes advanced by Golder and others in the vicinity of the proposed overhead signs and high mast light poles. The subsurface information used in this report was obtained from a report prepared by Golder for the proposed culvert north of Highway 407 (under the current assignment) and from previous Foundation Investigation Reports prepared by others for structures within the Highway 427 corridor, available from MTO Pavement and Foundations Section's GEOCRE database, as referenced in Section 3.0 of this report.



The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 2009-E-0075 dated September 2010, and in Section 5.8 of the *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

This project extends along Highway 427 at the north western end of the City of Toronto, from the Canadian National (CN) Rail corridor south of Albion Road to Highway 7 in south western end of the City of Vaughan. The ground surface generally rises from approximately Elevation 170 m near the CN Rail corridor at the southern project limit, to approximately Elevation 180 m near Highway 7 at the northern project limit. The topography of this area is generally flat, with Highway 427 and/or the local roads constructed on embankments at the grade separation areas.

3.0 EXISTING SUBSURFACE INVESTIGATION DATA

As part of the current foundation investigations along the Highway 427 corridor, two boreholes were completed in December 2012 by Golder. These two boreholes were advanced as part of the investigation for the Culvert 18 Extension under G.W.P. 2144-07-00 (GEOCRES No. 30M12-359). These boreholes are located within the vicinity of the proposed high mast light pole locations and as such, have been considered appropriate subsurface information to supplement the development of a subsurface model for the site.

Furthermore, as a part of the Highway 427 northerly extension and widening in the 1980s and 1990's, various subsurface investigations were carried out by or on behalf of the MTO. Golder has reviewed the Foundation Investigation Reports for the Highway 427 corridor that are available in MTO's GEOCRES system, and considers that appropriate subsurface information is available within the Highway 427 corridor between the CN Rail corridor south of Albion Road and Highway 7 to supplement the development of a subsurface model for the new overhead sign and high mast light pole locations. Those reports that contain borehole information relevant to the proposed overhead sign and high mast light pole locations are summarized below:

- **MTO GEOCRES No. 30M12-152:** "Foundation Investigation Report for C.N.R. (Halton Subdivision) Overhead at Highway 427, W.P. 153-80-02", by Department of Highways Ontario, dated 1982.
- **MTO GEOCRES No. 30M12-164:** "Geotechnical Investigation, Proposed Albion Road Underpass Structure at Highway 427, W.P. 153-80-03", by Peto MacCullum Ltd., dated 1982.
- **MTO GEOCRES No. 30M12-290:** "Foundation Investigation and Design Report, Highway 427 Widening From Fasken Drive to Steeles Avenue, Albion Road Overpass, Toronto, Ontario, G.W.P. 202-95-00", by Thurber Engineering Ltd., dated 2009.
- **MTO GEOCRES No. 30M12-169:** "Foundation Investigation Report for Ramp 427S-407E Over Steeles Avenue (Bridge 13), W.P. 88-78-23", by Department of Highways Ontario, dated 1982.
- **MTO GEOCRES No. 30M13-56:** "Foundation Investigation Report for Ramp Structure 407E – 427S and Retaining Wall – Ramp 427 N – 407E, W.P. 88-78-25" by Department of Highways Ontario, dated 1982.
- **MTO GEOCRES No. 30M13-63:** "Foundation Investigation Report for Highway 7 Underpass, W.P. 153-80-07" by Department of Highways Ontario, dated 1989.



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- **MTO GEOCREs No. 30M13-67:** "Report on Foundation Investigation for Proposed Highway 407 and Highway 427 Interchange, W.P. 150-87-01 and W.P. 150-87-02" by B. P. Walker Associates Ltd., dated 1988.
- **MTO GEOCREs No. 30M13-114:** "Foundation Investigation Report for Ramp 427S-407W Over Steeles Avenue, W.P. 368-87-02", by Department of Highways Ontario, dated 1990.

The previous boreholes used in this report have been renamed to show the MTO GEOCREs reference number followed by the original borehole designation. For example, the boreholes from MTO GEOCREs Report No. 30M12-152 have been renamed as "152-X" where "X" is the original borehole number. The locations of the compiled boreholes extracted from the above-noted reports are shown on Drawings 1 to 6. In general, the boreholes from the MTO GEOCREs reports were referenced to a global datum, and could be converted to the MTM NAD83 coordinate system. The accuracy of these borehole locations is considered to be consistent with that of the original survey.

Based on the compiled borehole locations and information, one borehole considered to be representative of the subsurface conditions was chosen for each proposed overhead sign and high mast light location. The table below shows the relevant boreholes advanced as part of the previous investigations along the Highway 427 corridor as assessed by Golder for each of the proposed overhead sign and high mast light locations, along with the borehole location (northing and easting coordinates) and the ground surface elevation at the time of the borehole investigation.

Overhead Sign Station	Borehole Designation	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	As-drilled Ground Surface Elevation (m)	Borehole Depth (m)
10+912	152-1	4845043.3	294344.0	171.9	13.9
11+247	152-2	4845069.0	294375.7	171.6	23.4
11+691	164-6	4845390.2	294324.7	173.2	15.7
13+161	63-6	4847802.2	294043.2	179.6	12.2
13+531	63-6	4847802.2	294043.2	179.6	12.2

High Mast Light Station	Borehole Designation	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	As-drilled Ground Surface Elevation (m)	Borehole Depth (m)
12+526	56-9	4846173.9	294224.3	176.9	9.1
12+638	12-01	4846478.4	294115.9	178.3	15.8
12+810	12-01	4846478.4	294115.9	178.3	15.8
12+971	63-5	4847790.6	294009.3	179.3	10.9
13+151	63-5	4847790.6	294009.3	179.3	10.9
13+319	63-5	4847790.6	294009.3	179.3	10.9
13+458	63-5	4847790.6	294009.3	179.3	10.9
13+601	63-5	4847790.6	294009.3	179.3	10.9



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High Mast Light Station	Borehole Designation	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	As-drilled Ground Surface Elevation (m)	Borehole Depth (m)
13+743	63-5	4847790.6	294009.3	179.3	10.9
13+869	63-6	4847802.2	294043.2	179.6	12.2
13+927	63-4	4847785.2	293982.7	179.3	12.3

The procedures used in carrying out the previous investigation are generally similar to current procedures; the boreholes were drilled by truck-mounted drill rigs using continuous flight augers and, in some cases, diamond core drill rigs adapted for soil sampling purposes. Soil sampling was performed at regular intervals of depth using a 50 mm outside diameter split-spoon sampler driven by a manual hammer. The number of hammer blows necessary to drive the split-spoon sampler for 0.3 m of penetration under an impact of 350 ft-lbs (a 140-pound hammer falling 30 inches) was recorded as the Standard Penetration Test “N” value.

The groundwater conditions in the open boreholes were observed either immediately after the drilling operations or a few days thereafter, with the dates noted on the borehole records.

The samples were identified in the field and underwent further visual examination in the laboratory. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

This section of Highway 427 is located within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984).

The Peel Plain physiographic region covers the central portions of the Regional Municipalities of York, Peel and Halton. The general topography of this region consists of level to gently rolling terrain, sloping gradually southward toward Lake Ontario. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till, which is mapped in this area as the Halton Till, typically consists of clayey silt to silty clay, with occasional sand to silt zones. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay. The study area, in the western portion of the Peel Plain, is underlain by grey shale of the Georgian Bay Formation.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing, where available, are given on the borehole records contained in the appendices following the text of this report. The stratigraphic boundaries shown on the borehole records are considered to have been inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.



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In general, the soils encountered along the Highway 427 corridor between the CN Rail corridor, south of Albion Road and Highway 7 consist of embankment fill underlain by a glacial till deposit in the southern portion of the site or by surficial silty clay in the northern portion of the site. The glacial till varies in composition from cohesive clayey silt to silty clay to non-cohesive silty sand to sand and silt. A deposit of granular materials varying in composition from sand to silty sand to sand and silt to silt was encountered underlying the till deposits in the southern portion of the site or underlying the surficial silty clay deposit in the northern portion of the site. Towards the north limit of the site, the granular deposits are underlain by a deposit of clayey silt to silty clay. At the northern extent of the site, weathered shale bedrock was encountered at between 10.7 to 12.1 m depth below the existing ground surface (between Elevation 168.6 m and 167.3 m).

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Fill

With the exception of the recent boreholes advanced for the culvert investigation, under MTO GEOCRETS No. 30M12-359 (Borehole 12-01), all existing boreholes were drilled from original ground surface prior to the construction of the Highway 427 embankment. The present Highway 427 grade is up to approximately 10 m higher than the original ground surface, and the existing boreholes do not provide information on the material type and properties of the embankment fill.

