# Foundation Investigation and Design Report

*Markham Road Overpass Rehabilitation and Northward Widening (Site No. 37-218), Highway 401 Westbound Core and Collector Lanes, Neilson Road to Warden Avenue, City of Toronto, Ontario, Ministry of Transportation, Ontario G.W.P. No. 2162-11-00*

Submitted to:

**WSP**
610 Chartwell Road, Suite 300
Oakville, ON Canada
L6J 4A5


Submitted by:

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


1669995-4

January 17, 2019

**GEOCRES No.: 30M14-484**
Lat. 43.785728, Long. -79.235350

# Distribution List

1 Hard Copy, 1 E-Copy - MTO Central Region

1 Hard Copy, 1 E-Copy - MTO Foundations Section

1 E-Copy - WSP

1 E-Copy - Golder Associates Ltd.

# Table of Contents

**PART A – FOUNDATION INVESTIGATION REPORT**

**1.0 INTRODUCTION ..... 1**

**2.0 SITE DESCRIPTION ..... 1**

**3.0 INVESTIGATION PROCEDURES ..... 2**

3.1 1967 Investigation ..... 2

3.2 2011 Investigation ..... 2

3.3 2018 Investigation ..... 3

**4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS ..... 4**

4.1 Regional Geology ..... 4

4.2 Subsurface Conditions ..... 5

4.2.1 Topsoil ..... 5

4.2.2 Asphalt ..... 5

4.2.3 Fill ..... 5

4.2.4 Silt to Sand ..... 6

4.2.5 Sand and Gravel ..... 6

4.2.6 Clayey Silt to Clayey Silt with Sand ..... 7

4.2.7 Clayey Silt with Sand Till ..... 7

4.3 Groundwater Conditions ..... 7

4.4 Analytical Testing Results ..... 8

**5.0 CLOSURE ..... 9**

**PART B – FOUNDATION DESIGN REPORT**

**6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS ..... 10**

6.1 General ..... 10

6.2 Foundations Options ..... 10

6.3 General Foundation Design Context ..... 12

6.3.1 Consequence and Site Understanding Classification ..... 12

6.3.2 Correlation of Automatic and Manual Hammer for SPT “N” Values ....12
6.4 Seismic Design....12
6.4.1 Seismic Site Classification ....12
6.4.2 Spectral Response Values and Seismic Performance Category ....13
6.4.3 Soil Liquefaction....13
6.5 Assessment of Existing Foundations ....13
6.6 Strip Footings ....14
6.6.1 Founding Elevations ....14
6.6.2 Geotechnical Resistances ....15
6.6.3 Resistance to Lateral Loads ....15
6.7 Steel H-Pile or Pipe Pile Foundations....16
6.7.1 Founding Elevations ....16
6.7.2 Geotechnical Axial Resistances....17
6.7.3 Resistance to Lateral Loads ....17
6.8 Drilled Shafts (Caissons)....19
6.8.1 Founding Elevations ....19
6.8.2 Geotechnical Axial Resistance ....19
6.8.3 Resistance to Lateral Loads ....20
6.9 Lateral Earth Pressures for Design of Abutment and Wing Walls ....20
6.9.1 Static Lateral Earth Pressures for Design....21
6.9.2 Seismic Lateral Earth Pressures for Design ....21
6.10 Approach Embankment Design and Construction ....22
6.10.1 Subgrade Preparation and Embankment Construction ....23
6.10.2 Global Stability ....23
6.10.3 Settlement....23
6.10.3.1 Settlement Performance Requirements....24
6.10.3.2 Results of Analysis....25
6.11 Corrosion Assessment and Protection....25
6.11.1 Potential for Sulphate Attack....25

6.11.2 Potential for Corrosion ........................................ 25

6.12 Construction Considerations ........................................ 25

6.12.1 Excavation and Control of Groundwater and Surface Water ........................................ 25

6.12.2 Temporary Protection Systems ........................................ 26

6.12.3 Subgrade Protection ........................................ 26

6.12.4 Obstructions ........................................ 27

6.12.5 Vibration Monitoring During Construction ........................................ 27

**7.0 CLOSURE ........................................ 28**

**REFERENCES**

**TABLES**

Table 1 Comparison of Foundation Alternatives – Markham Road Overpass Widening

**DRAWINGS**

Drawing 1 Borehole Locations and Soil Strata
Drawing 2 Soil Strata
Drawing 3 Soil Strata

**APPENDICES**

**APPENDIX A - Borehole Records from 1967 and 2011 Investigations (GEOCRES No. 30M14-32 and 30M14-338)**

**APPENDIX B - Borehole Records from 2018 Investigation**

Lists of Symbols and Abbreviations
Record of Boreholes MR-01 to MR-04

**APPENDIX C - Geotechnical Laboratory Test Results**

Figure C-1 Grain Size Distribution –Sand (Fill)
Figure C-2 Grain Size Distribution – Clayey Silt (Fill)
Figure C-3 Plasticity Chart – Clayey Silt (Fill)
Figure C-4A Grain Size Distribution – Silt to Sandy Silt to Silt and Sand to Sand
Figure C-4B Grain Size Distribution – Silt and Sand
Figure C-5 Plasticity Chart – Sandy Silt to Silt and Sand
Figure C-6 Grain Size Distribution – Sand and Gravel
Figure C-7 Grain Size Distribution – Sandy Clayey Silt
Figure C-8 Plasticity Chart – Sandy Clayey Silt

**APPENDIX D - Analytical Laboratory Test Results**

**APPENDIX E - Drawing Nos. D-6298-1, D-6298-5 and D-6298-6**

**APPENDIX F - Non-Standard Special Provisions**

Working Slab – Item No.
Vibration Monitoring – Item No.
Earth Excavation for Structure (Obstructions) – Item No.

Amendment to OPSS 903, April 2016
Dewatering Structure Excavations (Special Provision No. FOUN0003)
Protection Systems – Item No.

# PART A

## FOUNDATION INVESTIGATION REPORT
## MARKHAM ROAD OVERPASS REHABILITATION AND NORTHWARD WIDENING (SITE NO. 37-218)
## HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES, NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO, ONTARIO
## MTO, G.W.P. 2162-11-00

# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the rehabilitation and operational improvements of the Highway 401 westbound (WB) core and collector lanes, from Neilson Road to Warden Avenue in the City of Toronto, Ontario (GWP 2162-11-00).

This report addresses the foundation investigation carried out to support the rehabilitation and northward widening of the existing Markham Road Overpass. This report was developed based on information from the 2018 investigation, supplemented with information from a 1967 and 2011 foundation investigation completed by others and Golder, respectively, at the structure site, as follows:

- **MTO GEOCRES No. 30M14-32:** Report titled "Foundation Investigation Report for the Proposed New Structure at Markham Road and Highway 401, District #6 (Toronto), W.J. 67-F-40 – W.P. 262-61", prepared by MTO Foundation Section – Materials and Testing Division, dated June 9, 1967.
- **MTO GEOCRES No. 30M14-338:** Report titled "Preliminary Foundation Investigation and Design Report, Bridge Widening and Replacement, Highway 401 Rehabilitation from Warden Avenue to Brock Road, Toronto, Ontario, W.O. 07-20012," prepared by Golder Associates Ltd., dated April, 2012.

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal, dated November 21, 2016, which forms part of the Consultant Agreement (No. 2016-E-0009) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated July 10, 2017.

# 2.0 SITE DESCRIPTION

The Highway 401-Markham Road overpass is located in the City of Toronto, east of McCowan Road as shown on the Key Plan on Drawing 1. Based on the 1967 Borehole Location and Soil Strata drawing, the natural ground surface at this site varies from approximately Elevations 157 m and 160 m, rising to the north, with the Markham Road grade at about Elevation 158.5 m at the structure site. Highway 401 has been constructed on embankment fill, with its grade at approximately between Elevations 164 m to 164.5 m at the overpass location. The interchange is surrounded by commercial development.

The existing Markham Road Overpass consists of two spans, with a span arrangement of 18.8 m – 18.8 m between the abutments and the pier. Based on the available 1969 drawings, the existing east and west abutments for the westbound core and collector structure are supported on 3.9 m wide strip footings founded at Elevation 155.7 m, and the existing center pier is supported on a 3.4 m wide strip footing founded at Elevation 155.8 m. The existing WB core structure (Site No. 37-218/4) is approximately 38.4 m long and 19.5 m wide. The WB collector structure (Site No. 37-218/2) is approximately 38.4 m long and 23.6 m wide.

The Highway 401 approach embankments are up to approximately 7 m high relative to the surrounding grade, with the side slopes inclined at greater than approximately 6 horizontal to 1 vertical (6H:1V) at the steepest point on the north side. At the time of the 2018 investigation, visual observations suggested no evidence of settlement on the WB lanes adjacent to the overpass abutments, nor of global instability of the embankment side slopes.

# 3.0 INVESTIGATION PROCEDURES

## 3.1 1967 Investigation

A total of six boreholes (Borehole Nos 1 to 6) were advanced as part of the 1967 investigation (GEOCRES No. 30M14-32) at the Markham Road overpass site. Three of these boreholes are located within or immediately adjacent to the footprint of the WB collector lanes structure, while the other three are located within the eastbound (EB) collector lanes structure area; the EB lanes boreholes have been included in this report as they provide supplementary information on the adjacent geotechnical subsurface conditions. The previous boreholes used in this report have been renumbered to show the MTO GEOCRES reference number followed by the original borehole designation. For example, the boreholes from MTO GEOCRES Report No. 30M14-32 have been renumbered as 32-X, where X is the original borehole number.

The locations of the boreholes are summarized below and shown on Drawing 1. These borehole locations have been developed based on plotting the station and offset as shown on the 1967 borehole records and drawings, adjusted based on the site features shown on the drawings and converted to MTM NAD83 (Zone 10) coordinates. The borehole records from the 1967 investigation are presented in Appendix A and a summary of the borehole locations, ground surface elevation referenced to Geodetic datum and drilled depths are presented below.

| Borehole No. | Borehole Location | MTM NAD 83 (Zone 10) | | Borehole Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|---|
| | | Northing (m) | Easting (m) | | |
| 32-1 | EB Collector East Abutment | 4,849,502.2 | 326,139.3 | 157.7 | 9.6 |
| 32-2 | EB Collector Pier | 4,849,511.6 | 326,117.1 | 157.4 | 9.6 |
| 32-3 | EB Collector West Abutment | 4,849,489.1 | 326,104.6 | 157.3 | 9.6 |
| 32-4 | WB Collector West Abutment | 4,849,574.8 | 326,078.3 | 158.5 | 7.6 |
| 32-5 | WB Collector Pier | 4,849,566.6 | 326,099.6 | 158.1 | 9.1 |
| 32-6 | WB Collector East Abutment | 4,849,588.9 | 326,113.2 | 160.2 | 7.6 |

The Standard Penetration Test (SPT) “N”-values presented on the borehole records of the 1967 investigation were obtained using a manual hammer.

## 3.2 2011 Investigation

One borehole (Borehole 2011-05) was advanced as part of the 2011 investigation (GEOCRES No. 30M14-338) for the Markham Road overpass. The borehole is located adjacent to the footprint of the WB lanes collector structure. The location of the borehole is summarized below and shown on Drawing 1; the borehole location was measured on-site relative to the existing structures and site features and the ground surface elevation was obtained from the Digital Terrain Model for the site. The borehole record from the 2011 investigation is presented in Appendix A and a summary of the borehole location, ground surface elevation referenced to Geodetic datum and drilled depth is presented below.

| Borehole No. | Borehole Location | MTM NAD 83 (Zone 10) | | Borehole Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|---|
| | | Northing (m) | Easting (m) | | |
| 2011-05 | WB Collector East Abutment | 4,849,605.9 | 326,125.8 | 163.5 | 15.9 |

## 3.3 2018 Investigation

The foundation investigation for the Markham Road Overpass WB structure was carried out between February 28 and May 7, 2018, during which time four boreholes (designated as Boreholes MR-01 to MR-04) were drilled. Boreholes MR-01 and MR-03 were advanced adjacent to the east and west abutments, respectively, in the core lanes from the Highway 401 grade, Borehole MR-02 was advanced adjacent to the centre pier of the collector lanes from the Markham Road grade and Borehole MR-04 was advanced within the green space between Markham Road and the N-W Ramp, at the locations shown on Drawing 1.

The borehole investigation was carried out using a CME-55 and a CME 75 truck-mounted drill rigs, supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario. Boreholes MR-01 and MR-03 were advanced through the overburden using 165 mm outside diameter hollow stem augers to depths of 18.8 m and 18.9 m, respectively. Borehole MR-02 was advanced through the overburden using 203 mm outside diameter hollow stem augers to a depth of 18.7 m below existing ground surface. Borehole MR-04 was advanced through the overburden using 152 mm outside diameter hollow stem augers to a depth of 5.2 m below existing ground surface.

Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)[1].

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole MR-04 to permit monitoring of the water level. The installed piezometer consists of a 50 mm diameter PVC pipe, with a 1.5 m slotted screen sealed within a filter sand pack with the bottom of the piezometer within the borehole at about 5 m below ground surface. The borehole and annulus surrounding the piezometer pipe above the filter sand pack were backfilled to the ground surface with bentonite pellets. Boreholes MR-01 to MR-03 were backfilled to ground surface with bentonite, in accordance with Ontario Regulation 903, Wells (as amended) and both boreholes were caped at ground surface with cold patch asphalt.

The field work was monitored on a full-time basis by a member of Golder’s technical staff who located the boreholes in the field, directed the sampling and in situ testing operations, logged the boreholes and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder’s laboratory in Mississauga for further visual examination. Geotechnical laboratory index and classification testing,

[1] ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

consisting of natural moisture content, Atterberg limits and grain size distribution, were conducted on selected samples in accordance with MTO and / or ASTM Standards as applicable. One sample from each of Boreholes MR-01 to MR-03, obtained using appropriate sampling protocols, was submitted to a specialist analytical laboratory under chain of custody procedures for testing of conductivity / resistivity, pH and sulphate and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and corrosion to steel.

The borehole locations were laid out in the field by Golder personnel relative to existing road features and pre-selected coordinates using a hand-held global positioning system (GPS) unit with an accuracy of 1 m in the horizontal and vertical directions; the locations were then measured relative to existing site features, and the ground surface elevation on the pavement established from the digital terrain model for the project. The locations given on the borehole records and shown on Drawings 1 to 3 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates with an accuracy of 0.1 m or better in the horizontal and the ground surface elevations are referenced to Geodetic datum with an accuracy of 0.5 m or better vertically. The borehole locations, including both MTM NAD 83 and geographic coordinates, ground surface elevations and drilled depths are summarized below.

| Borehole No. | MTM NAD83 (Zone 10) | | Ground Surface Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|
| | Northing (m) (Latitude) | Easting (m) (Longitude) | | |
| MR-01 | 4849575.3 (43.785903) | 326129.5 (-79.234968) | 164.1 | 18.8 |
| MR-02 | 4849598.6 (43.785950) | 326094.3 (-79.235433) | 158.5 | 18.7 |
| MR-03 | 4849545.6 (43.785591) | 326074.8 (-79.235760) | 164.8 | 18.9 |
| MR-04 | 4849610.9 (43.786164) | 326041.6 (-79.236086) | 162.3 | 5.2 |

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

## 4.1 Regional Geology

This section of Highway 401 is located within the physiographic region known as the Peel Plain, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2].

A surficial till sheet, which generally follows the surface topography, is generally present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones and it is mapped in this area as the Halton Till. 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 melt water ponds scattered throughout the Peel Plain and concentrated near river valleys, such as the West Don and East Don 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.

[2] Chapman, L.J. and Putman, D.F., 1984, The Physiography of Southern Ontario, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the 2018 investigation and the results of the geotechnical laboratory tests carried out on selected soil samples are presented on the borehole records provided in Appendix B. The results of the in situ field tests (i.e., SPT "N"-values) as presented on the borehole records and in Section 4.2 are uncorrected. The Standard Penetration Test "N"-values from the 1967 investigation are based on use of a manual hammer with a weight of 63.6 kg and a drop of 760 mm, while those in the 2011 and 2018 investigations are based on use of an automatic hammer and the values are reported with no adjustment in this report, although it is recognized that SPT "N"-values obtained using a manual hammer are frequently higher than those obtained using an automatic hammer. Plots of the results of the geotechnical laboratory testing are presented in Appendix C. The results of the analytical testing as summarized in Section 4.4 and the analytical laboratory testing reports are provided in Appendix D.