Borehole 12-01 was advanced from the current Highway 427 grade. Fill was encountered immediately below the ground surface. The thickness of the fill was measured to be 2.7 m depth below ground surface, with the base of the fill encountered at Elevation 175.6 m. This fill varied in composition from cohesionless silty sand containing some gravel and trace clay to cohesive silty clay containing trace sand and gravel.

The Standard Penetration Test (SPT) "N" value measured on one sample of the cohesionless fill was 5 blows per 0.3 m of penetration, indicating a very loose relative density. The measured SPT "N" values within the cohesive fill range from 7 to 12 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

4.2.2 Surficial Silty Clay

A surficial silty clay deposit was encountered immediately below the ground surface in Boreholes 56-9, 63-4, 63-5, and 63-6. This surficial deposit varies in thickness from about 1.4 m to 3.5 m, and the base of the deposit encountered between approximately Elevation 177.9 m and 173.4 m.

The surficial silty clay deposit contains with to some sand and trace gravel. The measured SPT "N" values within the deposit range from 6 blows to 38 blows per 0.3 m of penetration with some values greater than 100 blows per 0.18 m of penetration, suggesting a firm to hard consistency.

4.2.3 Organic Silty Clay (North of Highway 407)

In Borehole 12-01 in the area just north of Highway 407, a 1.9 m thick deposit of organic silty clay was encountered below the fill, with the surface of the deposit encountered at approximately Elevation 175.6 m and the base of the deposit encountered at approximately Elevation 173.7 m.

Based on field observations, the silty clay contains some sand, trace gravel and also contains organics and rootlets to a depth of 3.8 m below ground surface (Elevation 174.5 m).

The Standard Penetration Test (SPT) "N" values measured within the organic silty clay material were 7 and 8 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.



4.2.4 Clayey Silt to Silty Clay Till and Silty Sand to Sand and Silt Till

A glacial till deposit that generally consists of clayey silt to silty clay till underlain by silty sand to sand and silt till was encountered immediately below the ground surface in Boreholes 152-1, 152-2, and 164-6, underlying the organic silty clay in Borehole 12-01 and underlying a deeper silty clay deposit in Borehole 63-4 (as outlined in Section 4.2.6). The surface of the clayey silt to silty clay till deposit was encountered at a depth of approximately 4.6 m below ground surface (Elevation 173.7 m) in Borehole 12-01 and a depth of approximately 10 m below ground surface (Elevation 169.3 m) in Borehole 63-4. The clayey silt to silty clay portion of the till deposit varies in thickness from about 2 m to 11.9 m, and the base of the deposit encountered between approximately Elevation 172.7 m and 160.0 m.

The silty sand to sand and silt till was encountered underlying the clayey silt to silty clay till at depths from 5.2 m to 5.6 m below ground surface, between approximately Elevation 172.7 m and 168.1 m. The silty sand to sand and silt till was measured to be 1.5 m thick in Borehole 12-01. Borehole 164-6 was terminated within the silty sand to sand and silt till deposit, where it was at least 10.5 m thick (Elevation 157.6 m).

The clayey silt to silty clay till deposit contains with sand and trace to some gravel, with occasional lenses of gravel and sand to silty sand. The silty sand to sand and silt till deposit contains trace gravel and trace clay.

The Standard Penetration Test (SPT) "N" values measured within the clayey silt to silty clay portion of the till generally range from 9 to 78 blows per 0.3 m of penetration, suggesting a stiff to hard consistency. The measured SPT "N" values within the silty sand to sandy silt portion of the till generally range from 94 blows per 0.3 m of penetration and 100 blows per 0.15 m of penetration, indicating a very dense consistency.

4.2.5 Sand to Silty Sand to Sand and Silt to Silt

A granular deposit of sand to silty sand to sand and silt to silt was encountered underlying the till in Boreholes 152-1, 152-2, and 12-01; and underlying the surficial silty clay in Boreholes 56-9, 63-4, 63-5 and 63-6. The deposit varies in thickness from about 2.0 m and 13.3 m, with its surface encountered between approximately Elevation 160.0 m and 177.9 m and the base of the deposit encountered between approximately Elevation 165.1 m and 175.2 m. Boreholes 152-1, 152-2, and 56-9 were terminated within the granular deposit, where it was measured to be at least 2.0 m to 13.3 m thick. These boreholes were terminated within the granular deposit between approximately Elevation 167.8 m and 148.2 m.

The sand to silty sand to sand and silt to silt deposit contains trace to some gravel and trace clay. The presence of cobbles and boulders was noted at various depths within the granular deposit in Boreholes 152-1, 152-2, 56-9 and 63-4 as indicated on the borehole records in Appendix A of this report. The Standard Penetration Test (SPT) "N" values measured within the sand and silt to silt deposit range from 37 blows per 0.3 m of penetration to 100 blows per 0.15 m of penetration, indicating a dense to very dense relative density.

4.2.6 Clayey Silt to Silty Clay

A cohesive deposit of clayey silt to silty clay was encountered underlying the sand to silty sand to sand and silt to silt in Boreholes 12-01, 63-4, 63-5 and 63-6. The deposit varies in thickness from about 2.6 m and 7.7 m, with its surface encountered between approximately Elevation 175.2 m and 165.1 m. Borehole 12-01 was terminated within the clayey silt to silty clay deposit, where it was measured to be at least 2.6 m thick. This borehole was terminated within the cohesive deposit at approximately Elevation 162.5 m.

The clayey silt to silty clay deposit contains trace sand with thin silt seams and laminations of sandy silt to silty sand. The presence of cobbles and boulders was noted at a depth of approximately 11.1 m below ground



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surface (Elevation 168.5 m) within the clayey silt to silty clay deposit in Borehole 63-6 as indicated on the borehole record in Appendix A of this report. The measured SPT “N” values within the deposit range from 21 to 80 blows per 0.3 m of penetration, indicating a very stiff to hard consistency.

4.2.7 Weathered Shale Bedrock

A weathered shale bedrock was encountered at the northern extent of the site underlying the clayey silt to silty clay deposit in Boreholes 63-5 and 63-6; and underlying the till deposit in Borehole 63-4 at depths ranging from 10.7 m and 12.1 m (between Elevation 168.6 m and 167.3 m). The boreholes were terminated within the weathered shale bedrock between approximate Elevation 168.4 m and 167.0 m, after penetrating it for a thickness ranging from about 0.1 m to 0.3 m.

4.3 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on borehole records in Appendix A of this report. In general, the water level in these boreholes was measured to be between 0.5 m and 9.8 m below ground surface. Borehole 12-01 was noted to be dry upon completion of overburden drilling. One standpipe piezometer was installed in Borehole 63-5 to monitor the groundwater level at the northern extent of the site. In addition, piezometers from selected previous investigations are also presented in the table below. The groundwater conditions measured in the piezometer from the previous investigations are summarized in the following table:

Borehole No.	Stratum Sealed	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date
67-16 (Highway 407)	Sandy Silt Till	177.7	4.7	173.0	Date not recorded
12-02 (Culvert 18)	Sand and Silt	176.5	4.7	171.8	Upon Completion of Drilling
			3.7	172.8	January 8, 2013
			4.4	172.8	January 21, 2013
63-5 (Highway 7)	Silt	179.3 m	0.1	179.2	Measured 1 day after completion of drilling (September 20, 1984)
			0.3	179.0	October 12, 1984
			0.2	179.1	November 8, 1984

The above-noted water level readings may not represent the stabilized groundwater level at the site. Further, the groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year.



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5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Mr. Matt Soderman, E.I.T., and reviewed by Ms. Sandra McGaghran, P.Eng. a geotechnical engineer and Associate with Golder. Mr. Fintan Heffernan, P.Eng., the Designated MTO Foundations Contact for this project, conducted an independent review of this report.

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PART B

**PRELIMINARY FOUNDATION DESIGN REPORT
HIGH MAST LIGHT POLES AND OVERHEAD SIGNS
HIGHWAY 427 WIDENING FROM ALBION ROAD TO HIGHWAY 7
CITY OF VAUGHAN AND REGIONAL MUNICIPALITY OF YORK
G.W.P. 2229-09-00(f)**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation recommendations for the design of the high mast light (HML) poles and overhead sign (OHS) supports. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the previous subsurface investigations along the Highway 427 corridor. The interpretation and recommendations contained in this report are intended to provide the designers with sufficient information to carry out detail design of the HML pole and OHS support 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 of 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.

The following points are noted regarding determining the locations of the previous boreholes, and assessing the previous boreholes for potential use with respect to the foundation design for the proposed HML pole and OHS support locations:

- The borehole locations in the previous Foundation Investigation GEOCRE Reports for the Highway 427 corridor are referenced to a global datum and could be converted to the MTM NAD83 coordinate system. The accuracy of these borehole locations is considered to be consistent with the original survey.
- At numerous proposed HML pole or OHS support locations, the closest existing boreholes were drilled from original ground surface prior to the construction of the Highway 427 embankment in these areas, and the existing boreholes do not provide information on the material type and properties of the embankment fill. To be conservative, where no information is available for the existing fill material, the geotechnical parameters provided in this report are based on an undrained shear strength of 50 kPa or an effective angle of friction of 28 degrees for the fill. The structural assessment should be completed for both cohesionless and cohesive soil cases, and the more conservative approach adopted.
- In general, an existing borehole is located within approximately 50 m to 300 m of each of the proposed HML pole or OHS support locations. For boreholes located at distances greater than 100 m, Golder has reviewed the topography and subsurface conditions for other boreholes in the general area of each proposed HML pole or OHS support location to confirm that the conditions are relatively consistent in the area and therefore applicable to the proposed HML pole or OHS support location.

6.2 Design of Overhead Sign Foundations

Caisson foundations for the five (5) overhead signs for this project (see Section 1.0 for locations) should be designed in accordance with the requirements in MTO's *Sign Support Manual* (MTO, 2011). The *Sign Support Manual* includes standard caisson foundation designs for each sign type as follows:

- **Trichord Overhead Signs:** Tri-Chord Static Sign Supports, Section 4 and Standard Drawings SS118-3, SS118-4 and SS118-5.



- **Cantilever Signs:** Cantilever Static Sign Supports, Section 3 and Standard Drawings SS118-3, SS118-4 and SS118-5.

In the standard caisson foundation design, the caisson is extended 5 m to 6.5 m below the design frost depth (i.e. 1.2 m for this site, as per OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario) resulting in a total length of 6.2 to 7.7 m below grade depending on the sign class and corresponding caisson diameter. The standard sign foundation designs presented in the MTO's Sign Support Manual have been developed based on the minimum soil conditions given below.

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials looser or softer than those of Case 1 or Case 2 are present. The standard foundation design is also not applicable where bedrock is encountered within the standard foundation depth. For such subsurface conditions, a site-specific design is required.

Based on the review of the borehole information, the subsurface conditions at the proposed sign locations have been compared to the standard design requirements to assess whether a standard or site-specific design is required. The requirement for either a standard or site-specific design is summarized in Table 1, following the text of this report, along with geotechnical parameters for design.

6.2.1 Site-Specific Caisson Foundation Design in Soil

A site-specific caisson foundation design may be carried out by the structural engineer 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 2 following the text of this report.

$$P_p = K_p \gamma d_w \quad \text{above the groundwater table, and}$$

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

where K_p is the passive earth pressure coefficient;
 γ is the bulk unit weight (kN/m³);
 γ' is the effective unit weight below the groundwater level (kN/m³);
 d is the depth below the ground surface (m); and
 d_w is the depth to the groundwater level (m).

In the design of the sign 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 unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit Status (ULS).

Where an undrained shear strength, S_u , is provided for a cohesive soil layer in Table 2, the undrained capacity of the caisson should be checked to determine whether the drained or undrained case will govern. 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 the surface to $9 S_u$ at and below a depth equivalent to three caisson diameters, acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at ULS.

6.3 Design of High Mast Light Pole Foundations

Eleven new HML pole foundations are required for the proposed widening of Highway 427 between Albion Road and Highway 7. These should consist of single caisson foundations designed using the geotechnical parameters provided in Table 2.

Caisson foundations for HML poles should be designed in accordance with the requirements in MTO's *Guidelines for the Design of High Mast Pole Foundations* (MTO, 2004), based on the interpolated stratigraphy and geotechnical design parameters given in Table 2 following the text of this report. As noted above, where both undrained shear strength and effective stress parameters are provided for fill and/or firm to stiff cohesive materials, the structural assessment should be completed for both cohesive and cohesionless soil cases, and the more conservative approach adopted. 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.

6.4 Construction Considerations

Water-bearing granular deposits and potentially water-bearing cohesionless soils lenses or interlayers within the cohesive deposits are present at this site. "Perched" groundwater may also be encountered at the base of any cohesionless fill materials, atop the underlying, less permeable clayey silt to silty clay till deposit. Wet cohesionless soils should be expected to run or flow into the caisson hole during or after drilling for the foundations. Therefore, temporary or permanent caisson liners and/or the use of drilling mud are recommended to minimize ground loss during drilling and concrete placement.

Cobbles and/or boulders were encountered in some of the boreholes drilled near the high mast light and overhead sign foundation locations, as noted on the borehole records and discussed in Section 4.2. Appropriate equipment and procedures will be required to penetrate the cobbles and/or boulders as part of caisson installation for the high mas light and overhead sign foundations.

It is recommended that consideration be given to including a Non Standard Special Provision (NSSP) in the Contract Documents at detail design to warn the Contractor of the potential presence of wet cohesionless soils and the potential presence of cobbles and boulders within the deposits, which may affect the installation of the high mast light and overhead sign caisson foundations at this site.



7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Matt Soderman, and reviewed by Ms. Sandra McGaghran, P.Eng. a geotechnical engineer and Associate with Golder. Mr. Fin Heffernan, P.Eng., the Designated MTO Foundations Contact for this project, conducted an independent review of this report.

Golder Associates Ltd.

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Sandra McGaghran, P.Eng.
Geotechnical Engineer, Associate



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Designated MTO Contact



MAS/SMM/FJH/jl

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FOUNDATION REPORT - HIGH MAST LIGHT POLES AND OVERHEAD SIGNS

REFERENCES

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- Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.
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- Ontario Geological Society, 1991. *Geology of Ontario*. Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

Ontario Provincial Standard Drawings (OPSD)

OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario

TABLE 1
GEOTECHNICAL DESIGN PARAMETERS FOR OVERHEAD SIGN FOUNDATIONS
HIGHWAY 427 WIDENING, G.W.P. 2229-09-00(f)

Overhead Sign Station	Approximate Ground Surface Elevation (m)	Borehole No.	Ground Surface Elevation at Reference Borehole (m)	Stratum	Standard or Site Specific Foundation-Design	Depth Below Proposed Ground Surface at HML Pole Location (m)	Elevation (m)	Approximate Groundwater Elevation (m)	Design Parameters				
									S _u (kPa)	Φ'	γ (kN/m ³)	γ' (kN/m ³)	K _p
10+912	175.9	152-1	171.9	Fill (Assumed - Existing/New)	Site Specific	0 - 4.0	175.9-171.9	171.4	50	28	19	-	2.8
				Stiff to hard silty clay till		4.0 - 15.9	171.9 - 160.0		-	34	21	11	3.5
				Dense silty sand till		Below 15.9	Below 160.0		-	34	22	12	3.5
11+247	180.0	152-2	171.6	Fill (Assumed - Existing/New)	Site Specific	0 - 8.4	180 - 171.6	171.1	50	28	19	-	2.8
				Very stiff to hard silty clay till		8.4 - 18.5	171.6 - 161.5		-	34	21	11	3.5
				Dense to very dense silty sand to sand		Below 18.5	Below 161.5		-	34	22	12	3.5
11+691	179.5	164-6	173.2	Fill (Assumed - Existing/New)	Site Specific	0 - 6.9	179.5 - 172.6	163.8	50	28	19	-	2.8
				Very stiff to hard clayey silt till		6.9 - 11.4	172.6 - 168.1		-	34	21	11	3.5
				Very dense silty sand till		Below 11.4	Below 168.1		-	34	22	12	3.5
13+161	176.8	63-6	179.6	Very dense silt	Standard	0 - 1.6	176.8 - 175.2	176.2	-	32	20	10	3.3
				Hard silty clay		1.6 - 9.3	175.2 - 167.5		-	32	20	10	3.3
				Shale bedrock		Below 9.3	Below 167.5		-	-	-	-	-
13+531	177.8	63-6	179.6	Very stiff to hard silty clay	Standard	0 - 0.3	177.8 - 177.5	177.2	-	32	20	10	3.3
				Very dense silt		0.3 - 2.6	177.5 - 175.2		-	32	20	10	3.3
				Hard silty clay		2.6 - 10.3	175.2 - 167.5		-	32	20	10	3.3
				Shale bedrock		Below 10.3	Below 167.5		-	-	-	-	-

Design parameters:

S_u

Φ'

γ

γ'

K_p

= undrained shear strength (kPa);
= effective friction angle (degrees);
= bulk unit weight (kN/m³);
= effective unit weight below the groundwater level (kN/m³);
= passive earth pressure coefficient; and

Depths are given at the proposed OHS locations relative to the estimated proposed ground surface following construction. Although Su, Φ' and Kp parameters are given for the full depth of the soil, the passive resistance in the upper 1.2 m should be neglected to account for frost action.