The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile and cross-section on Drawings 1 to 3 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations, however, the factual data presented in the borehole records governs any interpretation of the site conditions.

In general, the subsurface conditions encountered at the site consists of the Highway 401 embankment fill underlain by interlayered deposits that varies in composition from silt to silt and sand to sand, in places underlain or interlayered with deposits of sand and gravel or sandy clayey silt. Detailed descriptions of the subsurface conditions are provided in the following sections of this report.

### 4.2.1 Topsoil

An approximately 0.1 m and 0.2 m thick layer of topsoil was encountered immediately below ground surface in Boreholes MR-04 and 2011-05, respectively.

### 4.2.2 Asphalt

An approximately 200 mm thick layer of asphalt pavement was encountered immediately below ground surface in Boreholes MR-01 and MR-03, which were advanced along Highway 401. An approximately 150 mm thick layer of asphalt pavement was encountered immediately below ground surface in Borehole MR-02, which was advanced from the Markham Road grade.

### 4.2.3 Fill

A 7.4 m thick layer of fill was encountered underlying the pavement in Boreholes MR-01 and MR-03, a 1.4 m thick layer of fill was encountered underlying the pavement in Borehole MR-02, and a 5.6 m thick layer of fill was encountered underlying the topsoil in Borehole 2011-05. The base of the fill in the 2018 investigation extends to between approximately Elevations 157.2 m and 156.5 m. The fill is variable in composition, comprised of an upper 0.7 m to 2.9 m thick layer of gravelly sand, sand and gravel, and silty sand, sand, and a lower 2.7 m to 6.7 m thick layer of clayey silt to clayey silt with sand in Boreholes MR-01, MR-03 and 2011-05. Cobble fragments were noted within the fill layer in Boreholes MR-01 and MR-03 at a depth of about 6.1 m and 5.5 m, respectively. A 50 mm thick layer of topsoil was encountered at a depth of approximately 5.1 m in Borehole MR-01.

The Standard Penetration Test (SPT) "N"-values measured within the non-cohesive portion of the fill range from 4 blows to 44 blows per 0.3 m of penetration, indicating a loose to dense level of compactness. The SPT "N"-values measured within the cohesive fill range from 4 blows to 81 blows per 0.3 m of penetration, suggesting a firm to hard consistency.

Grain size distribution testing was carried out on one sample of the non-cohesive fill and the result is shown on Figure C-1 in Appendix C. Grain size distribution testing was carried out on one sample of the cohesive fill and the result is shown on Figure C-2 in Appendix C. Atterberg limits testing was carried out on two samples of the cohesive fill layer and measured liquid limits of 21 per cent and 22 per cent, plastic limits of 11 per cent and 13 per cent, and corresponding plasticity indices of 9 per cent and 11 per cent. These results, which are plotted on a plasticity chart on Figure C-3 in Appendix C, indicate that the cohesive fill consists of clayey silt of low plasticity. The natural water content measured on selected samples of the non-cohesive fill ranges from about 6 per cent to 15 per cent. The natural water content measured on selected samples of the cohesive fill ranges from about 7 per cent to 16 per cent.

### 4.2.4 Silt to Sand

A silt to sand deposit was encountered underlying the fill deposit in Boreholes MR-01 to MR-03 and 2011-05 and immediately below ground surface in Boreholes 32-3 to 32-6. The deposit was also encountered underlying the clayey silt till deposit (described in Section 4.2.7) in Borehole 2011-05, underlying the sand and gravel deposit (described in Section 4.2.5) in Borehole MR-02 and underlying the clayey silt deposit (described in Section 4.2.6) in Boreholes MR-04, 32-5 and 32-6. The deposit varies in composition from silt containing some sand, trace clay and trace gravel, to sandy silt to silty sand containing trace to some clay and trace gravel, to silt and sand containing trace to some clay and trace gravel, to sand containing trace to some silt and trace gravel. The surface of the silt to sand deposit was encountered between Elevations 160.9 m and 156.5 m. Boreholes MR-02, MR-04, 2011-05, 32-5 and 32-6 terminated within the silt to sand deposit, penetrating it for a thickness ranging from 0.9 m to 3.8 m. The thickness of the deposit varies between 1.2 m and 7.6 m in the remaining boreholes.

The SPT “N”-values measured within the silt to sand deposit range from 11 blows to 83 blows per 0.3 m of penetration and up to 102 blows for 0.05 m of penetration, but are generally over 50 blows per 0.3 m of penetration, indicating a compact to very dense, and generally very dense, level of compactness.

Grain size distribution testing was carried out on ten samples of the silt to sand deposit from the 2018 investigation, and the results are shown on Figure C-4 in Appendix C. Four Atterberg limits tests carried out on samples of the silt to sand deposit measured liquid limits between 12 per cent and 17 per cent, plastic limits between 12 per cent and 14 per cent, and plasticity indices between 1 per cent and 4 per cent. These results, which are plotted on a plasticity chart on Figure C-5 in Appendix C, indicate that the silt and sand deposit contains portions of silt of slight plasticity; one test on a sample of the silt portion of the deposit indicates a ‘non-plastic’ result. The natural water content measured on selected samples of the silt to sand deposit ranges from about 9 per cent to 22 per cent.

### 4.2.5 Sand and Gravel

A deposit of sand and gravel was encountered underlying the silt and sand and the sand deposits at Elevations 147.3 m and 146.8 m in Boreholes MR-01 and MR-02, respectively. Borehole MR-01 terminated within the sand and gravel deposit, penetrating it for a thickness of 2.1 m. The deposit is about 3.8 m thick in Borehole MR-02.

The SPT “N”-values measured within the sand and gravel deposit range from 48 blows to 106 blows per 0.3 m of penetration with one value of 50 blows for 0.1 m of penetration, indicating a dense to very dense level of compactness.

Grain size distribution testing was carried out on one sample of the sand and gravel deposit from the 2018 investigation, and the result is shown on Figure C-6 in Appendix C. The natural water content measured on two selected samples of the sand and gravel deposit is about 8 per cent and 25 per cent.

### 4.2.6 Clayey Silt to Clayey Silt with Sand

A clayey silt to sandy clayey silt to clayey silt with sand deposit was encountered underlying or interlayered with the silt and sand deposit in Boreholes MR-03 and 32-3 to 32-6, underlying the topsoil in Borehole MR-04, and immediately beneath the ground surface in Boreholes 32-1 and 32-2. The surface of the sandy clayey silt to clayey silt with sand deposit was encountered between approximately Elevations 162.2 m and 153.7 m. Boreholes MR-03 and 32-1 to 32-4 terminated within the clayey silt deposit, penetrating it for a thickness between 2.9 and 9.8 m. The deposit is 1.2 m to 2.8 m thick in Boreholes MR-04, 32-5 and 32-6.

The SPT "N"-values measured within the clayey silt deposit range from 14 blows to 150 blows per 0.3 m of penetration with values up to 50 blows per 0.1 m of penetration, but were generally greater than 50 blows per 0.3 m of penetration, suggesting a stiff to hard, and generally a hard consistency.

Grain size distribution testing was carried out on one sample of the clayey silt deposit from the 2018 investigation, and the result is shown on Figure C-7 in Appendix C. Atterberg limits testing was carried out on one selected sample of the clayey silt deposit from the 2018 investigation and measured a liquid limit of 16 per cent, a plastic limit of 12 per cent, and a corresponding plasticity index of 4 per cent. The result, which is plotted on a plasticity chart on Figure C-8 in Appendix C, indicate that the deposit consists of clayey silt of low plasticity. The natural water content measured on selected samples of the clayey silt deposit ranges from about 10 per cent to 15 per cent, typically around the plastic limit for the material.

### 4.2.7 Clayey Silt with Sand Till

A clayey silt with sand till deposit was encountered underlying the silt and sand deposit at Elevation 152.8 m in Borehole 2011-05. Borehole 2011-05 terminated within this deposit, penetrating it for a thickness of 4.2 m.

The SPT "N"-values measured within the cohesive till deposit range from 109 blows to 134 blows per 0.3 m of penetration, suggesting a hard consistency.

The results of a grain size distributions test and of an Atterberg limits test are presented on the Record of Borehole No, 2011-05. The natural water content measured on two selected samples of the till are about 11 per cent and 14 per cent, at about the plastic limit for the material.

## 4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations during the 2018, 2011 and 1967 investigations, as summarized below.

| Borehole No. | Ground Surface Elevation (m) | Depth to Groundwater (m) | Groundwater Elevation (m) | Date | Comments |
|---|---|---|---|---|---|
| MR-01 | 164.1 | Dry to 6.4 | - | March 1, 2018 | Open borehole (borehole caved to 6.4 m depth) |
| MR-02 | 158.5 | 1.6 | 156.9 | May 7, 2018 | Open borehole |
| MR-03 | 164.8 | Dry to 16.8 | - | March 5, 2018 | Open borehole (borehole caved to 16.8 m depth) |
| MR-04 | 162.3 | Dry | - | June 30, 2018 | Piezometer |
| 2011-05 | 163.5 | 8.0 | 155.5 | April 21, 2011 | Piezometer |
| 32-1 | 157.7 | 0.4 | 157.3 | May 15, 1967 | Open Borehole |
| 32-2 | 157.4 | 0.6 | 156.8 | May 15, 1967 | Open Borehole |
| 32-3 | 157.3 | 1.5 | 155.8 | May 16, 1967 | Open Borehole |
| 32-4 | 158.5 | 0.4 | 158.1 | May 17, 1967 | Open Borehole |
| 32-5 | 158.1 | 0.5 | 157.6 | May 16, 1967 | Open Borehole |
| 32-6 | 160.2 | 1.2 | 159.0 | May 17, 1967 | Open Borehole |

As these water levels were measured immediately after completion of drilling, they may not represent the stabilized groundwater level at the site, nor the current level in the case of the 1967 data. Based on the observed water conditions, together with soil colour transitions from brown to grey, the groundwater level will range between approximately Elevations 156 m and 157 m. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

## 4.4 Analytical Testing Results

Three soil samples were submitted to an accredited analytical laboratory for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. Detailed analytical test results are included in Appendix D and the test results are summarized below:

| Borehole No. / Sample No. | pH | Resistivity (ohm-cm) | Electrical Conductivity (umho/cm) | Chlorides (ug/g) | Soluble Sulphates (ug/g) |
|---|---|---|---|---|---|
| MR-01 / 10 | 8.08 | 1400 | 718 | 390 | 50 |
| MR-02 / 7 | 8.08 | 760 | 1310 | 670 | 70 |
| MR-03 / 11 | 7.79 | 1200 | 848 | 340 | 260 |

## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant of Golder, conducted an independent technical and quality control review of the report.

**Golder Associates Ltd.**



Nikol Kochmanová, Ph.D., P.Eng., PMP
*Geotechnical Engineer*

Jorge M.A. Costa, P.Eng.
*MTO Foundations Designated Contact, Senior Consultant*

NK/JMAC/nk/rb



https://golderassociates.sharepoint.com/sites/16003g/6. deliverables/4. markham road/4. final/1669995 fidr04 2019jan16 hwy 401wb markham rd overpass - copy.docx

# PART B

## FOUNDATION DESIGN REPORT
## MARKHAM ROAD OVERPASS REHABILITATION AND NORTHWARD WIDENING (SITE NO. 37-218)
## HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES, NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO, ONTARIO
## MTO G.W.P. 2162-11-00

# 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

## 6.1 General

This section of the report provides foundation recommendations for detail design for the proposed Markham Road overpass (Site No. 37-218/2 and 37-218/4) and northward widening associated with the operational improvements of the Highway 401 westbound core and collector lanes, from Neilson Road to Warden Avenue in the City of Toronto, Ontario. These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the 2018 subsurface investigation at this site, supplemented with data from the 1967 and 2011 investigations. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible foundation alternatives and carry out the design of the rehabilitation of the existing structure and widening of the structure foundations. The foundation investigation report, discussion and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and their designers, and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in the Foundation Investigation Report (Part A of this report). 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 the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

As part of the rehabilitation of the westbound (WB) lanes of Highway 401 from Neilson Road to Warden Avenue, the existing Markham Road WB core and collector structures will be rehabilitated and the collector structure will be widened to the north by about 1.2 m at the east abutment and 1.9 m at the west abutment. The existing Markham Road overpass (core and collectors) was constructed in 1971 and consists of two spans, with a span arrangement of 18.8 m – 18.8 m between the abutments and the pier. Based on the available 1969 drawings, the existing east and west abutments for the westbound core and collector structure are supported on 3.9 m wide strip footings founded at Elevation 155.7 m along its northern section, and the existing center pier is supported on a 3.4 m wide strip footing founded at Elevation 155.8 m along its northern section. The existing WB core structure (Site No. 37-218/4) is approximately 38.4 m long and 19.5 m wide. The WB collector structure (Site No. 37-218/2) is approximately 38.4 m long and 23.6 m wide.

The proposed bridge rehabilitation involves the replacement of the superstructure including the approach slabs, existing asphalt-covered deck and girders. The rehabilitation will also include conversion of the existing abutments to semi-integral abutments, with excavation of the existing abutment backfill to a depth of about 4 m (approximately Elevation 160 m) to facilitate this conversion. The Markham Road overpass is planned to be rehabilitated in four stages, with the collector superstructure replaced first, followed by the core superstructure, then followed by the median connection between the two superstructures. Temporary protection systems will be required along Highway 401 to facilitate the staged rehabilitation and conversion of the structure to a semi-integral abutment bridge while maintaining traffic along Highway 401. The geometry and design of the temporary protection system is the responsibility of the contractor.

## 6.2 Foundations Options

Based on the proposed overpass geometry and the subsurface conditions at this site, both shallow and deep foundation options have been considered to support the widening sections of the pier and abutments for the

Markham Road overpass. A summary of the advantages and disadvantages associated with each option is provided below.

Temporary protection systems will be required along Highway 401 to facilitate the staged rehabilitation and widening of the Markham Road overpass structure. It is anticipated that some groundwater seepage will occur into the excavations from “perched” water conditions within the cohesionless fills and native soils; however, in general the regional groundwater level is expected to be at or slightly below the proposed excavation depths for the overpass rehabilitation.

A comparison of the alternative foundation options based on advantages, disadvantages, risks and relative costs is provided in Table 1 following the text of this report.

- **Strip or spread footings founded on the very dense sandy silt to silt and sand to sand / hard clayey silt:** Strip or spread footings are feasible foundation elements to support the widening sections of pier, abutments and associated wing walls/retaining walls at this site. Significant excavation will be required through the existing embankment fill to reach the elevation of the existing abutment footings at the proposed foundation subgrade level. Temporary protection systems will be required along Highway 401 to permit the staged rehabilitation and widening of the existing structure foundations. Consideration of the suitability of utilizing the existing wing walls as a temporary protection system should be made on the basis of the adequacy of the existing wing wall and its foundation to provide sufficient resistance for the lateral earth pressure, base sliding and the need for the provision of an additional resistance system, such as tie-backs/anchors, consistent with Section 6.11.2, and it the responsibility of others to assess. This excavation would extend up to about 2.0 m below the Markham Road grade at the pier and abutments, and will extend through perched groundwater and may extend below the prevailing groundwater level, requiring dewatering. This option does not allow for the construction of or conversion to integral abutments, but would permit for the construction of or conversion to semi-integral abutments.

- **Driven steel H-piles or pipe piles**: Driven steel piles are suitable and feasible for support of the widened pier and abutments, as well as for the support of associated wing walls/retaining walls at this site. It is noted that deep foundations are not strictly required for support of the widening section of the abutments / pier / retaining -wing wall elements, as adequate settlement performance can be achieved using shallow foundations, and the existing structure is founded on shallow foundations and has performed well. Although a pile foundation option allows for the design / construction of integral abutments, the existing shallow foundations of the section of the existing structure will not be replaced, and therefore an integral abutment configuration is not feasible for these sections nor necessary for the widened abutment foundation elements. It is assumed further, as the pile caps would need to be founded at about 1.2 m below the Markham Road grade for protection from frost penetration, the required excavation depth is similar to that for shallow foundations, as shallow foundations would be constructed on very dense/hard strata present at shallow depths. In addition, it likely would be necessary to pre-auger into the dense/hard 100-blow soils at the pile locations prior to installing the piles. As such, driven pile foundations are not considered to be a preferred option for the widening from a foundations perspective.