Where both undrained shear strength and effective friction angle parameters have been provided for fill materials, the structural assessment should be completed for both cohesive soil and cohesionless soil cases, and the selected design should be based on the more conservative approach.

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TABLE 2
GEOTECHNICAL DESIGN PARAMETERS FOR HIGH MAST LIGHT FOUNDATIONS
HIGHWAY 427 WIDENING, G.W.P. 2229-09-00(f)

High Mast Light Station	Approximate Ground Surface Elevation (m)	Borehole No.	Ground Surface Elevation at Reference Borehole (m)	Stratum	Depth Below Proposed Ground Surface at HML Pole Location (m)	Elevation (m)	Approximate Groundwater Elevation (m)	Design Parameters				
								S _u (kPa)	Φ'	γ (kN/m ³)	γ' (kN/m ³)	K _p
12+526	178.0	56-9	176.9	Fill (Assumed - Existing/New)	0 - 1.1	178 - 176.9	170.0	50	28	19	-	2.8
				Very stiff to hard silty clay	1.1 - 4.6	176.9 - 173.4		-	32	20	-	3.3
				Very dense silty sand	Below 4.6	Below 173.4		-	34	21	11	3.5
12+638	178.5	12-01	178.3	Fill (Assumed - Existing/New)	0 - 2.9	178.5 - 175.6	173.0	50	28	19	-	2.8
				Firm to stiff organic silty clay	2.9 - 4.8	175.6 - 173.7		50	28	19	-	2.8
				Hard clayey silt to very dense sand and silt till	4.8 - 7.3	173.7 - 171.2		-	34	22	12	3.5
				Very dense sand and silt	7.3 - 13.5	171.2 - 165.1		-	34	21	11	3.5
				Very stiff clayey silt	Below 13.5	Below 165.1		-	32	20	10	3.3
12+810	178.0	12-01	178.3	Fill (Assumed - Existing/New)	0 - 2.4	178 - 175.6	173.0	50	28	19	-	2.8
				Firm to stiff organic silty clay	2.4 - 4.3	175.6 - 173.7		50	28	19	-	2.8
				Hard clayey silt to very dense sand and silt till	4.3 - 6.8	173.7 - 171.2		-	34	22	12	3.5
				Very dense sand and silt	6.8 - 13	171.2 - 165.1		-	34	21	11	3.5
				Very stiff clayey silt	Below 13.0	Below 165.1		-	32	20	10	3.3
12+971	177.0	63-5	179.3	Very dense silt	0 - 3.2	177 - 173.8	176.8	-	32	20	10	3.3
				Hard silty clay	3.2 - 8.4	173.8 - 168.6		-	32	20	10	3.3
				Shale bedrock	Below 8.4	Below 168.6		-	-	-	-	-
13+151	176.5	63-5	179.3	Very dense silt	0 - 2.7	176.5 - 173.8	176.3	-	32	20	10	3.3
				Hard silty clay	2.7 - 7.9	173.8 - 168.6		-	32	20	10	3.3
				Weather shale bedrock	Below 7.9	Below 168.6		-	-	-	-	-
13+319	177.0	63-5	179.3	Very dense silt	0 - 3.2	177 - 173.8	176.8	-	32	20	10	3.3
				Hard silty clay	3.2 - 8.4	173.8 - 168.6		-	32	20	10	3.3
				Shale bedrock	Below 8.4	Below 168.6		-	-	-	-	-
13+458	177.2	63-5	179.3	Very dense silt	0 - 3.4	177.2 - 173.8	177.0	-	32	20	10	3.3
				Hard silty clay	3.4 - 8.6	173.8 - 168.6		-	32	20	10	3.3
				Shale bedrock	Below 8.6	Below 168.6		-	-	-	-	-
13+601	178.0	63-5	179.3	Firm to hard silty clay	0 - 0.8	178 - 173.8	177.8	-	32	20	10	3.3
				Very dense silt	0.8 - 4.2	178 - 173.8		-	32	20	10	3.3
				Hard silty clay	4.2 - 9.4	173.8 - 168.6		-	32	20	10	3.3
				Shale bedrock	Below 9.4	Below 168.6		-	-	-	-	-
13+743	178.0	63-5	179.3	Firm to hard silty clay	0 - 0.8	178 - 173.8	177.8	-	32	20	10	3.3
				Very dense silt	0.8 - 4.2	178 - 173.8		-	32	20	10	3.3
				Hard silty clay	4.2 - 9.4	173.8 - 168.6		-	32	20	10	3.3
				Shale bedrock	Below 9.4	Below 168.6		-	-	-	-	-
13+869	178.1	63-6	179.6	Very stiff to hard silty clay	0 - 0.6	178.1 - 177.5	177.9	-	32	19	9	3.3
				Very dense silt	0.6 - 2.9	177.5 - 175.2		-	32	20	10	3.3
				Hard silty clay	2.9 - 10.6	175.2 - 167.5		-	32	20	10	3.3
				Shale bedrock	Below 10.6	Below 167.5		-	-	-	-	-

TABLE 2
GEOTECHNICAL DESIGN PARAMETERS FOR HIGH MAST LIGHT FOUNDATIONS
HIGHWAY 427 WIDENING, G.W.P. 2229-09-00(f)

High Mast Light Station	Approximate Ground Surface Elevation (m)	Borehole No.	Ground Surface Elevation at Reference Borehole (m)	Stratum	Depth Below Proposed Ground Surface at HML Pole Location (m)	Elevation (m)	Approximate Groundwater Elevation (m)	Design Parameters				
								S _u (kPa)	Φ'	γ (kN/m ³)	γ' (kN/m ³)	K _p
13+927	179.6	63-4	179.3	Fill (Assumed - Existing/New)	0 - 0.3	179.6 - 179.3	179.0	50	28	19	-	2.8
				Very stiff to hard silty clay	0.3 - 1.7	179.3 - 177.9		-	32	19	-	3.3
				Very dense silt	1.7 - 7	177.9 - 172.6		-	32	20	10	3.3
				Hard silty clay	7 - 10.3	172.6 - 169.3		-	32	20	10	3.3
				Silty clay till	10.3 - 12.3	169.3 - 167.3		-	34	22	12	3.5
				Shale bedrock	Below 12.3	Below 167.3		-	-	-	-	-

Design parameters:

- S_u = undrained shear strength (kPa);
- Φ' = effective friction angle (degrees);
- γ = bulk unit weight (kN/m³);
- γ' = effective unit weight below the groundwater level (kN/m³);
- K_p = passive earth pressure coefficient; and

Depths are given at the proposed HML locations relative to the estimated proposed ground surface following construction. Although Su, Φ' and Kp parameters are given for the full depth of the soil, the passive resistance in the upper 1.2 m should be neglected to account for frost action.

Where both undrained shear strength and effective friction angle parameters have been provided for fill and/or firm to stiff cohesive materials, the structural assessment should be completed for both cohesive soil and cohesionless soil cases, and the selected design should be based on the more conservative approach.