- **Drilled shafts (caissons)**: Drilled shafts foundation are suitable and feasible for support of the widened pier and abutments, as well as associated wing walls/retaining walls at this site. Temporary liners would be required to support the sides of the drilled shaft holes through the non-cohesive overburden soils and minimize ground loss during construction, particularly once the shafts extend below the groundwater table. Similar to pile foundations, it is noted that deep foundations are not strictly required for support of the widened section of the existing structures, as adequate settlement performance can be achieved using shallow foundations, and the existing structure is founded on shallow foundations and has performed well. The use of deep foundations comprised of drilled shafts (caissons) is not considered to be advantageous over the use of shallow foundations (strip or spread footings) at this site, given the presence of very dense/hard strata at shallow depth.

Based on the above considerations, the preferred option from a geotechnical/foundations perspective is to support the pier, abutments and associated wing walls/retaining walls for the proposed northward widening on shallow strip footings founded on the very dense sandy silt to silt and sand to sand / hard clayey silt.

## 6.3 General Foundation Design Context

### 6.3.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* CAN/CSA S6-14 (*CHBDC* (2014)) and its *Commentary*, the overpass and its foundation system may be classified as having large traffic volumes and their performance as having potential impacts on other transportation corridors, resulting in a "typical consequence level" associated with exceeding limit states design.

Based on the level of foundation investigation completed as part of the 1967, 2011 and 2018 investigations in comparison to the degree of site understanding in Section 6.5 of *CHBDC* (2014), the level of confidence for design for the Markham Road overpass has been assessed as "typical degree of site and prediction model understanding".

The corresponding consequence factor, $\Psi$, and geotechnical resistance factors, $\phi_{gu}$ and $\phi_{gs}$, from Tables 6.1 and 6.2, respectively, of the *CHBDC* (2014) have been used for the desktop assessment of the geotechnical resistance of the existing and new foundations.

### 6.3.2 Correlation of Automatic and Manual Hammer for SPT "N" Values

The results of the 2011 and 2018 investigations generally demonstrate lower Standard Penetration Test (SPT) "N"-values than encountered in Boreholes 32-1 to 32-6 from the 1967 investigation (GEOCRES No. 30M14-32). The differences are largely due to the use of an automated hammer with higher efficiency in the 2011 and 2018 investigations as compared to a manually operated hammer (i.e., rope cathead) that was used in the 1967 investigation. The 2011 and 2018 SPT "N"-values correlate reasonably well with the 1967 data when corrected to a 60% efficiency of hammer energy transfer. The foundation options and recommendations presented below are based on the correlated "$N_{60}$"-values, where applicable.

## 6.4 Seismic Design

### 6.4.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation and laboratory testing. The SPT "N"-values measured in the soil layers and the interpreted shear wave velocity of soils up to 30 m below founding level were used to define the seismic site classification in accordance with Table 4.1 of the *CHBDC* (2014). Based on this methodology, it is considered that a Site Class C would be applicable for the design of the Markham Road overpass.

### 6.4.2 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.4 of the *CHBDC* (2014) and as obtained from NRC (2017) website, the peak ground acceleration (PGA), Peak Ground Velocity, and design spectral acceleration (Sa) values for Site Class C are presented below.

| Seismic Hazard Values | 10% Exceedance in 50 years (475-year return period) | 5% Exceedance in 50 years (975-year return period) | 2% Exceedance in 50 years (2,475 return period) |
|---|---|---|---|
| **PGA (g)** | 0.041 | 0.073 | 0.138 |
| **PGV (m/s)** | 0.032 | 0.052 | 0.092 |
| **Sa (0.2) (g)** | 0.069 | 0.117 | 0.216 |
| **Sa (0.5) (g)** | 0.043 | 0.068 | 0.115 |
| **Sa (1.0) (g)** | 0.024 | 0.037 | 0.060 |
| **Sa (2.0) (g)** | 0.011 | 0.018 | 0.029 |
| **Sa (5.0) (g)** | 0.0025 | 0.0041 | 0.0070 |
| **Sa (10.0) (g)** | 0.0011 | 0.0017 | 0.0029 |

### 6.4.3 Soil Liquefaction

Given the generally very stiff to hard / compact to very dense compactness condition of the soils present at the site and the low seismic hazard classification for the site, it is considered that the risk of potential soil liquefaction due to a seismic event is very low.

## 6.5 Assessment of Existing Foundations

Based on the 1969 design drawings (Drawings D-6298-1 - General Layout and D-6298-5 - Footing Layout for WP No. 262-61, the Markham Road overpass is a two-span structure with the abutments and pier supported on spread footings. The design drawings are attached in Appendix E for reference.

The footing width, founding elevation and depth, and founding soils for the existing abutment and pier foundations are summarized below. Based on Golder's interpretation of the available information in the GEOCRES reports and on the above referenced 1969 design drawings, and applying the applicable resistance factors from Tables 6.1 and 6.2 of the *CHBDC* (2014) for a "typical" consequence level and "typical" degree of site understanding, the factored ultimate geotechnical resistance and the factored serviceability geotechnical resistance (for 25 mm of settlement) for the abutment and pier footings are summarized below.

| Foundation Element | Footing Width (m) | Founding Elevation (m) | Approximate Founding Depth (m)* | Founding Soil | Factored Ultimate Geotechnical Resistance (kPa) | Factored Serviceability Geotechnical Resistance (kPa) (for 25 mm of Settlement) |
|---|---|---|---|---|---|---|
| East and West Abutments | 3.9 | 155.7 | 2.3 | Compact to very dense sandy silt to sand/Hard clayey silt | 675 | 450 |
| Center Pier | 3.4 | 155.8 | 2.2 | Compact to very dense sandy silt to sand/Hard clayey silt | 600 | 500 |

* Based on Markham Road grade at Elevation 158 m

The geotechnical resistance values provided above are given for loads applied perpendicular to the surface of the footing. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Sections 6.10.4 and C6.10.4 in *CHBDC* (2014).

## 6.6 Strip Footings

### 6.6.1 Founding Elevations

Strip footings (shallow) foundations are feasible for the support of the widening sections of the Markham Road overpass structure and associated wingwalls/retaining walls. The footings should be founded below any fill or softened/loosened soils on the very dense sandy silt to silt and sand to sand / hard clayey silt at or below Elevations 156.5 m. All footings should be founded at a minimum depth of 1.2 m below the adjacent final grade to provide adequate protection against frost penetration, in accordance with Ontario Provincial Standard Drawing (OPSD) 3090.101 (*Foundation, Frost Penetration Depths for Southern Ontario).*

The footings may also be founded on a compacted granular pad comprised of Ontario Provincial Standard Specification (OPSS).PROV 1010 (*Aggregates*) Granular A or Granular B Type II fill should the removal of any existing fill or non-suitable soils be required to an elevation lower than noted above (i.e., to below Elevation 156.5 m). The founding level must be deep enough to provide adequate protection against frost penetration, but still and minimize the height of the abutment wall.

The widened footings will be constructed in close proximity to the existing footings. In this regard, the new footings should be constructed with the underside founded either at the elevation of the existing footings, or positioned/located above/below the existing footings and offset from the existing footing to beyond an area bounded by a line drawn up/down, as applicable, and away from the edge of the existing footings at 1 horizontal:1vertical (1H:1V).

### 6.6.2 Geotechnical Resistances

Strip footings placed on the native soils at or below the design elevations given in the preceding section, should be designed based on the factored ultimate geotechnical resistances and factored serviceability geotechnical resistances (for 25 mm of settlement) given below.

| Founding Stratum | Footing Width (m) | Factored Ultimate Geotechnical Resistance (kPa) | Factored Serviceability Geotechnical Resistance (kPa) (for 25 mm of Settlement) |
|---|---|---|---|
| Abutments, Piers and/or retaining wall footings on native very dense sandy silt to silt and sand to sand / hard sandy clayey silt to clayey silt with sand deposit – at or below Elevation 156.5 m | 2 | 500 | Does not govern |
| | 3 | 550 | 525 |
| | 3.4 (to match existing pier foundations) | 600 | 450 |
| | 3.9 (to match existing abutment foundations) | 650 | 400 |
| | 4 | 650 | 400 |
| | 5 | 750 | 350 |

The geotechnical resistances should be reviewed if the selected footing width or founding elevations differ from those given above. The factored geotechnical resistances provided above are given for loads that will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the *CHBDC (2014).*

The footing subgrade should be inspected, in accordance with OPSS 902 *(Excavating and Backfilling - Structures)* to check that all existing fill, loosened/softened native soils and other deleterious materials have been removed.

The native soil subgrade will be susceptible to disturbance from ponded water, precipitation from inclement weather and/or construction traffic. If the concrete for the footings cannot be poured immediately after excavation and inspection, it is recommended that a concrete working slab (100 mm thick of 20 MPa compressive strength concrete) be placed in the excavation within four hours to protect the integrity of the subgrade. A Non-Standard Special Provision (NSSP) to address this item is included in Appendix F, which should be included in the Contract Documents.

### 6.6.3 Resistance to Lateral Loads

Resistance to lateral forces / sliding resistance between the new concrete footings and the subgrade should be calculated in accordance with Section 6.10.5 of the *CHBDC* (2014). For cast-in-place concrete footings constructed directly on native soils, or on a concrete working slab, the sliding resistance may be calculated based on the unfactored coefficient of friction, tan $\Phi$’ or $\delta$ respectively, which can be taken as follows:

- Cast-in-place footing or working slab to native deposits: tan $\Phi$' = 0.5
- Cast-in-place footing to concrete working slab: tan $\delta$ = 0.7

## 6.7 Steel H-Pile or Pipe Pile Foundations

### 6.7.1 Founding Elevations

Consideration can be given to supporting the widened abutments and pier on steel HP 310x110 piles, or closed-end, concrete-filled, 324 mm (12 ¾ in.) diameter steel pipe piles having a minimum wall thickness of 9.5 mm (3/8 in.). Due to the shallow depth to “100-blow” material in some of the boreholes, it may be necessary to pre-auger into the “100-blow” soils at shallow depths at the pile locations prior to installing the piles.

The pile tip elevations provided below may be used for design of pile foundations driven to refusal a minimum of 3 m into the “100-blow” soils. The pile length has been estimated based on assumed underside of pile cap at Elevation 157.1 m.

| Foundation Element | Surface Elevation of “100-blow” Material (m) | Estimated Design Pile Tip Elevation (m) | Estimated Pile Length (m) |
|---|---|---|---|
| West Abutment | 155.5 | 151.5 | 5.6 |
| East Abutment | 152.5 | 149.5 | 7.6 |
| Center Pier | 152.5 | 149.5 | 7.6 |

Given the variability in the SPT “N”-values, it is recommended that an allowance for varying pile lengths be provided in the Contract Documents to ensure that adequate pile lengths are available on site and to reduce splicing needs, especially for the piles at the centre pier where “N”-values greater than “100-blows” per 0.3 m of penetration were measured at inconsistent depths.

Consideration must be given to the potential presence of cobbles and boulders within the fill and glacially-derived native soils at this site as inferred present from auger grinding in Boreholes MR-1 and MR-3. In this regard, steel H-piles are preferred over steel tube piles given that steel tubes are considered to pose a slightly higher risk of “hanging up” or being deflected from their vertical or battered orientation during installation, due to their larger end area. The piles should be reinforced at the tip for protection during driving to reduce the potential for damage to the piles in the event that cobbles/ boulders and/or very dense layers are encountered within the soil deposits. The steel H-piles should be reinforced at the tip to protect the pile using driving shoes such as OPSD 3000.100 (*Steel H-Pile Driving Shoe*) Type II (or a proprietary driving shoe such as Titus Standard “H” Points). Similarly, if steel pipe piles are being considered, driving shoes should be in accordance with OPSD 3001.100 Type II (*Steel Tube Pile Driving Shoe*). The requirement for driving shoes should be included in the Contract Drawings.

The pile caps for the abutments and pier should be provided with a minimum of 1.2 m of soil cover to provide adequate protection against frost penetration as interpreted from OPSD 3090.101 (*Frost Penetration Depths for Southern Ontario*).

### 6.7.2 Geotechnical Axial Resistances

For HP 310 x 110 piles driven into the "100-blow" soil at or below the design tip elevations provided in Section 6.7.1, the factored ultimate geotechnical resistance may be taken as 1,200 kN. The factored serviceability geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored ultimate geotechnical resistance and therefore does not govern the design. The following Note 2 from Section 3.3.3 of MTO's *Structural Manual* (MTO, 2016), should be shown on the Contract Drawing assuming that a resistance factor of 0.5 is applied to the use of the Hiley calculation based on MTO experience in the Southern Ontario region:

> *"Piles to be driven in accordance with Standard SS-103-11 using an ultimate geotechnical resistance of 2,400 kN per pile, but must be driven to or below, the following tip Elevations:"*

| Foundation Element | Pile Tip Elevation (m) |
|---|---|
| West Abutment | 151.5 |
| East Abutment | 149.5 |
| Center Pier | 149.5 |

Similar axial resistances and drawing note may be used in the foundation design using closed-end, concrete filled 324 mm (12 ¾ in.) diameter steel pipe piles having a minimum wall thickness of 6.4 mm (¼ in.).

Pile installation should be in accordance with OPSS.PROV 903 *(Deep Foundations).* The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile and length of pile; the criteria must therefore be established at the time of construction after the piling equipment is known to ensure that the piles are not overdriven and to avoid possible damage to the piles. The pile capacity should be verified in the field by the use of the Hiley formula (MTO Standard Drawing SS103-11) during the final stages of driving to achieve an ultimate capacity, as indicated in the Contract Drawing Note above. Pile dynamic analyzer (PDA) testing should also be completed on at least two piles at each foundation element. If pile foundations are adopted for support of the widened structure, the Contract Documents must include the Special Provision that has been developed to amend OPSS.PROV 903 to address PDA testing, as well as an NSSP to specify the minimum number of piles to be tested by PDA; an example NSSP is included in Appendix F.

### 6.7.3 Resistance to Lateral Loads

Resistance to lateral loading may be derived using vertical piles, with enhanced support offered by inclined (battered) piles, if required. For vertical piles, the resistance to lateral loading will be derived solely from the soil in front of the piles, whereas inclined piles derive lateral resistance from the soil in front of the piles as well as the horizontal component of the axial load present in the inclined pile.

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

The factored serviceability geotechnical response of the soil in front of the piles under lateral loading at this site may be calculated using subgrade reaction theory suggested in *CHBDC* (2014) Commentary (Section C6.11.2.2), where the coefficient of horizontal subgrade reaction, $k_h$, (kPa/m) is based on the equation given below, as described by Terzaghi (1955) and the Canadian Foundation Engineering Manual (CFEM, 1992).

For non-cohesive soils:

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

Where $n_h$ is the constant of subgrade reaction (kPa/m);
z is the depth (m); and
B is the pile diameter or width (m).

For cohesive soils:

$$k_h = \frac{67 s_u}{B}$$

Where $s_u$ is the undrained shear strength of the soil (kPa); and
B is the pile diameter or width (m).

The following values of $n_h$ and $s_u$ (Terzaghi, 1995) may be incorporated into the calculations of horizontal subgrade reaction ($k_h$) for structural analyses for a single vertical pile, based on the interpreted stratigraphic profiles shown on Drawings 2 and 3. The ranges in values reflect the variability in the subsurface conditions, the soil properties and the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that $k_h$ is a function of deflection).

| Soil Unit | $n_h$ (kPa/m) | $s_u$ (kPa) |
|---|---|---|
| Existing loose to compact non-cohesive fill | 4,000 | - |
| Existing firm to hard cohesive fill | - | 50 |
| Compact to very dense silt to sandy silt to silt and sand to sandy silt; above the water table (assumed at Elevation 157 m) | 12,000 | - |
| Compact to very dense silt to sandy silt to silt and sand to sandy silt; below the water table (assumed at Elevation 157 m) | 7,000 | - |
| Hard sandy clayey silt to clayey silt with sand | - | 200 |

Both the structural and geotechnical resistances of the piles should be evaluated to establish the governing case at Ultimate Limit States (ULS). At Serviceability Limit States (SLS), the horizontal reaction of the piles will be controlled by deflections and the horizontal resistance of the pile should be calculated based on the coefficient of horizontal subgrade reaction ($k_h$) of the soil as discussed above. The SLS reaction should be taken as that corresponding to a horizontal deflection of 10 mm at the underside of the pile cap for units supporting the abutments (CHBDC (2014) Commentary Section 6.11.2.2).

The upper zone of the soil (down to a depth below the pile cap equal to about 1.5xB (where B is the pile diameter) should be neglected in the calculation of lateral resistance of the pile to account for disturbance effects during installation.