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

CONT No.
WP No. 2229-09-00



HIGHWAY 427 WIDENING
OVERHEAD SIGN AND HIGH MAST LIGHT
STA. 10+800 TO 11+400
BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE

1.5 0 1.5 3 km



LEGEND

- Borehole - Previous Investigation
- Proposed Overhead Sign Location
(and approximate location by reference to Station)

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
152-1	171.9	4845043.3	294344.0
152-2	171.6	4845069.0	294375.7
152-3	171.5	4845091.2	294369.9
152-4	171.4	4845060.9	294329.4
152-5	171.5	4845142.7	294372.2
152-6	170.6	4845086.6	294332.0
152-7	171.7	4845102.2	294326.1
152-8	170.8	4845117.7	294373.4

NOTES

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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

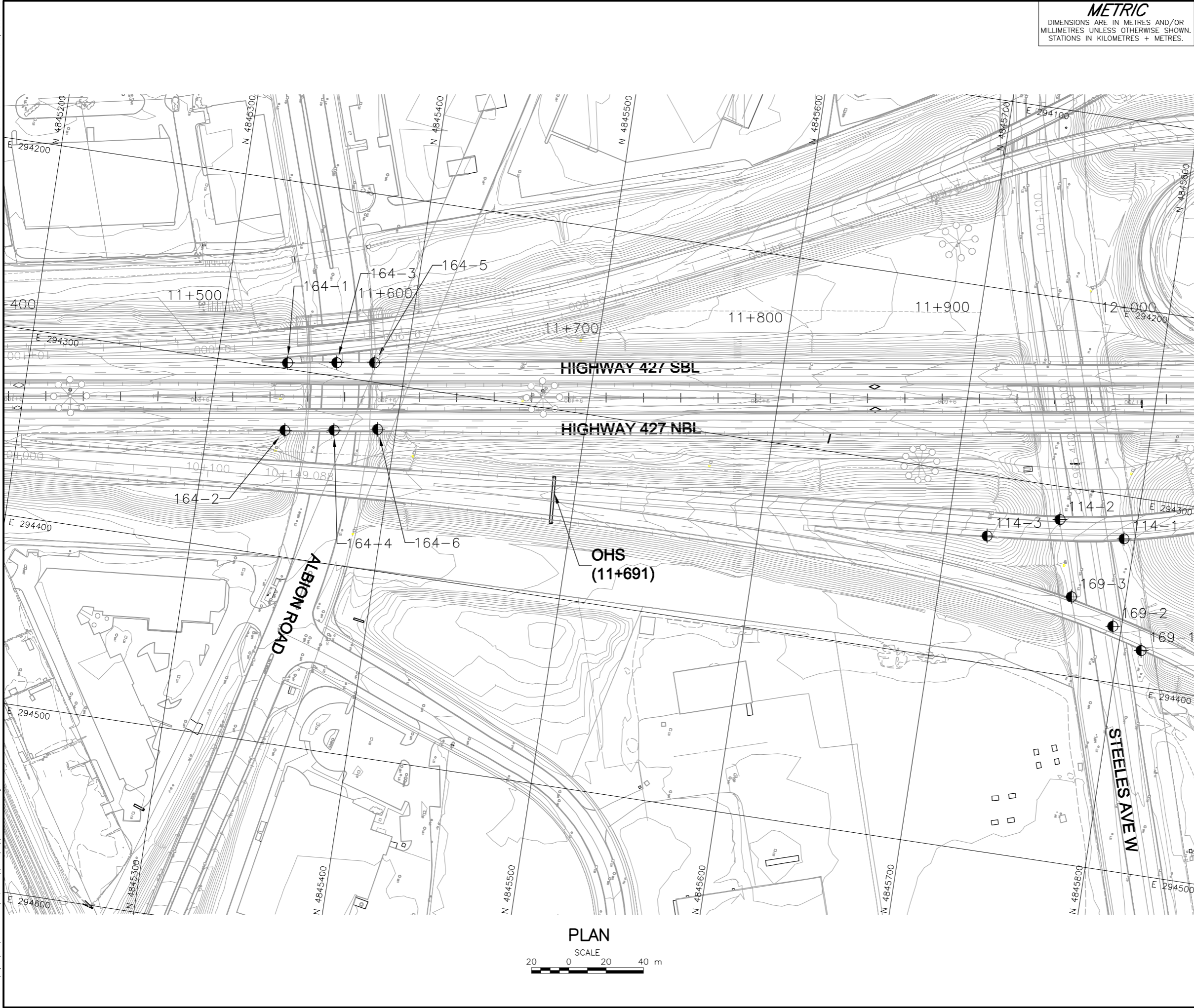
Base plans provided in digital format by MRC, drawing file nos.
3211001-base map.dwg, 3211001-PARCELS.dwg, Hwy 427 Preferred Plan
-Hwy427 Only.dwg, received October 29, 2013 and E3211001-XN1-LTG
-HM.DWG, received November 5, 2013.

PLAN

SCALE

20 0 20 40 m





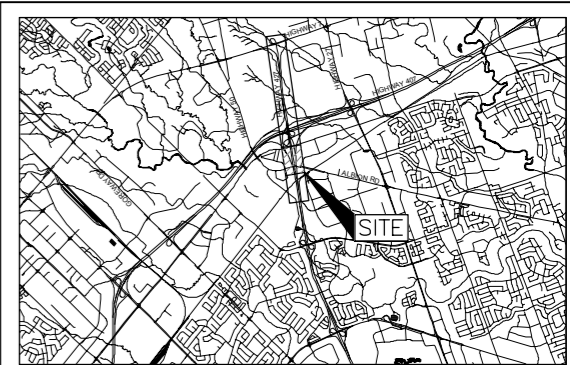
METRIC
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STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 2229-09-00

HIGHWAY 427 WIDENING
OVERHEAD SIGN AND HIGH MAST LIGHT
STA. 11+400 TO 12+000
BOREHOLE LOCATIONS



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Previous Investigation
- Proposed Overhead Sign Location
(and approximate location by reference to Station)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
114-1	174.8	4845794.2	294322.7
114-2	175.0	4845758.7	294317.7
114-3	174.7	4845721.5	294332.2
164-1	172.4	4845337.2	294296.7
164-2	172.7	4845341.2	294332.7
164-3	172.6	4845363.2	294292.7
164-4	172.6	4845367.2	294328.7
164-5	172.9	4845383.2	294289.7
164-6	173.2	4845390.2	294324.7
169-1	174.0	4845812.2	294380.5
169-2	173.6	4845795.3	294369.9
169-3	174.3	4845771.0	294357.7

NOTES

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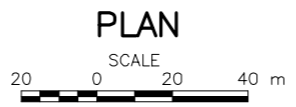
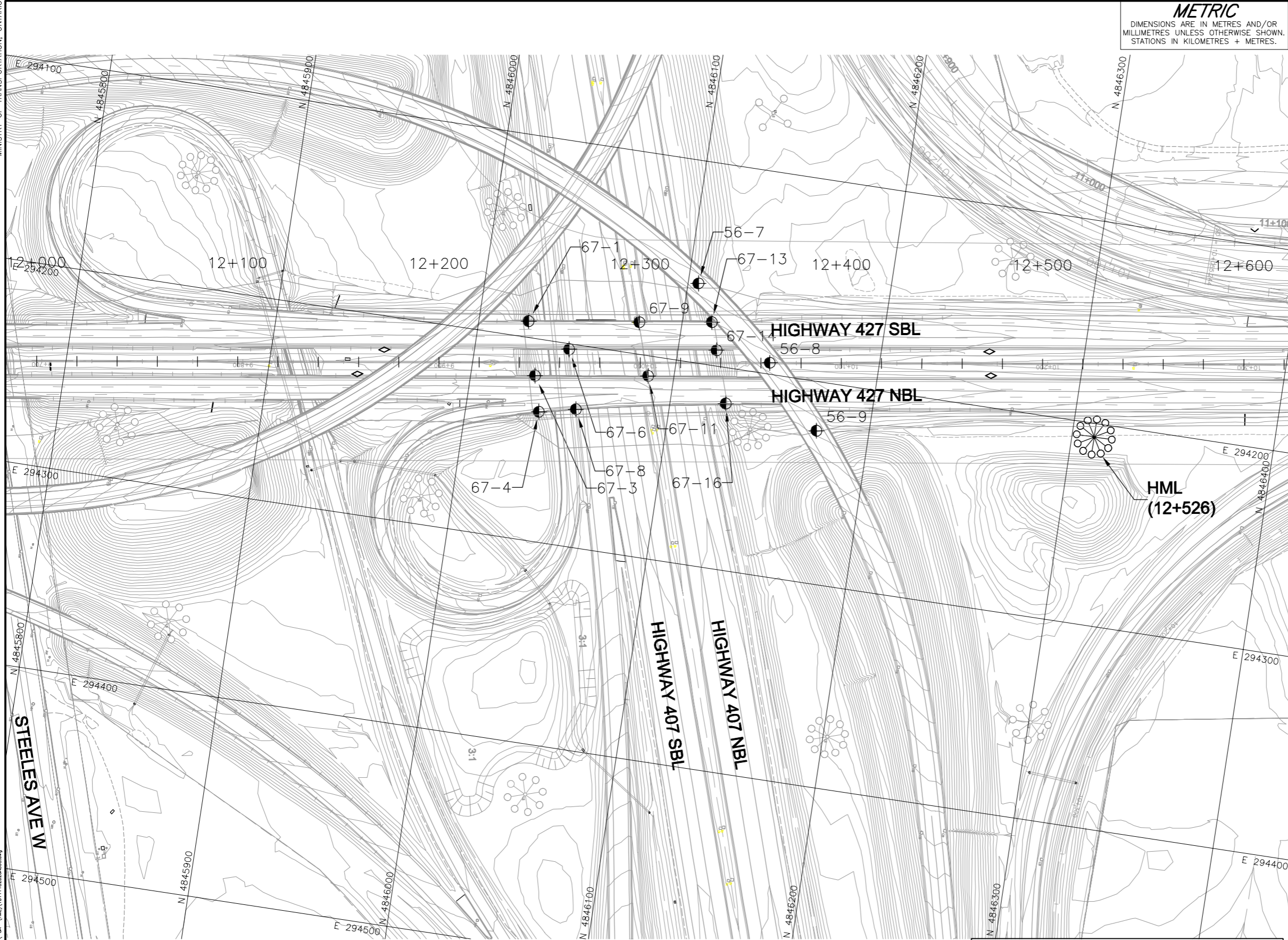
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REFERENCE