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters between rows of driven steel H-piles. Group action can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor, R (NAVFAC DM-7.2, 1986) as follows:

| Pile Spacing in Direction of Loading (D = Pile Diameter) | Subgrade Reaction Reduction Factor, R |
|---|---|
| 8D | 1.00 |
| 6D | 0.70 |
| 4D | 0.40 |
| 3D | 0.25 |

The subgrade reaction reduction factor should be interpolated for pile spacings in between those provided in the above summary. Reduction for group effects is negligible when the centre to centre pile spacing exceeds three pile diameters measured in the direction perpendicular to loading.

## 6.8 Drilled Shafts (Caissons)

### 6.8.1 Founding Elevations

Drilled shaft foundations could also be considered for support of the widened sections of the abutments and pier. Drilled shafts should be socketed at least 2 m into the “100-blow” soil. The estimated drilled shaft tip elevations for the widened abutment and pier foundations are summarized below.

| Foundation Element | Surface Elevation of “100-blow” Material (m) | Estimated Design Pile Tip Elevation (m) |
|---|---|---|
| West Abutment | 155.5 | 152.5 |
| East Abutment | 152.5 | 150.5 |
| Center Pier | 152.5 | 150.5 |

### 6.8.2 Geotechnical Axial Resistance

For drilled shafts socketed approximately 2 m into “100-blow” soil at the elevations given in Section 6.8.1, the factored ultimate geotechnical resistance and factored serviceability geotechnical resistance may be taken as follows, based on a caisson length equal to 5.6 m for the west abutment and 7.6 m for the east abutment and center pier:

| Foundation Element | Drilled Shaft Diameter (m) | Factored Ultimate Geotechnical Resistance (kN) | Factored Serviceability Geotechnical Resistance (kN) (for 25 mm of settlement) |
|---|---|---|---|
| West Abutment | 0.9 | 1,500 | Does not govern [1] |
| | 1.2 | 2,000 | Does not govern [1] |
| | 1.5 | 2,700 | Does not govern [1] |
| East Abutment and Centre Pier | 0.9 | 2,000 | Does not govern [1] |
| | 1.2 | 3,600 | Does not govern [1] |
| | 1.5 | 5,600 | Does not govern [1] |

[1] The factored serviceability geotechnical resistance (at SLS) for 25 mm of settlement will be greater than the factored ultimate geotechnical axial resistance (at ULS) and as such, the SLS condition does not apply.

### 6.8.3 Resistance to Lateral Loads

The geotechnical resistance to lateral loading for the caissons should be calculated in accordance with Section 6.7.3, using the horizontal subgrade formulas and parameter values presented therein.

## 6.9 Lateral Earth Pressures for Design of Abutment and Wing Walls

The lateral earth pressures acting on the abutment walls and any associated wing walls / retaining walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the abutment/wing/retaining walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular B Type II, should be used as backfill behind the walls. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*). Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3101.150 (*Walls, Abutment, Backfill*) and OPSD 3121.150 (*Walls, Retaining, Backfill*)

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with *CHBDC* (2014) Section 6.12.3 and Figure 6.6. Hand-operated compaction equipment should be used to compact the backfill soils immediately behind the walls as per OPSS.PROV 501. Other surcharge loadings should be accounted for in the design, as required.

- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.2 m behind the back of the wall on Figure C6.20(a) of the Commentary to the *CHBDC* (2014). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at / or flatter than 1.1 horizontal to 1 vertical (1.1H:1V) extending up and back from the rear face of the footing or pile cap on Figure C6.20(b) of the *Commentary* to the *CHBDC* (2014).

### 6.9.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes then new lateral earth pressures will need to be calculated.

For a restrained wall, the pressures are based on the fill behind the granular backfill zone, and the following parameters (unfactored) may be used assuming the use of earth fill:

| Material | Earth Fill |
|---|---|
| Soil Unit Weight: | 20 kN/m3 |
| Coefficients of static lateral earth pressure:<br>Active, $K_a$<br>At rest, $K_o$ | <br>0.33<br>0.50 |

- For an unrestrained wall, the pressures are based on the engineered granular fill within the backfill zone, and the following parameters (unfactored) may be used:

| Material | Granular 'A' | Granular 'B' Type II |
|---|---|---|
| Soil Unit Weight: | 22 kN/m3 | 21 kN/m3 |
| Coefficients of static lateral earth pressure:<br>Active, $K_a$<br>At rest, $K_o$ | <br>0.27<br>0.43 | <br>0.27<br>0.43 |

- If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.
- If the wall support and superstructure allow lateral yielding, active earth pressures may be used in the geotechnical design of the structure. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the *Commentary* to the *CHBDC* (2014).

### 6.9.2 Seismic Lateral Earth Pressures for Design

Depending on the seismic class of the structure, seismic (earthquake) loading may have to be taken into account in the design of abutment walls / wingwalls / retaining walls in accordance with Section 4.6.5 of the *CHBDC* (2014). In this regard, the following should be included in the assessment of lateral earth pressures:

- Seismic loading will result in increased lateral earth pressures acting on the abutment stem and/or retaining walls. The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the earthquake-induced dynamic earth pressure.
- In accordance with Sections 4.6.5 and C.4.6.5 of the *CHBDC* (2014) and its *Commentary*, for structures which allow lateral yielding, the horizontal seismic coefficient, $k_h$, used in the calculation of the seismic active pressure coefficient, is taken as 0.5 times the site-specific PGA. For structures that do not allow lateral yielding, $k_h$ is

taken as equal to the site-specific PGA. For both cases the value of the vertical seismic coefficient $k_v$ is taken as zero.

- The following seismic active pressure coefficients ($K_{AE}$) may be used in design; these coefficients reflect the maximum $K_{AE}$ obtained for each of the earthquake design periods and backfill conditions. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is level. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

| | Design Earthquake | Site PGA | Seismic Active Pressure Coefficients, $K_{AE}$ | | |
|---|---|---|---|---|---|
| | | | Granular A | Granular B Type II | Earth Fill |
| **Yielding Wall (Unrestrained)** | **475-Yr** | 0.041g | 0.26 | 0.26 | N/A |
| | **975-Yr** | 0.073g | 0.27 | 0.27 | N/A |
| | **2,475 Yr** | 0.138g | 0.29 | 0.29 | N/A |
| **Non-Yielding Wall (Restrained)** | **475-Yr** | 0.041g | N/A | N/A | 0.33 |
| | **975-Yr** | 0.073g | N/A | N/A | 0.35 |
| | **2,475 Yr** | 0.138g | N/A | N/A | 0.40 |

- The $K_{AE}$ value for a yielding wall is applicable provided that the wall can move up to $250k_h$ mm, where $k_h$ is the site specific PGA as given in the table above. This corresponds to displacements of 10 mm, 18 mm, and 34 mm for the 475-year, 975-year, and 2,475-year design earthquakes at this site.
- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined per Section C4.6.5 of the *Commentary* to *CHBDC* (2014).

## 6.10 Approach Embankment Design and Construction

It is our understanding that the existing Markham Road structure will be widened by about 1 m to 2 m to the north and new wing walls / retaining walls will be constructed at the northeast and northwest corners of the new structure. Approach embankment widening at this site will require placement of fill on / along the north side of the existing embankment up to about 7 m thick relative to the toe of the existing side slopes.

Along the north side of the west approach embankment, Borehole MR-04 was advanced to the north of the northerly widening footprint and encountered a thin layer of topsoil underlain by a 1.3 m thick layer of stiff clayey silt fill, which is underlain by a compact to very dense silt and sand deposit.

Along the north side of the east approach embankment, Borehole 2011-05 was advanced near the northerly widening footprint and encountered a thin layer of topsoil underlain by a 5.6 m thick layer of loose to compact silty sand fill and stiff to very stiff clayey silt with sand fill, underlain by deposits of dense to very dense sand and silt, hard clayey silt with sand till and compact sand.

### 6.10.1 Subgrade Preparation and Embankment Construction

Prior to construction of the new widening sections of the approach embankments it is recommended that any topsoil and loosened/softened fill be removed.

Fill for construction of the new embankment widenings should consist of Granular 'B' Type I or Select Subgrade Material meeting the specifications of OPSS.PROV 1010 (*Aggregates*). The embankment fill should be placed and compacted on the slopes in accordance with OPSD 208.010 (*Benching of Earth Slopes*), OPSS.PROV 501 (*Compacting*) and OPSS.PROV 206 (*Grading*). The final embankment side slopes should be constructed to an inclination no steeper than 2H:1V in granular fill.

All granular fill should be placed in lifts as per OPSS.PROV 206 (*Grading*) and compacted to at least 95 per cent of the Standard Proctor Maximum Dry Density of the material. Inspection and field density testing should be carried out by qualified personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

To reduce surface water erosion on the embankment side slopes, topsoil and seeding as per OPSS 802 (*Topsoil*) and OPSS.PROV 804 (*Seed and Cover*) should be carried out as soon as possible after construction of the embankments. If this slope protection is not in place before winter, then alternate protection measures, such as covering the slope with straw or gravel sheeting, as per OPSS 511 (*Rip Rap, Rock Protection and Granular Sheeting*) and OPSS.PROV 1004 (*Aggregates – Miscellaneous*), should be carried out to reduce the potential for erosion and the requirement of remedial works on the side slopes in the spring prior to topsoil dressing and seeding.

### 6.10.2 Global Stability

Limit equilibrium slope stability analyses for the widened embankment side slopes was carried out using the commercially available program Slide (version 8.0), developed by Rocscience Inc., employing the Morgenstern Price method of analysis. For all analyses, the Factors of Safety (FoS) of numerous potential failure surfaces were computed for the critical embankment cross section in order to establish the minimum FoS. Based on the results of the analysis for deep seated global failure surfaces, the minimum FoS for the widened approach embankment side slopes, for the short-term (undrained) and long-term (drained) cases is greater than 1.3 and 1.5, respectively, which is considered acceptable for this site.

### 6.10.3 Settlement

Settlement of the subgrade soils beneath the widened approach embankment areas can be expected as a result of the loading from the new fills on the existing fill material and underlying native soil deposits. Settlement of new granular fill that is properly placed and compacted for construction of the widened embankments is expected to occur during construction.

To estimate the magnitude of the expected settlements of the existing fill material and native soil deposits, analyses were carried out using hand and spreadsheet calculations. The immediate compression of the cohesive and non-cohesive deposits was modelled by estimating an elastic modulus of deformation based on the SPT "N"-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990).

The simplified stratigraphy, together with the associated strengths and unit weights employed for the different foundation soil types at the widened west and east approach embankments, as encountered in Boreholes MR-04, and 2011-05, respectively, are summarized below.

| Borehole/Approach | Soil Type | Approximate Thickness (m) | Bulk Unit Weight (kN/m$^3$) | Elastic Modulus (MPa) |
|---|---|---|---|---|
| Borehole MR-04 at West Approach | Stiff sandy clayey silt | 1.3 | 19 | 15 |
| | Compact to very dense silt and sand | >3.8 | 21 | 30 |
| Borehole 2011-05 at East Approach | Loose to compact silty sand (fill) | 2.9 | 19 | 10 |
| | Stiff to very stiff clayey silt with sand (fill) | 2.7 | 19 | 15 |
| | Dense to very dense sand and silt | 4.9 | 20 | 75 |
| | Hard clayey silt with sand Till | 4.2 | 21 | 150 |
| | Compact Sand | 1.0 | 19 | 30 |

#### 6.10.3.1 Settlement Performance Requirements

The settlement performance criterion for design of high fill embankments is in accordance with MTO's Guideline "Embankment Settlement Criteria for Design" (2010), Tables 1.2 and 1.3.

For new embankments approaching structural elements, the following post-construction settlement and differential settlement criteria are considered acceptable for settlements to occur within 20 years post-paving for the bridge approach embankments at this site.

| Location | Maximum Limits During Pavement Design Life | |
|---|---|---|
| | Distance from Transition Point (i.e., Abutment) | Total Post-Construction Settlement |
| Transition/Taper to Bridge Abutments (Max. Total Settlement for Widening is 50 mm) | 0 m to 20 m | 25<br>(max 5 mm at structure interface) |
| | 20 m to 50 m | 50 |

These performance criteria form part of the overall design performance for the widened sections of the approach embankments in the vicinity of the abutments.

#### *6.10.3.2 Results of Analysis*

Based on the analysis using the parameters presented in Section 6.10.3, the estimated settlement of the approach embankment widening fill is less than 25 mm, which meets the requirements of the above noted embankment settlement criteria for design.

## 6.11 Corrosion Assessment and Protection

Soil corrosivity may affect the concrete foundations and reinforced steel and other concrete elements buried in the soil. The long-term performance and durability of the foundations are directly related to their respective corrosion resistance. Generally, the corrosivity potential to a structure depends on the soil resistivity / electrical conductivity, hydrogen ion concentration, and salts (chloride and sulphate) concentrations. The results of the analytical testing of three samples submitted to an accredited analytical laboratory are summarized in Section 4.4 and the analytical laboratory test reports are included in Appendix D.

### 6.11.1 Potential for Sulphate Attack

The analytical test results were compared to CSA Standard, CAN/CSA-A23.1-14 Table 3 *("Additional requirements for concrete subjected to sulphate attack")* for potential sulphate attack on concrete. The sulphate concentrations measured in the three tested samples (ranging from 0.005 per cent to 0.026 per cent) are below the exposure class of S-3 (Moderate). Therefore, based on the three samples of soil tested, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

### 6.11.2 Potential for Corrosion

The test results indicate a pH ranging between 7.79 to 8.08 and a resistivity ranging between 760 ohm-cm and 1,200 ohm-cm. According to the Gravity Pipe Design Guidelines (MTO, 2014), the pH is not considered detrimental to concrete durability. However, the resistivity indicates that the soil corrosiveness is “Severe” (R < 2,000 ohm-cm), as per Table 3.2 of the Gravity Pipe Design Guidelines (MTO, 2014), and some level of corrosion protection should be applied to the foundation element / materials. Further, given that the foundations are located adjacent to the roadway shoulder and will be exposed to de-icing salt, consideration should be given to selection of a “C” type exposure class as defined by CSA A23.1 Table 1.

It is ultimately up to the structural designer to determine the appropriate exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 “Durability Requirements” are followed.

## 6.12 Construction Considerations

### 6.12.1 Excavation and Control of Groundwater and Surface Water

The foundation excavations at the abutments for spread footings or pile cap construction will extend to depths of about 2.0 m below the Markham Road grade, through the existing fill and into the compact to very dense sandy silt to silty sand.

Open-cut excavations must be carried out in accordance with the guidelines outlined in the most recent version of the Occupational Health and Safety Act and Regulation for Construction Activities. The existing fill materials are classified as Type 3 soils, while the native deposits are classified as Type 2 soils, according to the OHSA. Temporary excavations (i.e. those that are open for a relatively short time period) should be made with side slopes no steeper than 1H:1V.

It is expected that for construction staging, temporary protection systems will be required along Highway 401 to facilitate the staged rehabilitation and widening of the Markham Road overpass structure. Recommendations for temporary protection systems are provided in Section 6.12.2 below.

Excavations for construction of the retaining walls may extend below the groundwater level, which is interpreted to be at approximately Elevation 157 m; however, it is expected that water inflow from granular zones of fill or present within the native material, can be handled by pumping from well filtered sumps located outside the foundation footprint. Dewatering should be carried out in accordance with OPSS.PROV 517 (Dewatering) as referenced in OPSS 902 (Excavating and Backfilling - Structures) as amended by SP FOUN0003; reference to this SP is provided in Appendix F. It is noted that the designer will need to fill in the data for “return period” in this SP.

Surface water seepage into the excavations should be expected and will be heavier during periods of sustained precipitation and all surface water should be directed away from the excavations.

### 6.12.2 Temporary Protection Systems

To facilitate the staged rehabilitation and widening of the Markham Road overpass structure, temporary protection systems are expected to be required between the WB and EB core lanes, between the WB core and collector lanes, and possibly between the WB collector lanes and Markham Road S-W ramp. Temporary protection systems may also be required in front of the existing/new abutment foundations, and on either side of the pier foundation, to protect Markham Road.

The temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems).* The lateral movement of the temporary protections systems along Highway 401 and Markham Road should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any existing adjacent structures or utilities can tolerate this magnitude of deformation.

It is considered that it may be difficult to install a driven, interlocking sheet pile system at this site due to the presence of dense to very dense soils at relatively shallow depth below the fills. In this case, a soldier pile and lagging system is likely more suitable. Although groundwater seepage is anticipated to be minor, it would be necessary to control seepage or include measures to mitigate loss of soil particles through the lagging boards.

The sheet piles or soldier piles would have to be driven or socketted to a sufficient depth to provide the necessary passive resistance for the retained soil height, including any surcharge loads behind the protection system within at least a 1H:1V zone relative to the base of the excavation. Lateral support to the sheet piles or soldier piles could be provided in the form of struts, rakers or temporary anchors.

Consideration should be given to either partial or full removal of the protection system upon completion of construction. Where possible, full removal of the protection system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work on the highway surface or north bridge abutment. An NSSP is included in Appendix F which addressed the fill removal or cut-off of the temporary protection system.

The selection and design of the protection systems will be the responsibility of the contractor.

### 6.12.3 Subgrade Protection

The native soils that will be exposed at the foundation subgrade level will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the footing / pile cap subgrade. This requirement can be addressed with a note on the drawings and/or with an NSSP. An example NSSP for the concrete working slab is included in Appendix F.

### 6.12.4 Obstructions

Cobbles and/or boulders were encountered and inferred due to difficulty to augering at varying depths in two of the boreholes drilled during the current subsurface investigation, which may affect the installation of steel H-piles, pipe piles, or drilled shafts, as well as temporary protection systems. It is recommended that driving shoes be used on all steel H-piles or pipe piles to facilitate driving into the overburden soils. In addition it is recommended that an NSSP be included in the Contract Documents to warn the Contractor of the possible presence of cobbles and/or boulders within the overburden soils and an example NSSP is presented in Appendix F.

### 6.12.5 Vibration Monitoring During Construction

It is considered prudent to carry out vibration monitoring during pile driving or drilled shaft installation operations, as well as during protection system installation, to ensure that the vibration levels at the existing structure, nearby residential/commercial structures are maintained below tolerable levels.

A maximum peak particle velocity (PPV) of 100 mm/s is generally considered applicable for bridge structures in good condition. Based on vibration monitoring experience, it is considered unlikely that vibrations induced by conventional construction activities such as pile driving and protection system installation will reach this threshold level and, therefore, vibration monitoring for the existing overpass structure is not expected to be required during construction at this site but should be carried out during the early stages of construction to verify the level of vibration being impacted to the structure.

Commercial buildings and residential condominium towers are located about 100 m to 150 m from the structure location. A lower PPV threshold of 50 mm/s is generally considered applicable for vibration impacts on buildings.

Pre- and post-construction condition surveys and vibration monitoring are recommended at and near existing structures within approximately a 200 m radius of any deep foundation or protection system installation. An NSSP describing the requirements for vibration monitoring is presented in Appendix F.

# 7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant of Golder, conducted an independent technical and quality control review of the report.

**Golder Associates Ltd.**



Nikol Kochmanová, Ph.D., P.Eng., PMP
*Geotechnical Engineer*

Jorge M.A. Costa, P.Eng.
*MTO Foundations Designated Contact, Senior Consultant*

NK/JMAC/nk/rb

Golder and the G logo are trademarks of Golder Associates Corporation

https://golderassociates.sharepoint.com/sites/16003g/6. deliverables/4. markham road/4. final/1669995 fidr04 2019jan16 hwy 401wb markham rd overpass - copy.docx

# REFERENCES

Bowles, J.E., 1984. *Physical and Geotechnical Properties of Soils*, Second Edition. McGraw Hill Book Company, New York.

Canadian Geotechnical Society. 1992. *Canadian Foundation Engineering Manual (CFEM)*, 3rd Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.

Canadian Geotechnical Society. 2006. *Canadian Foundation Engineering Manual (CFEM)*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Canadian Standards Association (CSA). 2014. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-14*. CSA Special Publication.

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.

CSA Group. 2014. A23.1-14/A23.2-14 - Concrete materials and methods of concrete construction / Test methods and standard practices for concrete.

Kulhawy, F.H. and Mayne, P.W. 1990. *Manual on Estimating Soil Properties for Foundation Design*. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.

National Resources Canada, 2017. *Earthquake Hazard*. http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2015-en.php. Accessed on July 18, 2018.

Terzaghi, K., 1955. *Evaluation of Coefficients of Subgrade Reaction*. In Geotechnique, Vol. 5, No. 4, pp. 297-326. Discussion in Vol. 6, No. 2, pp. 94-98.

Unified Facilities Criteria, U.S. Navy. 1986*. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures*. Alexandria, Virginia.

**ASTM International:**

| | |
|---|---|
| ASTM D1586 | Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils |

**Commercial Software:**

Slide (Version 7) by Rocscience Inc.

**Ontario Provisional Standard Drawing:**

| | |
|---|---|
| OPSD 208.010 | Benching of Earth Slopes |
| OPSD 3000.100 | Foundation, Piles, Steel H-Pile Driving Shoe |
| OPSD 3001.100 | Foundation, Piles, Steel Tube Pile Driving Shoe |
| OPSD 3090.101 | Foundation Frost Penetration Depths for Southern Ontario |
| OPSD 3101.150 | Walls, Abutment, Backfill, Minimum Granular Requirements |
| OPSD 3121.150 | Walls, Retaining, Backfill, Minimum Granular Requirements |

**Ontario Provincial Standard Specification:**

| | |
|---|---|
| OPSS.PROV 206 | Construction Specification for Grading |
| OPSS.PROV 501 | Construction Specifications for Compacting |
| OPSS 511 | Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting |
| OPSS.PROV 517 | Construction Specification for Dewatering |
| OPSS.PROV 539 | Construction Specification for Temporary Protection Systems |
| OPSS 802 | Construction Specification for Topsoil |
| OPSS.PROV 804 | Construction Specification for Seed and Cover |
| OPSS 902 | Construction Specification for Excavating and Backfilling - Structures |
| OPSS.PROV 903 | Construction Specification for Deep Foundations |
| OPSS.PROV 1004 | Material Specification for Aggregates – Miscellaneous |
| OPSS.PROV 1010 | Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material |

**Ontario Water Resources Act:**

Ontario Regulation 903 Wells (as amended)

**Ontario Occupational Health and Safety Act:**

Ontario Regulation 213/91 Construction Projects (as amended)

**Ministry of Transportation, Ontario**

*Gravity Pipe Design Guideline*. Drainage and Hydrology Design and Contract Standards Office, 2014.

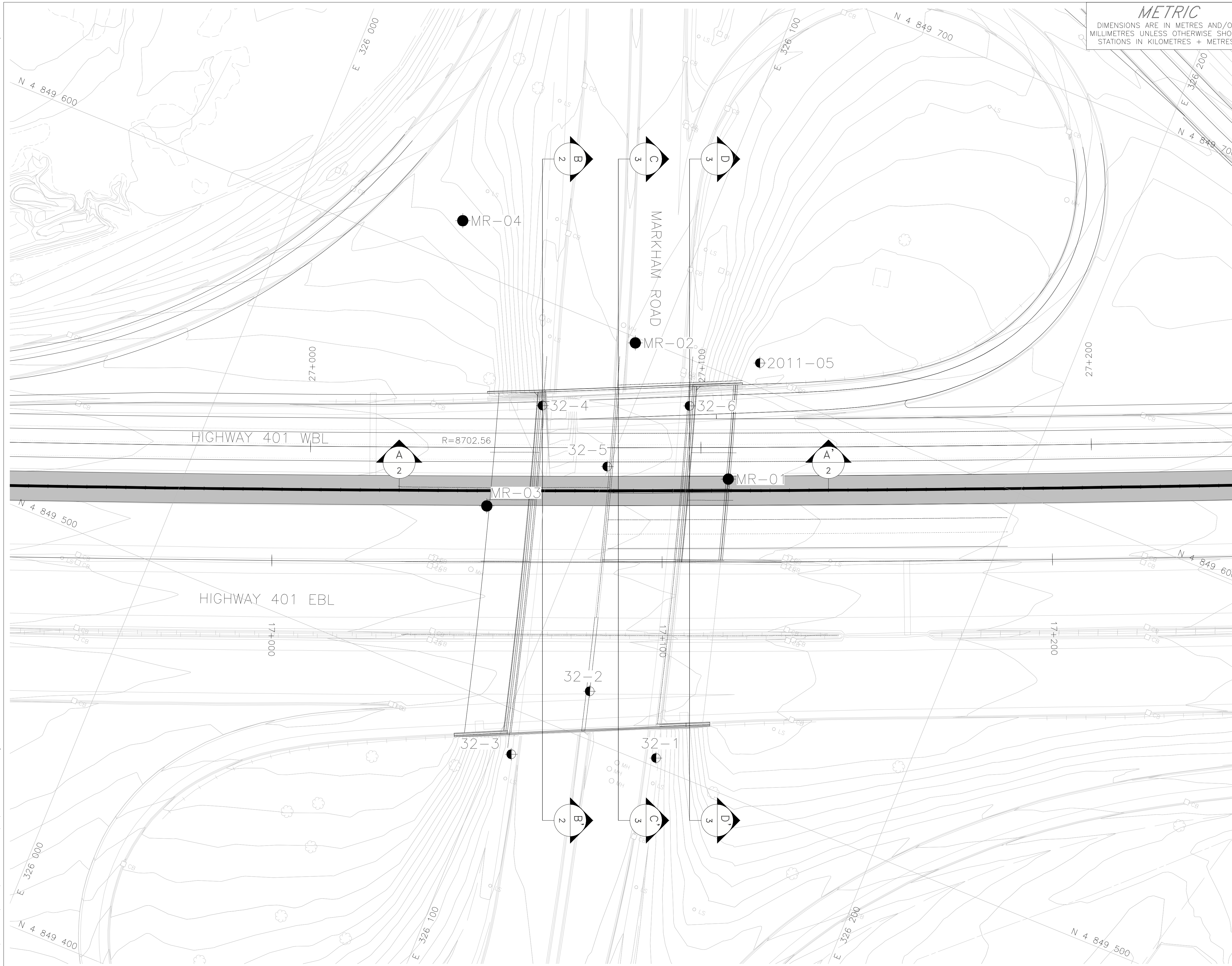
*Structural Manual*, Provincial Highways Management Division, Highway Standards Branch, Bridge Office, August 2016.

*Standard Drawing SS103-11.* Pile Driving Control, April 2008.

*Embankment Settlement Criteria for Design*. July 2, 2010.

**TABLE 1 – COMPARISON OF FOUNDATION ALTERNATIVES – MARKHAM ROAD OVERPASS WIDENING**

| Foundation Option | Feasibility | Advantages | Disadvantages | Constructability | Estimated Costs |
|---|---|---|---|---|---|
| Spread/strip footings founded on native soils | Feasible for support of the abutments and pier; requires temporary protection for staged construction. | • Suitable founding strata at shallow depths reducing depth of excavation and temporary excavation support requirements.<br>• Existing structure is supported on shallow foundations, and has performed well.<br>• Permits semi-integral abutment configuration as also proposed for the rehabilitation (conversion) of the existing foundations.<br>• Smaller working area required at center pier than for deep foundation options. | • Temporary protection systems required along edges of Highway 401 between WB and EB core lanes, between WB Core and Collector lanes, as well as along Markham Road.<br>• Lower bearing geotechnical resistances compared to deep foundation options.<br>• Excavations may extend below the groundwater level; however, it is expected that water inflow from granular zones of fill, or present within the native material, can be handled by pumping from well filtered sumps located outside the foundation footprint. | • Conventional excavation and construction techniques. | • Lower relative cost than deep foundations. |
| Steel H-piles founded within "100-blow" material | Feasible for support of the abutments and pier; requires temporary protection for staged construction. | • Abutment pile caps could be maintained higher than footings founded on native soils, slightly reducing excavation depth and associated protection system requirements.<br>• Allows for integral abutment construction; although the existing shallow foundations will not be replaced, only rehabilitated to a semi-integral abutment configuration. | • Temporary protection systems will be required along edges of Highway 401 WB Core and Collector lanes to facilitate excavation to pile cap level and would may be required along Markham Road.<br>• Pre-augering into the "100-blow" soils may be required to achieve the required pile lengths.<br>• Risk of encountering obstructions that could impact pile installation.<br>• Larger/specialized equipment required for installation of piles than for construction of shallow foundations. | • Conventional construction methods for driven piles; augering into the "100-blow" material may be required to achieve minimum pile lengths. | • Estimated cost is approximately \$250/m length for pile installation and \$600/m3 for pile cap construction; the cost may be higher to account for pre-augering and for temporary liners.<br>• Potentially less costly maintenance over life of the structure than semi-integral abutment structures; however, only for the widened portion of the structure. |
| Drilled shafts founded within "100-blow" material | Feasible for support of abutments and pier. | • Higher bearing resistances than for shallow foundation or steel H-pile foundations, requiring fewer elements.<br>• Pile cap can be constructed at underside of superstructure eliminating need for excavation at Markham Road grade. | • Temporary liners would be required during construction to control potential ground losses in the non-cohesive soils and to mitigate for groundwater seepage.<br>• Cleaning of the base below the water table could be difficult.<br>• Concrete would have to be placed by tremie methods below the water level. | • Conventional construction methods for drilled shaft foundations; temporary liners required for ground and groundwater control. | • Estimated cost is approximately \$1000/m length for caisson installation and \$600/m3 for pile cap construction (if pile caps are adopted at the pier); this cost expected to be higher to account for temporary liners. |




PLAN

SCALE 10 0 10 20 m

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

CONT No.
GWP No. 2162-11-00

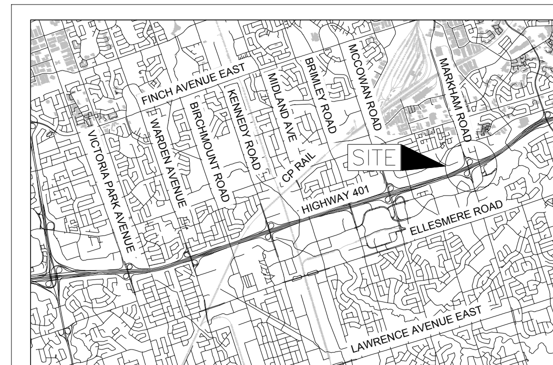
SHEET

# MARKHAM ROAD OVERPASS

HIGHWAY 401 WESTBOUND CORE AND COLLECTORS

## BOREHOLE LOCATIONS

GOLDER




KEY PLAN

SCALE 1.5 0 1.5 3 km

## LEGEND

- Borehole – Current Investigation
- Borehole – 1967 Investigation (GEOCRES No. 30M14-32 and 30M14-338)

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| 32-1 | 157.7 | 4849502.2 | 326139.3 |
| 32-2 | 157.4 | 4849511.6 | 326117.1 |
| 32-3 | 157.3 | 4849489.1 | 326104.6 |
| 32-4 | 158.5 | 4849574.8 | 326078.3 |
| 32-5 | 158.1 | 4849566.6 | 326099.6 |
| 32-6 | 160.2 | 4849588.9 | 326113.2 |
| 2011-05 | 163.5 | 4849605.9 | 326125.8 |
| MR-01 | 164.1 | 4849575.3 | 326129.5 |
| MR-02 | 158.5 | 4849598.6 | 326094.3 |
| MR-03 | 164.8 | 4849545.6 | 326074.8 |
| MR-04 | 162.3 | 4849610.9 | 326041.6 |

## 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.

## REFERENCE

Base plan provided in digital format by WSP, drawings files no. H17M-01449-00_XA01.dwg, No.H17M-01449-00_XB01.dwg and H17M-01449-00_XY01.dwg, received October 26, 2017.
Design Layout provided in digital format by WSP, drawing file no. H17M-01449-00_XN01.dwg, received November 28, 2017.
Existing ground contours provided in digital format by WSP, drawing file no. Contours Sept. 12, 2019.dwg, received September 12, 2018.
General Arrangement provided in digital format by WSP, drawing file no. S17M-01449-00-306-001GA.dwg, received June 5, 2018.