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NO.	DATE	BY	REVISION
Geocres No. 30M13-203			
HWY. 427		PROJECT NO. 10-1111-0202	DIST.
SUBM'D. MAS	CHKD. SMM	DATE: 1/7/2014	SITE:
DRAWN: JFC	CHKD. MAS	APPD. SMM	DWG. 2



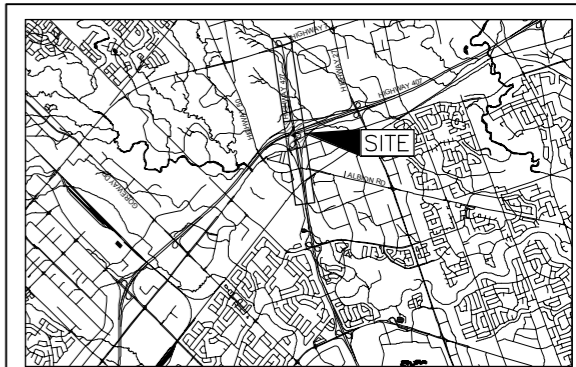
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 2229-09-00

HIGHWAY 427 WIDENING
OVERHEAD SIGN AND HIGH MAST LIGHT
STA. 12+000 TO 12+600
BOREHOLE LOCATIONS



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Previous Investigation
- Proposed High Mast Light (and approximate location by reference to Station)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
56-7	179.2	4846105.0	294160.7
56-8	178.1	4846146.0	294194.4
56-9	176.9	4846174.0	294224.3
67-1	177.8	4846024.4	294191.9
67-3	177.1	4846031.6	294218.2
67-4	177.1	4846036.2	294235.7
67-6	178.1	4846046.4	294202.7
67-8	177.2	4846054.2	294231.7
67-9	178.1	4846078.9	294184.2
67-11	178.1	4846087.2	294209.9
67-13	178.6	4846114.5	294178.7
67-14	178.3	4846118.9	294192.2
67-16	177.7	4846127.4	294217.7

NOTES

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NO.	DATE	BY	REVISION
Geocres No. 30M13-203			
HWY. 427		PROJECT NO. 10-1111-0202	DIST.
SUBM'D. MAS	CHKD. SMM	DATE: 1/7/2014	SITE:
DRAWN: JFC	CHKD. MAS	APPD. SMM	DWG. 3



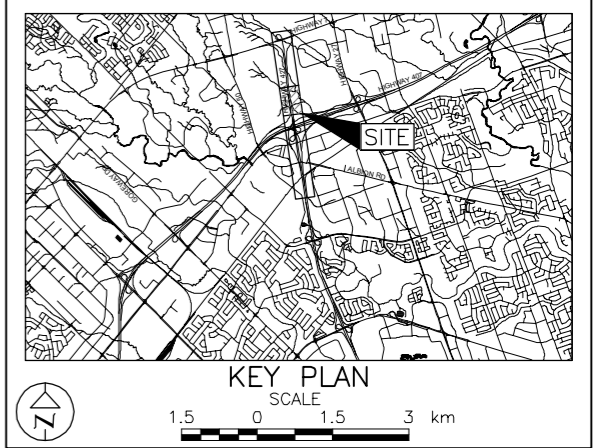
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 2229-09-00

SHEET

HIGHWAY 427 WIDENING
OVERHEAD SIGN AND HIGH MAST LIGHT
STA. 12+600 TO 13+200
BOREHOLE LOCATIONS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole—Current Investigation
- Proposed High Mast Light (and Approximate Location by Reference to Station)
- Proposed Overhead Sign Location (and approximate location by reference to Station)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
12-01	178.3	4846478.4	294115.9
12-02	176.5	4846477.9	294104.3

NOTES

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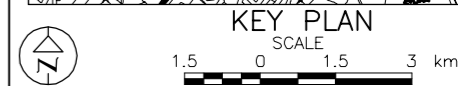
REFERENCE

Base plans provided in digital format by MRC, drawing file nos. 3211001-base map.dwg, 3211001-PARCELS.dwg, Hwy 427 Preferred Plan -Hwy427 Only.dwg, received October 29, 2013 and E3211001-XN1-LTG -HM.DWG, received November 5, 2013.

NO.	DATE	BY	REVISION
Geocres No. 30M13-203			
HWY. 427		PROJECT NO. 10-1111-0202	DIST.
SUBM'D. MAS	CHKD. SMM	DATE: 1/7/2014	SITE:
DRAWN: JFC	CHKD. MAS	APPD. SMM	DWG. 4



SHEET



 Proposed High Mast Light (and Approximate Location by Reference to Station)

 Proposed Overhead Sign Location (and approximate location by reference to Station)

(See Drawing 6 for Location)

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.

Base plans provided in digital format by MRC, drawing file nos.
3211001-base map.dwg, 3211001-PARCELS.dwg, Hwy 427 Preferred Plan
-Hwy427 Only.dwg, received October 29, 2013 and E3211001-XN1-LTG
-HM.DWG, received November 5, 2013.

NO.	DATE	BY	REVISION						
Geocres No. 30M13-203									
HWY. 427			PROJECT NO. 10-1111-0202					DIST.	
SUBM'D. MAS		CHKD. SMM		DATE: 1/7/2014				SITE:	
DRAWN: JFC		CHKD. MAS		APPD. SMM				DWG. 5	

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

CONT No.
WP No. 2229-09-00

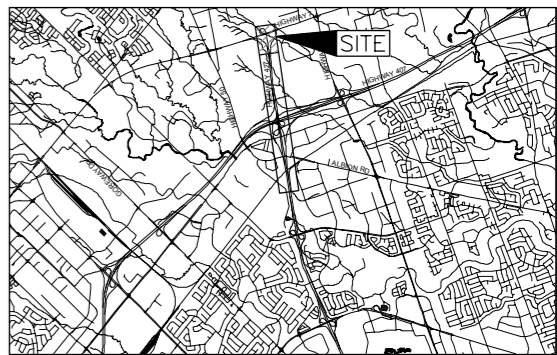


HIGHWAY 427 WIDENING
OVERHEAD SIGN AND HIGH MAST LIGHT
STA. 13+800 TO 14+100
BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE

1.5 0 1.5 3 km

LEGEND

- Borehole - Previous Investigation
- Proposed High Mast Light (and approximate location by reference to Station)

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
63-1	180.8	4847816.5	293979.3
63-2	180.7	4847826.0	294008.9
63-3	180.7	4847835.4	294037.5
63-4	179.3	4847785.2	293982.7
63-5	179.3	4847790.6	294009.3
63-6	179.6	4847802.2	294043.2

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.

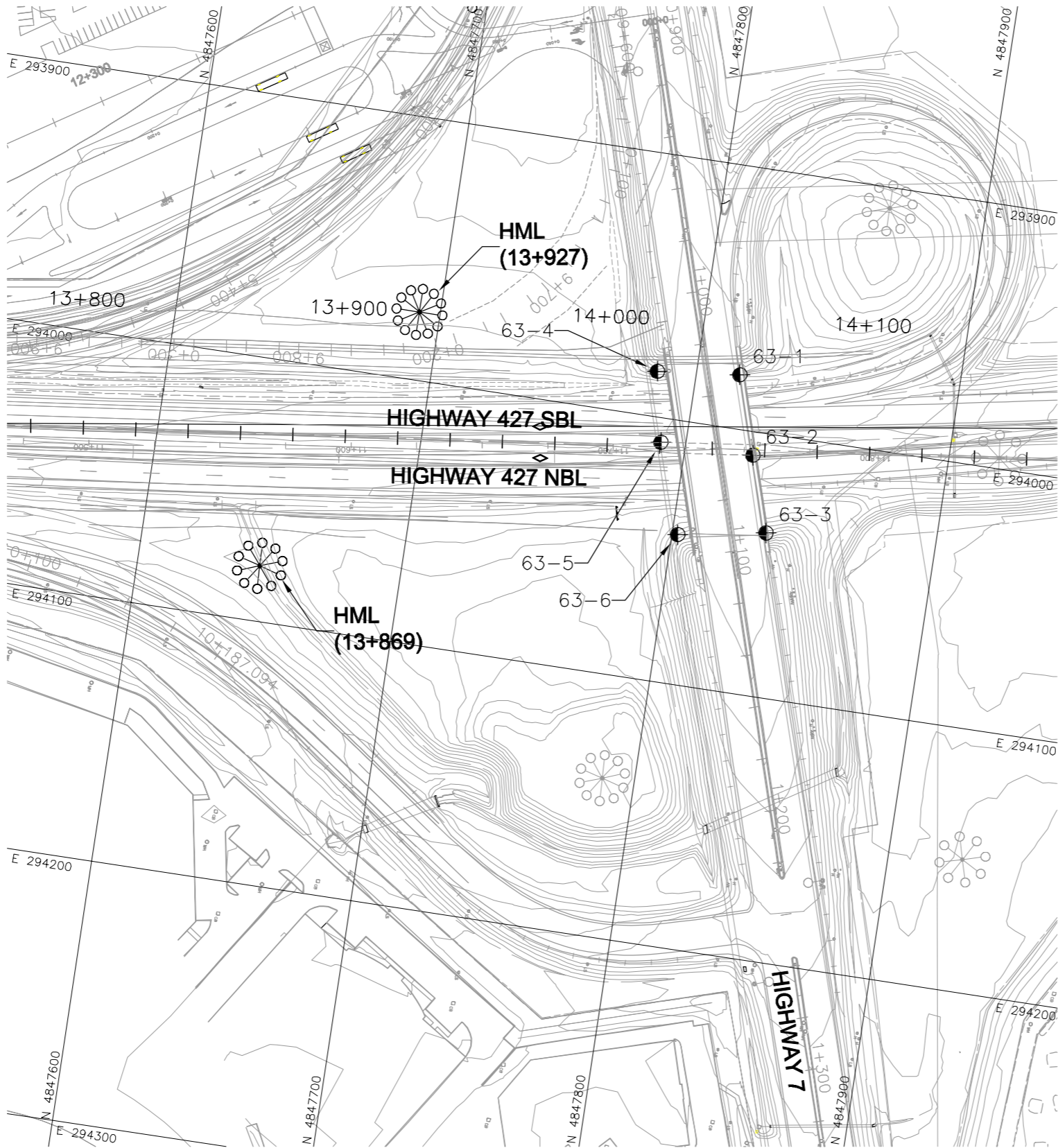
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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 MRC, drawing file nos. 3211001-base map.dwg, 3211001-PARCELS.dwg, Hwy 427 Preferred Plan -Hwy427 Only.dwg, received October 29, 2013 and E3211001-XN1-LTG -HM.DWG, received November 5, 2013.

NO.	DATE	BY	REVISION
Geocres No. 30M13-203			
HWY. 427		PROJECT NO. 10-1111-0202	DIST.
SUBM'D. MAS	CHKD. SMM	DATE: 1/7/2014	SITE:
DRAWN: JFC	CHKD. MAS	APPD. SMM	DWG. 6



PLAN

SCALE

20 0 20 40 m



APPENDIX A

Borehole Records

152-1


 Ministry of
Transportation and
Communications

RECORD OF BOREHOLE No 1

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 821.2; E 294 328.3 ORIGINATED BY V.P.
 DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY V.P.
 DATUM Geodetic DATE 81-12-10 to 81-12-11 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
171.9 0.0	Ground Surface												
	Mottled		1	SS	9								
			2	SS	13								
			3	SS	29								
			4	SS	27								
	(Glacial Till) Silty Clay with Sand trace of Gravel		5	SS	21								
			6	SS	35								
			7	SS	14								
	Stiff to Hard		8	SS	16								
			9	SS	53								
			10	SS	37								
160.0													
11.9	Silty Sand Dense		11	SS	37								
158.0													
13.9	Break corebarrel in borehole Abandon hole End of Borehole		12	BC									
	* Borehole caved at shallow depth. Perched water level at 0.5 metres.												

 +3, x5: Numbers refer to
Sensitivity

 20
15
10
+5 (%) STRAIN AT FAILURE



Ministry of
Transportation and
Communications
Ontario

RECORD OF BOREHOLE No 2

152-2

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 846.8; E 294 360.0 ORIGINATED BY V.P.
DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY V.P.
DATUM Geodetic DATE 81-12-11, 81-12-14, 81-12-15 CHECKED BY CP.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
171.6	Ground Surface																
0.0			1	SS	27		170										5-28-52-15
	Brown		2	SS	32												
	Grey		3	SS	51												
	(Glacial Till)		4	SS	32		168										
	Silty Clay		5	SS	47												
	with Sand		6	SS	43												
	trace of Gravel		7	SS	33		166										12-15-41-32
			8	SS	40		164										
	Very Stiff		9	SS	78		162										
	to Hard		10	SS	91		160										25-37-35-3
161.5	Grey		11	SS	40												25-43-30-2
10.1	Silty Sand		12	SS	52		158										1-72-16-11
	to		13	SS	94												
	Sand		14	SS	65		156										31-53-(16)
			15	SS	106	18 cm											2-65-32-1
	Sand		16	SS	70	15 cm	154										
	and Gravel		17	SS	100	15 cm	152										30-56-(14)
	with varying						150										
	Amounts of Gravel																
	Occasional																
	Cobbles and																
	Boulders throughout																
	Dense to																
	Very Dense																
148.2	Refusal to Augering																
23.4	End of Borehole																
	* Note: Perched water																
	table, B.H.																
	caved at 3.5																
	metres.																

+3, x5: Numbers refer to
Sensitivity

20
15 +5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

Metric

W P 153-20402 LOCATION Co-ords. 4, 845, 168N1 294, 309E ORIGINATED BY B.L.K.
DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Auger COMPILED BY S.P.
DATUM Geodetic DATE February 17/18, 1982 CHECKED BY R

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
173.22	Ground Level															
172.67	Topsoil, silty clay, low organic, Dark Brown															
0.61	Silty clay with sand, trace gravel, fissured, thin fine sand layers (Glacial Till)		1	SS	15											
	Intermediate plasticity		2	SS	21											
170.46	Very stiff brown		3	TW	PH											
2.74	Silty clay, with sand, trace gravel, fissured, thin fine sand layers, (Glacial Till)		4	SS	59											
	Low plasticity		5	SS	52											
168.1	Hard Brown to Grey		6	SS	27											
5.18	Silty sand, fine to coarse with gravel (Glacial Till)		7	SS	88	250 mm										
	Very Dense Grey		8	SS	100	200 mm										
			9	SS	100	200 mm										
			10	SS	100	180 mm										
			11	SS	94											
			12	SS	100	150 mm										
153.52			13	SS	100	250 mm										
15.65	End of Borehole															

Note:
After removal of auger upon completion of drilling, water level at elevation 163.47 and borehole caved at elevation 167.43



Ministry of
Transportation and
Communications

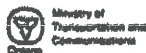
H. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

67-16

RECORD OF BOREHOLE No 16										METRIC		
150-87-01 W P 150-87-02		LOCATION N 4 845 905.2; E 294 202.0				ORIGINATED BY LSR						
DIST 6 HWY 407/427		BOREHOLE TYPE 100mm dia. Solid Stem Augering				COMPILED BY LSR						
DATUM Geodetic		DATE 1987 - 10 - 30 & 31 and 11 - 02				CHECKED BY LSR						
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	'N' VALUES					
177.7	Ground Level											
0.0	0.4m Topsoil											
	Silty Clay, some Sand		1	SS	36							
	trace Gravel		2	SS	41							
	Glacial Till		3	SS	85							
	Hard Brown Damp		4	SS	83/0	15m						
173.7	Seal											
4.0	Silt with Fine Sand lenses moist saturated		5	SS	85/0	15m						0 18 72 10
			6	SS	88/0	10m						
	Very Dense Brown		7	SS	80/0	15m						
			8	SS	100/0	22m						
			9	SS	100/0	39m						2 11 78 9
168.4			10	SS	100/0	17m						
9.3	Sandy, Silt, trace Gravel with Gravelly and Sandy lenses		11	SS	100/0	23m						
	Glacial Till		12	SS	100/0	13m						
	Gray		13	SS	100/0	10m						
	Very Dense Moist											
	Traces of Shale Fragments		14	SS	100/0	14m						
			15	SS	100/0	14m						
159.2			16	SS	100/0	09m						
18.5	End of Borehole											