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 Jan. 14, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA Jan. 14, 2019 PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|

Geocres No. 30M14-484

| | | | |
|---|---|---|---|
| HWY. 401 | PROJECT NO. 1669995 | | DIST. |
| SUBM'D. NK | CHKD. NK | DATE: 12/12/2018 | SITE: 37-218 |
| DRAWN: DD | CHKD. MK | APPD. JMAC | DWG. 1 |

PLOT DATE: January 15, 2019
FILENAME: S:\Clients\MTO\Hwy_401\99_PROJ\1669995_WBL\40_PROJ\0005_Markham_Rd_Overpass\1669995-0005-BD-0001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

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

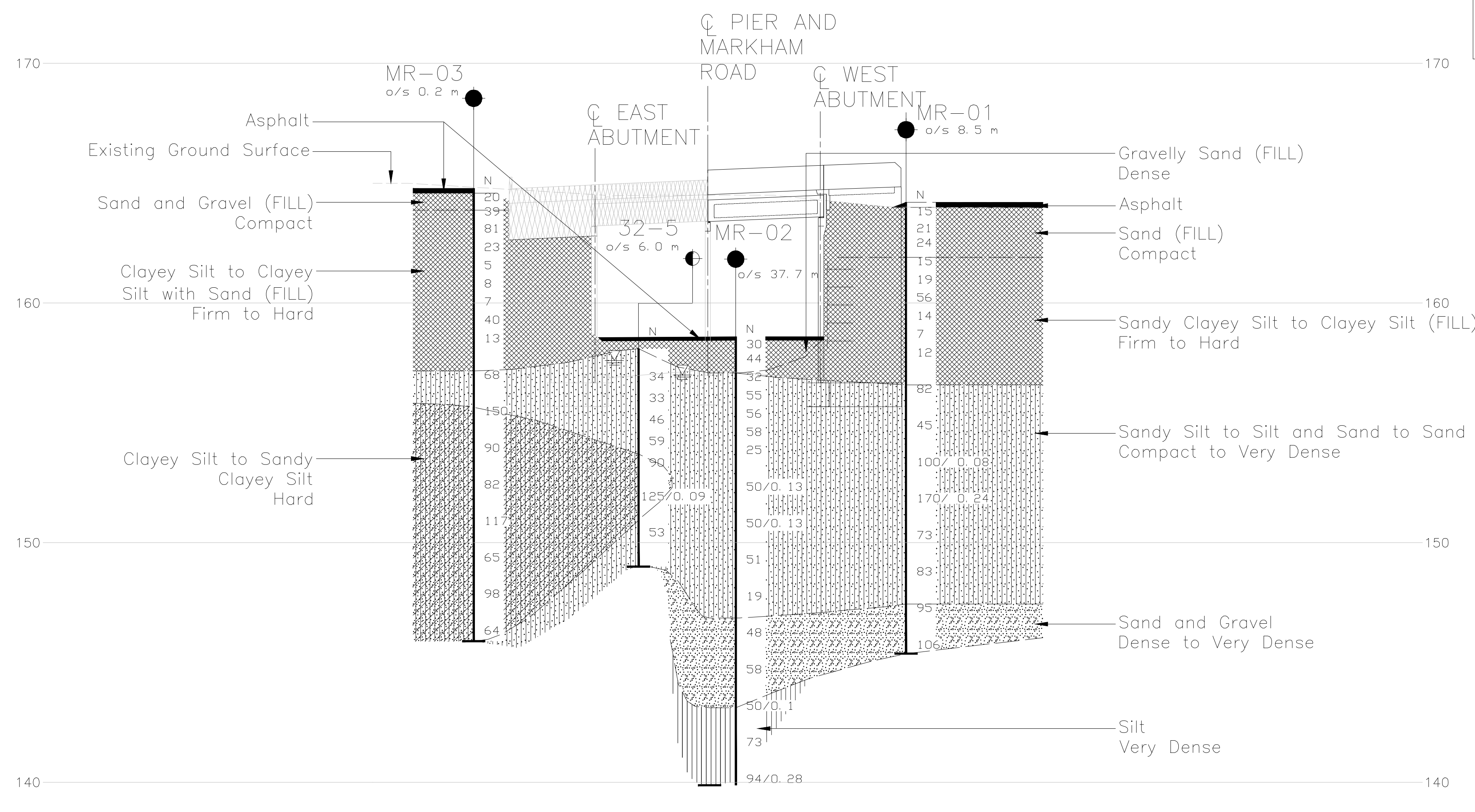
CONT No.
GWP No. 2162-11-00

MARKHAM ROAD OVERPASS
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS

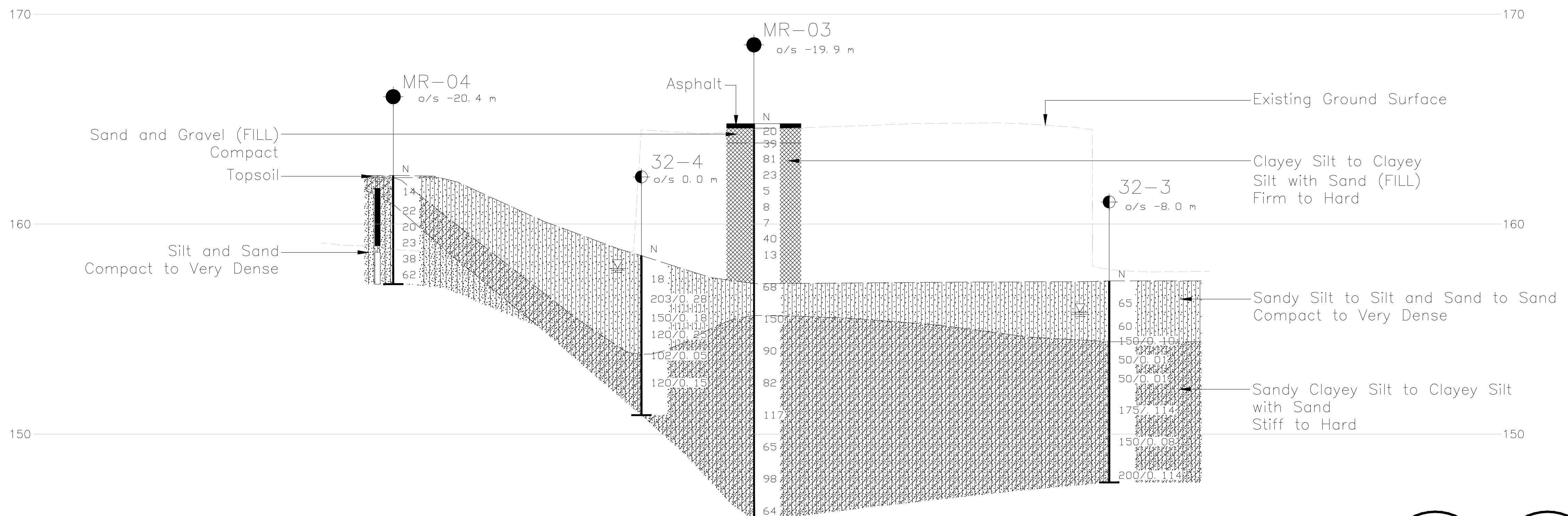
SOIL STRATA

SHEET

GOLDER



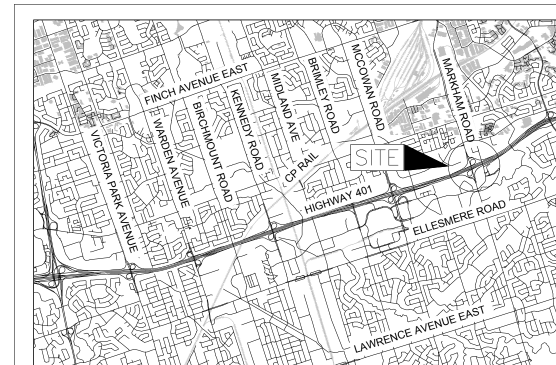

(A-A / 1) HIGHWAY 401 CENTRELINE PROFILE




(B-B / 1) CROSS-SECTION — WEST ABUTMENT

HORIZONTAL SCALE
10 0 10 20 m

SCALE
2.5 0 2.5 5 m




KEY PLAN
SCALE
1.5 0 1.5 3 km

## LEGEND

| | |
|---|---|
| ● | Borehole – Current Investigation |
| ◐ | Borehole – 1967 Investigation (GEOCRES No. 30M14-32 and 30M14-338) |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow) |
| ▼ | WL in piezometer, measured on June 30, 2018 |
| ▽ | WL upon completion of drilling |

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| 32-3 | 157.3 | 4849489.1 | 326104.6 |
| 32-4 | 158.5 | 4849574.8 | 326078.3 |
| 32-5 | 158.1 | 4849566.6 | 326099.6 |
| MR-01 | 164.1 | 4849575.3 | 326129.5 |
| MR-02 | 158.5 | 4849598.6 | 326094.3 |
| MR-03 | 164.8 | 4849545.6 | 326074.8 |
| MR-04 | 162.3 | 4849610.9 | 326041.6 |

## 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.

## REFERENCE

Base plan provided in digital format by WSP, drawings files no. H17M-01449-00_XA01.dwg, No.H17M-01449-00_XB01.dwg and H17M-01449-00_XY01.dwg, received October 26, 2017.
Design Layout provided in digital format by WSP, drawing file no. H17M-01449-00_XN01.dwg, received November 28, 2017.
Existing ground contours provided in digital format by WSP, drawing file no. Contours Sept. 12, 2019.dwg, received September 12, 2018.
General Arrangement provided in digital format by WSP, drawing file no. S17M-01449-00-306-001GA.dwg, received June 5, 2018.

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 Jan. 14, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA Jan. 14, 2019 PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|

Geocres No. 30M14-484

| | | | |
|---|---|---|---|
| HWY. 401 | PROJECT NO. 1669995 | | DIST. |
| SUBM'D. NK | CHKD. NK | DATE: 12/12/2018 | SITE: 37-218 |
| DRAWN: DD | CHKD. MK | APPD. JMAC | DWG. 2 |

PLOT DATE: January 15, 2019
FILENAME: S:\Clients\MTO\Hwy_401\99_PROJ\1669995_WB_L40_PROJ\0005_Markham_Rd_Overpass\1669995-0005-RD-0002.dwg

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

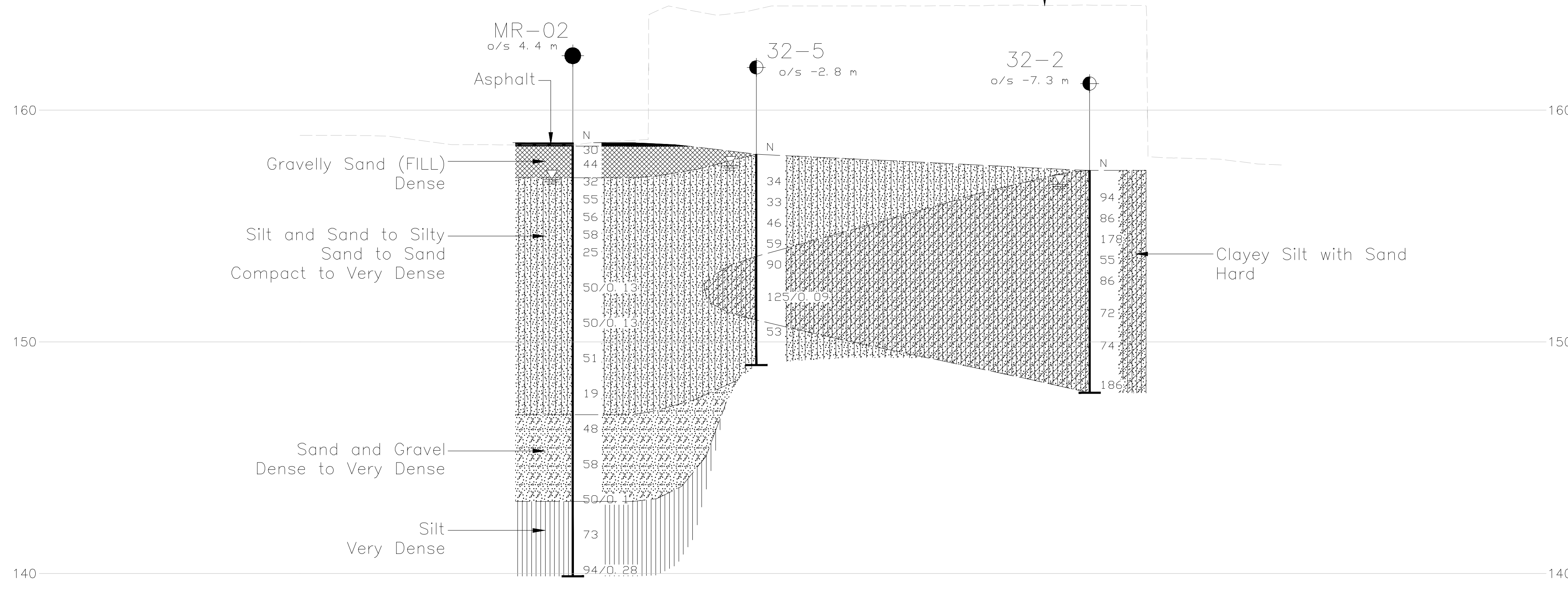
CONT No.
GWP No. 2162–11–00

# MARKHAM ROAD OVERPASS
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS

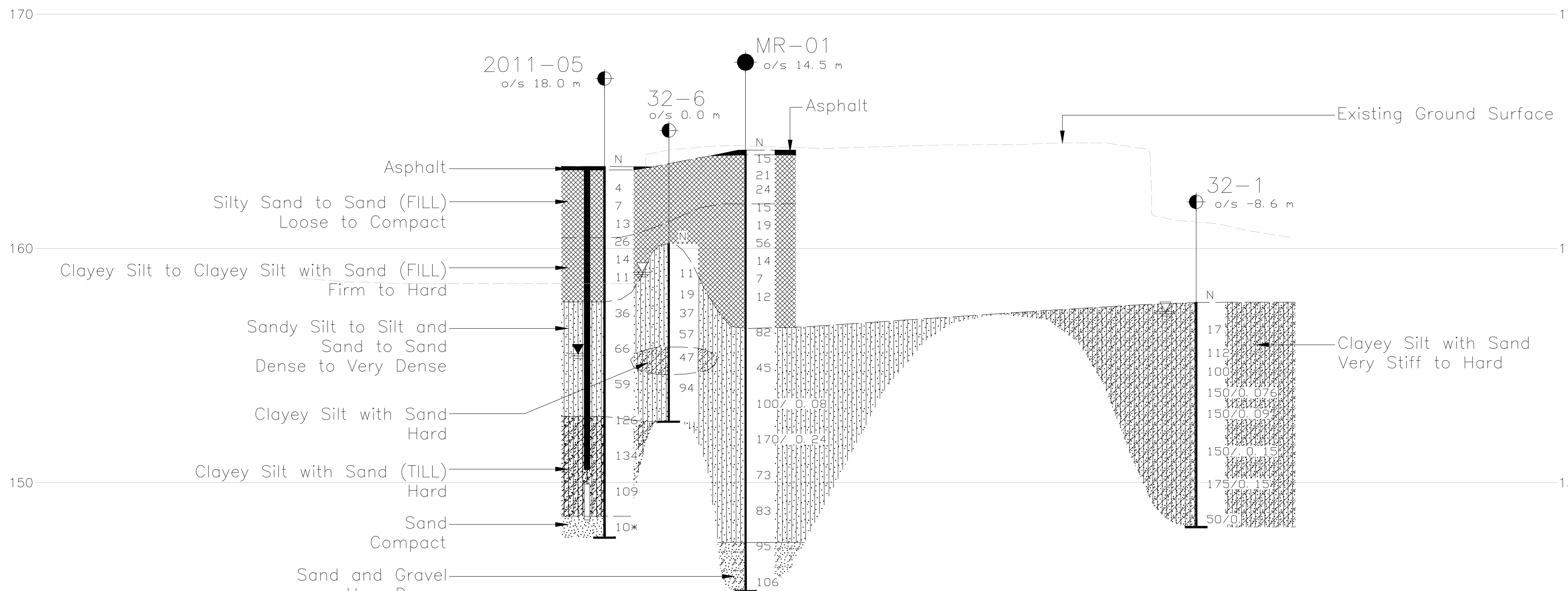
## SOIL STRATA

SHEET

GOLDER



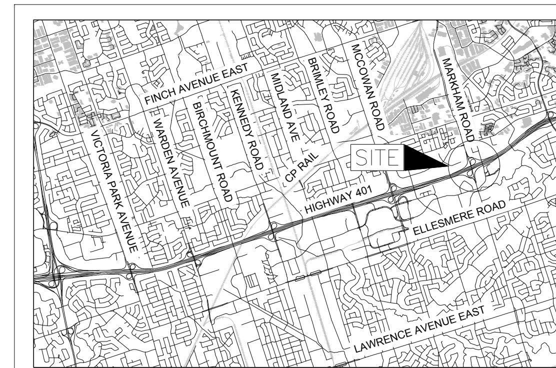

C–C
1
CROSS–SECTION – CENTER PIER




D–D
1
CROSS–SECTION – EAST ABUTMENT

HORIZONTAL SCALE
10 0 10 20 m

SCALE
2.5 0 2.5 5 m




KEY PLAN
SCALE
1.5 0 1.5 3 km

## LEGEND

- Borehole – Current Investigation
- Borehole – 1967 Investigation (GEOCRES No. 30M14–32 and 30M14–338)
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- WL in piezometer

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| 32–1 | 157.7 | 4849502.2 | 326139.3 |
| 32–2 | 157.4 | 4849511.6 | 326117.1 |
| 32–5 | 158.1 | 4849566.6 | 326099.6 |
| 32–6 | 160.2 | 4849588.9 | 326113.2 |
| 2011–05 | 163.5 | 4849605.9 | 326125.8 |
| MR–01 | 164.1 | 4849575.3 | 326129.5 |
| MR–02 | 158.5 | 4849598.6 | 326094.3 |

## 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.

## REFERENCE

Base plan provided in digital format by WSP, drawings files no. H17M–01449–00_XA01.dwg, No.H17M–01449–00_XB01.dwg and H17M–01449–00_XY01.dwg, received October 26, 2017.
Design Layout provided in digital format by WSP, drawing file no. H17M–01449–00_XN01.dwg, received November 28, 2017.
Existing ground contours provided in digital format by WSP, drawing file no. Contours Sept. 12, 2019.dwg, received September 12, 2018.
General Arrangement provided in digital format by WSP, drawing file no. S17M–01449–00–306–001GA.dwg, received June 5, 2018.