*3, *5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10



56-9

RECORD OF BOREHOLE No 9

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 951.7; E 294 208.6 ORIGINATED BY JW
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY TJK
DATUM Geodetic DATE 82 07 15 CHECKED BY CF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				FLUIDIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PROF.	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L	
176.9	Ground Surface															
0.0	Brown mottled Silty Clay with Sand		1	SS	25		176									
	Trace of Gravel		2	SS	38											6 19 43 32
	V. Stiff to Hard		3	SS	100/25 cm											
173.4			4	SS	100/28 cm		174									13 23 42 22
3.5	Silt		5	SS	100/15 cm											13 4 76 7
	Silty Sand		6	SS	100/10 cm		172									
	Trace Clay															
	and Sandy Silt		7	SS	70/13 cm		170									2 22 70 6
	Gravel		8	SS	100/28 cm											
167.8	Occ. Cobbles															
	Very Dense						168									
9.1	End of Borehole															
	Note: Borehole caved @ 7.0 m															

OFFICE REPORT ON SOIL EXPLORATION

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

PROJECT <u>10-1111-0202</u>	RECORD OF BOREHOLE No 12-01	SHEET 2 OF 2	METRIC
G.W.P. <u>2229-09-00(e)</u>	LOCATION <u>N 4846478.4 ; E 294115.9</u>	ORIGINATED BY <u>SB</u>	
DIST <u>Central</u> HWY <u>427</u>	BOREHOLE TYPE <u>200mm Outside Diameter Hollow Stem Augers</u>	COMPILED BY <u>TWB</u>	
DATUM <u>Geodetic</u>	DATE <u>December 11 and 12, 2012</u>	CHECKED BY <u>SMM</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60			
	--- CONTINUED FROM PREVIOUS PAGE ---													
162.5 15.8	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.		14	SS	21		163							

PROJECT 10-1111-0202		RECORD OF BOREHOLE No 12-02		SHEET 1 OF 2		METRIC	
G.W.P. 2229-09-00(e)		LOCATION N 4846477.9 ; E 294104.3		ORIGINATED BY SB			
DIST Central HWY 427		BOREHOLE TYPE 200mm Outside Diameter Hollow Stem Augers		COMPILED BY TWB			
DATUM Geodetic		DATE December 12, 2012		CHECKED BY SMM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								20	40						60	80	100	○ UNCONFINED	+ FIELD VANE
176.5	GROUND SURFACE																		
0.0	Clayey silt, trace sand and gravel, containing organics and rootlets (FILL) Firm Brown and grey Moist		1	SS	6														
			2	SS	6														
175.0																			
1.5	CLAYEY SILT to SILTY CLAY, some sand, trace gravel (TILL) Very stiff to hard Brown to grey at a depth of 3.1 m Moist		3	SS	20									2 16 44 38					
			4	SS	80														
			5	SS	70/23														
172.8																			
3.7	SAND and SILT, some gravel, trace clay (TILL) Very dense Grey Moist		6	SS	81									17 41 37 5					
			7	SS	62														
170.9																			
5.6	CLAYEY SILT with thin layers of brown fine sand Hard Grey Moist		8	SS	37														
169.4																			
7.1	SAND and SILT, trace clay Very dense Grey Moist to wet		9	SS	60									0 57 39 4					
			10	SS	69														
166.3																			
10.2	CLAYEY SILT, trace sand, laminated with sandy silt and silty sand interlayers Hard Greyish brown Moist		11	SS	50														
164.0			12A	SS	34														
163.7	Silty SAND, trace clay Dense Grey Wet		12B																
12.8																			
END OF BOREHOLE																			

Continued Next Page

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

GTA-MTO 001 101110202.GPJ GAL-GTA.GDT 4/1/13

PROJECT <u>10-1111-0202</u>	RECORD OF BOREHOLE No 12-02	SHEET 2 OF 2	METRIC
G.W.P. <u>2229-09-00(e)</u>	LOCATION <u>N 4846477.9 ; E 294104.3</u>	ORIGINATED BY <u>SB</u>	
DIST <u>Central</u> HWY <u>427</u>	BOREHOLE TYPE <u>200mm Outside Diameter Hollow Stem Augers</u>	COMPILED BY <u>TWB</u>	
DATUM <u>Geodetic</u>	DATE <u>December 12, 2012</u>	CHECKED BY <u>SMM</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					w _p w w _L							
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100	20	40	60					
	NOTES: 1. Water level in piezometer at a depth of 4.7 m below ground surface (Elev. 171.8 m) upon completion of drilling. 2. Water level measurements in piezometer: Date Depth (m) Elev. (m) Jan 8/13 3.7 172.8 Jan 21/13 3.7 172.8																			

RECORD OF BOREHOLE No 4 **63-4** METRIC

W P 153-80-07 LOCATION Co-ords. N 4 847 563.0; E 293 967.0 ORIGINATED BY DT
 DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DT
 DATUM Geodetic DATE 84 09 18 CHECKED BY SP

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
179.3	Ground Surface											
0.0	Silty Clay some sand trace gravel Firm		1	SS	6							
177.9			2	SS	66							
1.4	Silt with Sand traces of clay and gravel		3	SS	130/	18 cm						16 35 38 11
	Occasional Cobbles or Boulders		4	SS	100/	15 cm						
			5	SS	114							
	Silty Clay Seam Hard		6	SS	70							6 33 47 14
	Silt Very Dense		7	SS	63							
172.6			8	SS	60							
8.7	Silty Clay with very Thin Silt Seams Hard		9	SS	47							
169.3			10	SS	100/	8 cm						
10.0	Heterogeneous Mixture of Silty Clay Sand and Gravel (Glacial Till) Hard											
167.3												
167.0	Weathered Shale Bedrock											
12.3	End of Borehole											

+3, x5: Numbers refer to Sensitivity
 20
 15
 10
 (% STRAIN AT FAILURE)

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5 <u>63-5</u> METRIC																					
W P <u>153-80-07</u>		LOCATION <u>Co-ords. N 4 847 568.4; E 293 993.6</u>				ORIGINATED BY <u>DT</u>															
DIST <u>5</u> HWY <u>427</u>		BOREHOLE TYPE <u>Hollow Stem Auger</u>				COMPILED BY <u>DT</u>															
DATUM <u>Geodetic</u>		DATE <u>84 09 19</u>				CHECKED BY <u>CP</u>															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100						WATER CONTENT (%) 10 20 30							
179.3 0.0	Ground Surface																				
	Silty Clay some sand trace gravel		1	SS	7																
	Firm to Hard		2	SS	43																
177.2 2.1			3	SS	81																
	Silt		4	SS	127																
	Very Dense		5	SS	171																
			6	SS	114																
173.8 5.5			7	SS	53																
	Silty Clay with Very Thin Silt Seams		8	SS	59																
	Hard																				
168.6																					
168.4	Weathered Shale Bedrock		9	SS	70/8 cm																
10.9	End of Borehole																				
<p>Water Table Elevations Measured</p> <table border="1"> <thead> <tr> <th>Date</th> <th>Elevation</th> </tr> </thead> <tbody> <tr> <td>84-09-20</td> <td>179.2</td> </tr> <tr> <td>84-10-12</td> <td>179.0</td> </tr> <tr> <td>84-11-08</td> <td>179.1</td> </tr> </tbody> </table>														Date	Elevation	84-09-20	179.2	84-10-12	179.0	84-11-08	179.1
Date	Elevation																				
84-09-20	179.2																				
84-10-12	179.0																				
84-11-08	179.1																				

+3, x5: Numbers refer to
Sensitivity

20
15 \pm 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 63-6 METRIC

W P 153-80-07 LOCATION Co-ords. N 4 847 580.0; E 294 027.5 ORIGINATED BY DT
DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DT
DATUM Geodetic DATE 84 09 19 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	IN VALUES			20	40	60	80	100					
179.6	Ground Surface																
0.0	Silty Clay some sand trace gravel Very Stiff to Hard		1	SS	29		179										
			2	SS	37		178										
177.5																	
2.1	Silt Very Dense		3	SS	83		177										
			4	SS	96		176										
			5	SS	97		175										
175.2			6	SS	53		174										
4.4																	
	Silty Clay with very Thin Silt Seams		7	SS	32		173										
			8	SS	47		172										
							171										
	Hard		9	SS	39		170										
							169										
			10	SS	80		168										
167.5	Occasional Cobbles, or Boulders																
167.4	Weathered Shale Bedrock		11	SS	100% 5 cm												
12.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

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