LICENSED PROFESSIONAL ENGINEER
N. KOCHMAN
100117863
Jan. 14, 2019
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J.M.A.COSTA
Jan. 14, 2019
PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|
| | | | |

Geocres No. 30M14–484

| | | | |
|---|---|---|---|
| HWY. 401 | PROJECT NO. 1669995 | | DIST. |
| SUBM'D. NK | CHKD. NK | DATE: 12/12/2018 | SITE: 37–218 |
| DRAWN: DD | CHKD. MK | APPD. JMAC | DWG. 3 |

**APPENDIX A**

# Borehole Records from 1967 and 2011 Investigations (GEOCRES No. 30M14-32 and 30M14-338)

Golder Associates

# RECORD OF BOREHOLE No 2011-05

 **METRIC**

PROJECT 09-1111-6055
G.W.P. 07-20012 LOCATION N 4849605.9 ;E 326125.8 ORIGINATED BY SB
DIST Central HWY 401 BOREHOLE TYPE CME 55 Track-mount, 108 mm Inner Diameter Hollow Stem Augers COMPILED BY MAS
DATUM Geodetic DATE April 11, 2011 CHECKED BY LCC

| ELEV / DEPTH (m) | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | WATER CONTENT (%) | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 163.5 | GROUND SURFACE | | | | | |
| 0.0 | TOPSOIL | | | | | |
| 0.2 | Silty sand, trace clay, trace gravel, containing organics (FILL) Loose to compact Brown to grey-brown Moist | 1 | SS | 4 | o | |
| | | 2 | SS | 7 | | |
| | | 3 | SS | 13 | o | |
| 160.5 / 3.1 | Clayey silt with sand, trace gravel, containing organics (FILL) Very stiff to stiff Grey Moist | 4 | SS | 26 | | |
| | | 5 | SS | 14 | o | 5 45 33 17 |
| | | 6 | SS | 11 | | |
| 157.7 / 5.8 | SAND and SILT, trace clay, trace gravel Dense to very dense Grey Moist | 7 | SS | 36 | | |
| | | 8 | SS | 66 | o | 0 42 49 9 |
| | Becoming wet below a depth of 9.1 m | 9 | SS | 59 | | |
| 152.8 / 10.7 | CLAYEY SILT with sand, trace gravel (TILL) Hard Grey Moist | 10 | SS | 126 | o | |
| | | 11 | SS | 134 | $w_P$–$w$–$w_L$ | 1 26 60 13 |
| | | 12 | SS | 109 | | |
| 148.6 | | | | | | |

Column headers: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED 20 40 60 80 100; PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Elevation scale: 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   $\bigcirc^{3\%}$ STRAIN AT FAILURE

Golder Associates



# RECORD OF BOREHOLE No 2011-05

 **METRIC**

| | | | |
|---|---|---|---|
| PROJECT 09-1111-6055 | | | |
| G.W.P. 07-20012 | LOCATION N 4849605.9 ;E 326125.8 | | ORIGINATED BY SB |
| DIST Central | HWY 401 | BOREHOLE TYPE CME 55 Track-mount, 108 mm Inner Diameter Hollow Stem Augers | COMPILED BY MAS |
| DATUM Geodetic | DATE April 11, 2011 | | CHECKED BY LCC |

| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$; WATER CONTENT (%) (10 20 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | |
| 14.9 | SAND, some gravel, trace silt<br>Compact<br>Brown<br>Wet | | 13 | SS | 10* | | 148 | | o | | |
| 147.7<br>15.9 | END OF BOREHOLE | | | | | | | | | | |

NOTES:

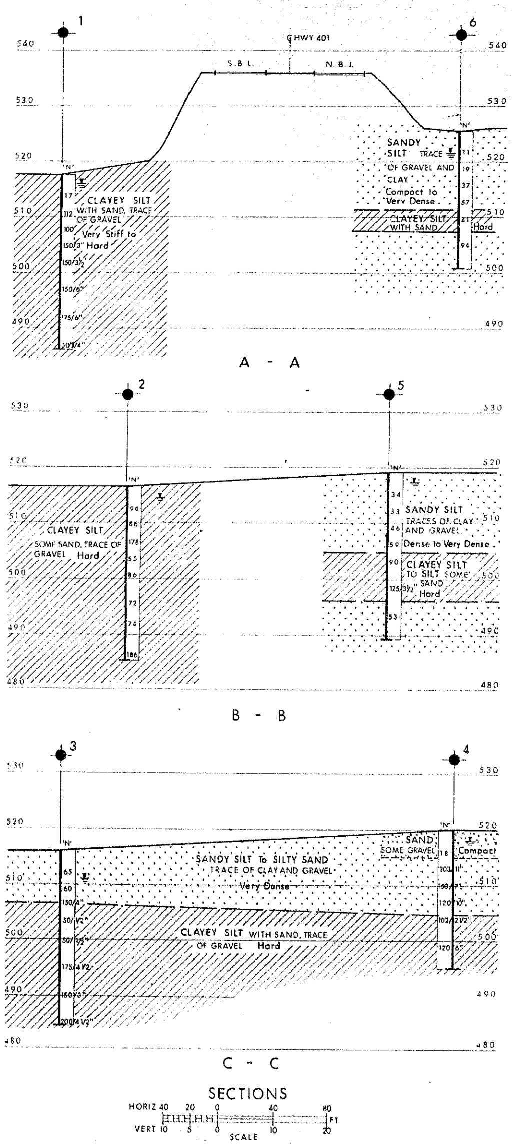
* SPT "N" value considered to have been affected by sample disturbance due to groundwater inflow to borehole.

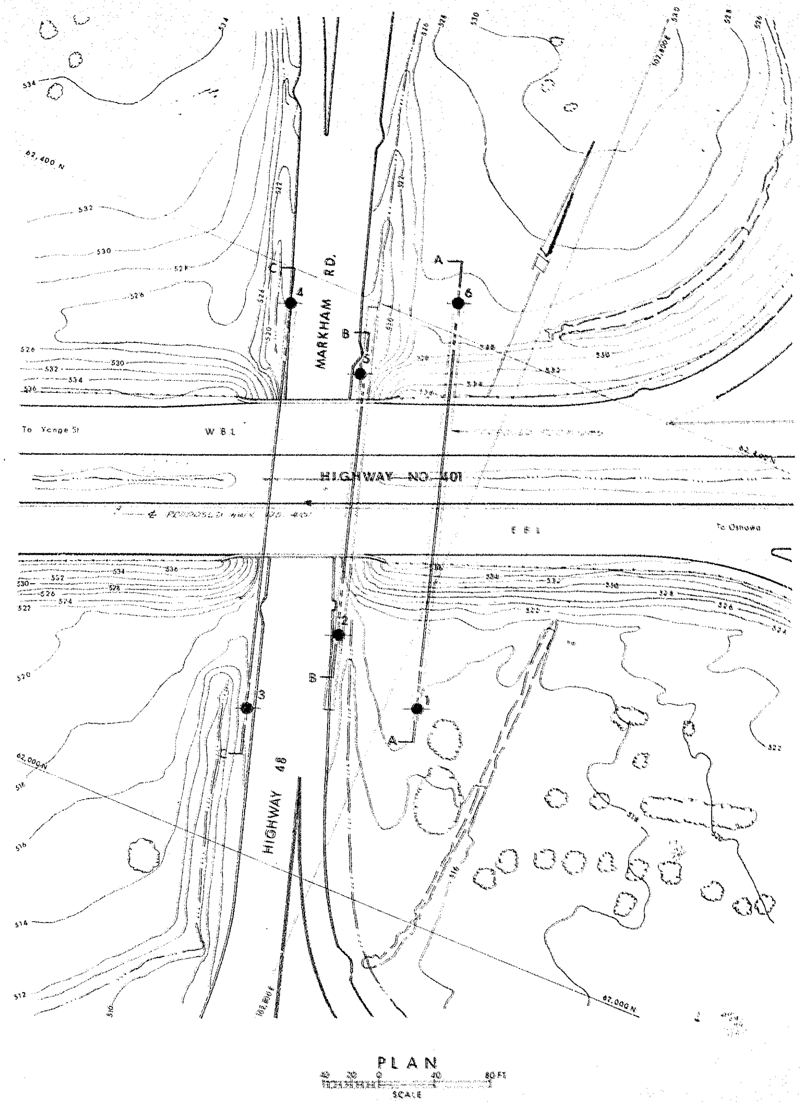
1. Water level in piezometer at a depth of 8.4 m (Elev. 155.1 m) on completion of installation.

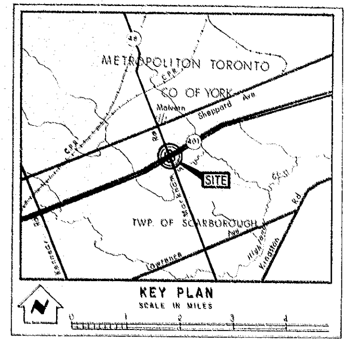
2. Water level in piezometer at a depth of 8.0 m (Elev. 155.5 m) on April 21, 2011.

GTA-MTO 001 09-1111-6055.GPJ GAL-MISS.GDT 11/7/11 SIB

$+^3, \times^3$: Numbers refer to Sensitivity    O $^{3\%}$ STRAIN AT FAILURE




## LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation. MAY 1967

| NO. | ELEVATION | CO-ORDINATES NORTH | EAST |
|---|---|---|---|
| 1 | 517.5 | 62,143 | 102,822 |
| 2 | 516.4 | 62,170 | 102,750 |
| 3 | 516.0 | 62,098 | 102,710 |
| 4 | 520.0 | 62,377 | 102,628 |
| 5 | 518.7 | 62,370 | 102,694 |
| 6 | 525.5 | 62,422 | 102,470 |

**- NOTE -**

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

| PRINT RECORD | | |
|---|---|---|
| NO. | FOR | DATE |

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION - FOUNDATION SECTION

# MARKHAM ROAD

KING'S HIGHWAY NO. 401 DIST. NO. 6
CO. YORK METRO TORONTO
TWP. SCARBOROUGH LOT CON.

## BORE HOLE LOCATIONS & SOIL STRATA

| | | | |
|---|---|---|---|
| SUBM'D A.S. | CHECKED | W.P. NO. 262-61 | M.&T. DRAWING NO. 67-F-40A |
| DRAWN M.D. | CHECKED | JOB NO. 67-F-40 | |
| DATE 20 JUNE 1967 | | SITE NO. | BRIDGE DRAWING NO. |
| APPROVED PRINCIPAL FOUNDATION ENGINEER | | CONT. NO. | |

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 32-1

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

# RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 67-F-40
W.P. 262-61
DATUM Geodetic

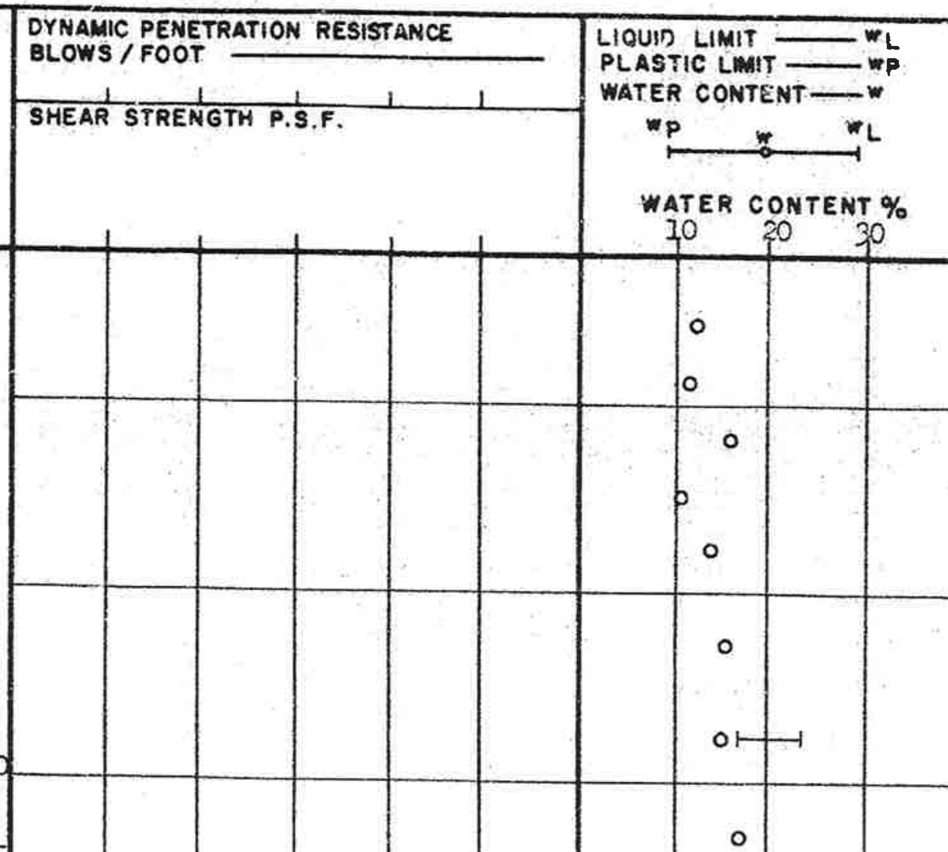
LOCATION Co-ordinates 62,143 N. 102,822 E.
BORING DATE May 15, 1967
BOREHOLE TYPE Continuous Flight Auger

ORIGINATED BY AMS
COMPILED BY AMS
CHECKED BY [signature]

| (m) | ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS / FOOT | ELEV. SCALE | BULK DENSITY γ P.C.F. | REMARKS Gr.Sa.Si.Cl |
|---|---|---|---|---|---|---|---|---|---|
| 157.7 | 517.5 | GROUND LEVEL | | | | | | | |
| | 0.0 | Clayey silt with sand and trace of gravel. | | | | | | | ▼516.0 |
| | | | | 1 | SS | 17 | | | |
| | | | | 2 | SS | 112 | 510 | | 0 25 62 13 |
| | | Very Stiff to Hard | | 3 | SS | 100 | | | |
| | | | | 4 | SS | 150/3" | | | |
| | | | | 5 | SS | 150/3½" | 500 | | |
| | | | | 6 | SS | 150/6" | | | |
| | | | | 7 | SS | 175/6" | 490 | | |
| 148.1 | 486.0 | | | 8 | SS | 50/¾" | | | |
| 9.6 | 31.5 | End of Borehole | | | | | | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F.

LIQUID LIMIT — $w_L$
PLASTIC LIMIT — $w_P$
WATER CONTENT — $w$



FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 32-2

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

# RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

JOB 67-F-40
W.P. 262-61
DATUM Geodetic

LOCATION Co-ordinates 62,170 N; 102,750 E.
BORING DATE May 15, 1967
BOREHOLE TYPE Continuous Flight Auger

ORIGINATED BY AMS
COMPILED BY AMS
CHECKED BY [illegible]

| (m) | ELEV. DEPTH | SOIL PROFILE DESCRIPTION | STRAT. PLOT | SAMPLES NUMBER | TYPE | BLOWS / FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. | LIQUID LIMIT $w_L$, PLASTIC LIMIT $w_P$, WATER CONTENT $w$ — WATER CONTENT % 10 20 30 | BULK DENSITY $\gamma$ P.C.F. | REMARKS Gr.Sa.Si.Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 157.4 | 516.4 | GROUND LEVEL | | | | | | | | | |
| | 0.0 | Clayey silt with some sand and trace of gravel. | | | | | | | | | ▽ 514.4 |
| | | | | 1 | SS | 94 | | | | | |
| | | | | 2 | SS | 86 | 510 | | | | 0 35 51 14 |
| | | | | 3 | SS | 178 | | | | | |
| | | | | 4 | SS | 55 | | | | | |
| | | Hard | | 5 | SS | 86 | 500 | | | | |
| | | | | 6 | SS | 72 | | | | | |
| | | | | 7 | SS | 74 | 490 | | | | 0 3 81 16 |
| 147.8 | 484.9 | | | 8 | SS | 186 | | | | | |
| 9.6 | 31.5 | End of Borehole | | | | | | | | | |

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 32-3

DEPARTMENT OF HIGHWAYS – ONTARIO

MATERIALS & TESTING DIVISION

# RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

JOB 67-F-40
W.P. 262-61
DATUM Geodetic

LOCATION CoOrdinates 62,098 N; 102,710 E.
BORING DATE May 16, 1967
BOREHOLE TYPE Continuous Flight Auger

ORIGINATED BY AMS
COMPILED BY AMS
CHECKED BY [signature]

| (m) | SOIL PROFILE ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | SAMPLES NUMBER | TYPE | BLOWS / FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. | LIQUID LIMIT $w_L$, PLASTIC LIMIT $w_P$, WATER CONTENT $w$; WATER CONTENT % (10, 20, 30) | BULK DENSITY $\gamma$ P.C.F. | REMARKS Gr.Sa.Si.Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 157.3 | 516.0 | GROUND LEVEL | | | | | | | | | |
| | 0.0 | Fine sandy silt to silty fine sand and trace of gravel. Very Dense. | | 1 | SS | 65 | | | | | 2 50 (48) ▼511.0 |
| | | | | | | | 510 | | | | |
| | | | | 2 | SS | 60 | | | | | |
| 154.4 / 2.9 | 506.5 / 9.5 | Clayey silt with sand and trace of gravel. Hard. | | 3 | SS | 150/4" | | | | | |
| | | | | 4 | SS | 50/½" | | | | | |
| | | | | 5 | SS | 50/½" | 500 | | | | 0 10 73 17 |
| | | | | 6 | SS | 175/4½" | | | | | |
| | | | | 7 | SS | 150/3" | 490 | | | | 0 24 59 17 |
| 147.7 / 9.6 | 484.5 / 31.5 | End of Borehole | | 8 | SS | 200/4½" | | | | | |

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 32-4

DEPARTMENT OF HIGHWAYS -- ONTARIO
MATERIALS & TESTING DIVISION

# RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 67-F-40
W.P. 262-61
DATUM Geodetic

LOCATION Co-ordinates 62,377 N; 102,628 E.
BORING DATE May 17, 1967
BOREHOLE TYPE Continuous Flight Auger

ORIGINATED BY AMS
COMPILED BY AMS
CHECKED BY [signature]

| (m) | ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS / FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. | WATER CONTENT % (10, 20, 30) | BULK DENSITY γ P.C.F. | REMARKS Gr.Sa.Si.Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 158.5 | 520.0 | GROUND LEVEL | | | | | | | | | |
| | 0.0 | Sand with some gravel | | | | | | | | | ▼518.6 |
| 157.0 | 515.0 | Compact | | 1 | SS | 18 | | | | | 19 75 ( 6) |
| 1.5 | 5.0 | Sandy silt to sand with traces of clay and gravel. | | 2 | SS | 203/11" | | | | | |
| | | | | 3 | SS | 150/7" | 510 | | | | 9 55 (36) |
| | | Very Dense. | | 4 | SS | 120/10" | | | | | |
| 153.8 | 504.5 | | | | | | | | | | |
| 4.7 | 15.5 | Clayey silt with sand & trace of gravel. | | 5 | SS | 102/2½" | | | | | |
| | | | | 6 | SS | 120/6" | 500 | | | | 0 26 59 15 |
| 150.9 | 495.0 | Hard | | | | | | | | | |
| 7.6 | 25.0 | End of Borehole | | | | | | | | | |

LIQUID LIMIT — $w_L$
PLASTIC LIMIT — $w_P$
WATER CONTENT — $w$

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 32-5

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

# RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 67-F-40
W.P. 262-61
DATUM Geodetic

LOCATION Co-ordinates 62,370 N; 102,694 E.
BORING DATE May 16, 1967
BOREHOLE TYPE Continuous Flight Auger

ORIGINATED BY AMS
COMPILED BY AMS
CHECKED BY [illegible]

| (m) | ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS / FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. | WATER CONTENT % (10, 20, 30) | BULK DENSITY γ P.C.F. | REMARKS Gr.Sa.Si.Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 158.1 | 518.7 | GROUND LEVEL | | | | | | | | | |
| | 0.0 | Fine sand with some silt and traces of clay and gravel. Dense to V.Dense. | | | | | | | | | ▼517.2 |
| | | | | 1 | SS | 34 | | | | | |
| | | | | 2 | SS | 33 | | | | | 1 36 54 9 |
| | | | | | | | 510 | | | | |
| | | | | 3 | SS | 46 | | | | | |
| 153.7 | 504.2 | | | 4 | SS | 59 | | | | | |
| 4.4 | 14.5 | Clayey silt to silt with some sand. Hard. | | 5 | SS | 90 | | | | | |
| | | | | | | | 500 | | | | |
| | | | | 6 | SS | 125/3½" | | | | | 0 29 56 15 |
| 150.9 | 495.2 | | | | | | | | | | |
| 7.2 | 23.5 | Fine sand Very dense | | 7 | SS | 53 | | | | | |
| | | | | | | | 490 | | | | |
| 149.0 | 488.7 | | | | | | | | | | |
| 9.1 | 30.0 | End of Borehole | | | | | | | | | |

LIQUID LIMIT —— $w_L$
PLASTIC LIMIT —— $w_P$
WATER CONTENT —— $w$

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 32-6

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

# RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 67-F-40
W.P. 262-61
DATUM Geodetic
LOCATION Co-ordinates 62,422N; 102,470 E.
BORING DATE May 16 & 17, 1967
BOREHOLE TYPE Continuous Flight Auger
ORIGINATED BY AMS
COMPILED BY AMS
CHECKED BY [illegible]

| (m) | ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | SAMPLE NUMBER | SAMPLE TYPE | BLOWS / FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. | WATER CONTENT % (10 20 30) | BULK DENSITY γ P.C.F. | REMARKS Gr.Sa.Si.Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 160.2 | 525.5 | GROUND LEVEL | | | | | | | | | |
| | 0.0 | Silty sand to sand, Traces of gravel & clay. Compact to V.Dense. | | 1 | SS | 11 | 520 | | | | ▼521.5 |
| | | | | 2 | SS | 19 | | | | | 2 44 45 9 |
| | | | | 3 | SS | 37 | | | | | |
| | | | | 4 | SS | 57 | | | | | |
| 155.8 / 4.4 | 511.0 / 14.5 | Clayey silt with sand. Hard. | | 5 | SS | 41 | 510 | | | | 0 35 55 10 |
| 154.5 / 5.6 | 507.0 / 18.5 | Fine sand. Very Dense. | | 6 | SS | 94 | | | | | |
| 152.6 / 7.6 | 500.5 / 25.0 | End of Borehole | | | | | | | | | |

**APPENDIX B**

# Borehole Records from 2018 Investigation

## 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 |
| $\upsilon$ | 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

**(a) Index Properties**

| | |
|---|---|
| $\rho(\gamma)$ | 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 |

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

**(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 |

**Notes:** 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (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, 60º 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 $cm^2$ 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**

| Compactness Condition | N 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 | $c_u$, $s_u$ 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[1] |
| CIU | consolidated isotropically undrained triaxial test with porewater pressure measurement[1] |
| $D_R$ | 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<br>Silty Clay with sand / Clayey Silt with sand |

GOLDER



# RECORD OF BOREHOLE No MR-01

SHEET 1 OF 2 **METRIC**

PROJECT 1669995

G.W.P. 2219-14-00 LOCATION N 4849575.3; E 326129.5 MTM NAD 83 ZONE 10 (LAT. 43.785903; LONG. -79.234968) ORIGINATED BY AB

DIST Central HWY 401 BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 165 mm O.D. Hollow Stem Augers COMPILED BY KAW

DATUM Geodetic DATE February 28 and March 1, 2018 CHECKED BY NK/LCC

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | WATER CONTENT (%) | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 164.1 | GROUND SURFACE | | | | | |
| 0.0 | ASPHALT (203 mm) | | | | | |
| 0.2 | Sand, some gravel, trace to some silt, trace clay (FILL) Compact Brown Moist | 1 | SS | 15 | | |
| | | 2 | SS | 21 | o | 19 72 7 2 |
| | | 3 | SS | 24 | | |
| 161.8 / 2.3 | Sandy clayey silt to clayey silt, some sand, trace to some gravel, trace organics below 5.3 m (FILL) Firm to hard Brown to grey Moist to wet - No recovery; gravel/cobble at tip of sampler in sample 5 | 4 | SS | 15 | o | |
| | | 5 | SS | 19 | | |
| | | 6 | SS | 56 | | |
| | | 7 | SS | 14 | o | |
| | - 50 mm thick layer of topsoil encountered at a depth of approximately 5.1 m | 8 | SS | 7 | wP–w–wL | |
| | - Grinding on inferred cobbles between depths of approximately 6.1 m and 6.4 m | 9 | SS | 12 | o | |
| 156.5 / 7.6 | Sandy SILT, some clay, trace gravel Very dense Grey Wet - Grinding between depths of approximately 7.6 m and 9.1 m | 10 | SS | 82 | | |
| 155.3 / 8.8 | SAND, some silt Dense Grey Wet | 11 | SS | 45 | o | 0 82 18 0 |
| 153.4 / 10.7 | Sandy SILT, trace to some clay Very dense Grey Wet | 12 | SS | 100/ 0.08 | o | 0 24 68 8 |
| | | 13 | SS | 170/ 0.24 | o | |
| 150.4 / 13.7 | SILT and SAND, some clay, trace gravel Very dense Grey Wet | 14 | SS | 73 | | |

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (164–150); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

# RECORD OF BOREHOLE No MR-01

SHEET 2 OF 2

**METRIC**

PROJECT 1669995

G.W.P. 2219-14-00

LOCATION N 4849575.3; E 326129.5 MTM NAD 83 ZONE 10 (LAT. 43.785903; LONG. -79.234968)

ORIGINATED BY AB

DIST Central HWY 401

BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 165 mm O.D. Hollow Stem Augers

COMPILED BY KAW

DATUM Geodetic

DATE February 28 and March 1, 2018

CHECKED BY NK/LCC

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | --- CONTINUED FROM PREVIOUS PAGE --- | | | | | | | | | | | |
| | SILT and SAND, some clay, trace gravel<br>Very dense<br>Grey<br>Wet | 15 | SS | 83 | | 149 / 148 | ○ | | 1 | 45 | 41 | 13 |
| 147.3 / 16.8 | SAND and GRAVEL, trace to some silt, trace clay<br>Very dense<br>Grey<br>Wet | 16 | SS | 95 | | 147 / 146 | | | | | | |
| | | 17 | SS | 106 | | | | | | | | |
| 145.3 / 18.8 | END OF BOREHOLE<br><br>NOTES:<br><br>1. Open borehole dry upon completion of drilling.<br><br>2. Borehole caved to a depth of approximately 6.4 m upon removal of augers. | | | | | | | | | | | |

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$; WATER CONTENT (%) 10 20 30; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

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

GOLDER



# RECORD OF BOREHOLE No MR-02

SHEET 1 OF 2 **METRIC**

PROJECT 1669995
G.W.P. 2219-14-00
LOCATION N 4849598.6; E 326094.3 MTM NAD 83 ZONE 10 (LAT. 43.785950; LONG. -79.235433)
ORIGINATED BY KG
DIST Central HWY 401
BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 203 mm O.D. Hollow Stem Augers
COMPILED BY SE
DATUM Geodetic
DATE May 7, 2018
CHECKED BY NK/LCC

| ELEV DEPTH | SOIL PROFILE DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | WATER CONTENT (%) | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 158.5 | GROUND SURFACE | | | | | | | |
| 0.0 | ASPHALT (150 mm) | | | | | | | |
| 0.2 | Gravelly sand, some silt (FILL) Dense Brown Moist | 1 | SS | 30 | | 158 | | |
| | | 2 | SS | 44 | | | | |
| 157.0 / 1.5 | SILT and SAND, trace to some gravel, trace to some clay Compact to very dense Grey Moist to wet below 3.8 m depth | 3 | SS | 32 | ▽ | 157 | ○ | 6 36 50 8 |
| | | 4 | SS | 55 | | 156 | | |
| | - 0.2 m clayey silt seam at 3.1 m depth | 5 | SS | 56 | | 155 | | |
| | | 6 | SS | 58 | | | ○ | 0 58 37 5 |
| | | 7 | SS | 25 | | 154 | | |
| | | 8 | SS | 50/0.13 | | 153, 152 | ○ | |
| | | 9 | SS | 50/0.13 | | 151, 150 | | |
| 149.4 / 9.1 | SAND, some silt, trace clay, trace gravel Compact to very dense Grey Wet | 10 | SS | 51 | | 149 | ○ | 1 81 15 3 |
| | | 11 | SS | 19 | | 148 | | |
| 146.8 / 11.7 | SAND and GRAVEL, trace to some silt, trace clay Dense to very dense Grey Wet | 12 | SS | 48 | | 147, 146 | | |
| | | 13 | SS | 58 | | 145, 144 | ○ | 36 53 10 1 |

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $W_L$; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

Continued Next Page

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

# RECORD OF BOREHOLE No MR-02



**METRIC**

PROJECT 1669995

G.W.P. 2219-14-00

LOCATION N 4849598.6; E 326094.3 MTM NAD 83 ZONE 10 (LAT. 43.785950; LONG. -79.235433)

ORIGINATED BY KG

DIST Central HWY 401

BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 203 mm O.D. Hollow Stem Augers

COMPILED BY SE

DATUM Geodetic

DATE May 7, 2018

CHECKED BY NK/LCC

--- CONTINUED FROM PREVIOUS PAGE ---

| ELEV DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT kN/m³ | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 14 | SS | 50/0.1 | | ~22 | | | | | |
| 143.0<br>15.5 | SILT, some sand, trace clay, trace gravel<br>Very dense<br>Grey<br>Wet | | | | 143 | | | | | | |
| | | | | | 142 | | | | | | |
| | | 15 | SS | 73 | | ~21 | NP | 1 | 14 | 84 | 1 |
| | | | | | 141 | | | | | | |
| 139.8<br>18.7 | END OF BOREHOLE | 16 | SS | 94/0.28 | 140 | ~20 | | | | | |

NOTE:

1. Water level measured in open borehole at a depth of 1.6 m below ground surface (Elev. 157.0 m) on completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED

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

GOLDER

# RECORD OF BOREHOLE No MR-03

SHEET 1 OF 2 **METRIC**

PROJECT 1669995
G.W.P. 2219-14-00
LOCATION N 4849545.6; E 326074.8 MTM NAD 83 ZONE 10 (LAT. 43.785591; LONG. -79.235760)
ORIGINATED BY AB
DIST Central HWY 401
BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 165 mm O.D. Hollow Stem Augers
COMPILED BY KAW
DATUM Geodetic
DATE March 4 and 5, 2018
CHECKED BY NK/LCC

| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$; WATER CONTENT (%) (10 20 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 164.8 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | ASPHALT (203 mm) | | | | | | | | | | |
| 0.2 | Sand and gravel, trace silt (FILL)<br>Compact<br>Brown<br>Moist | | 1 | SS | 20 | | 164 | | | | |
| 163.9<br>0.9 | Sandy clayey silt, trace gravel to gravelly (FILL)<br>Brown<br>Hard<br>Moist<br>- Grinding on inferred cobbles between depths of approximately 1.5 m and 2.1 m | | 2 | SS | 39 | | | | | | |
| | | | 3 | SS | 81 | | 163 | | | | |
| 162.5<br>2.3 | Clayey silt, some sand to clayey silt with sand, trace to some gravel, trace organics (FILL)<br>Firm to hard<br>Brown to grey<br>Moist | | 4 | SS | 23 | | 162 | | | | |
| | | | 5 | SS | 5 | | 161 | | | | |
| | | | 6 | SS | 8 | | | | | | 6 42 39 13 |
| | | | 7 | SS | 7 | | 160 | | | | |
| | - Grinding on inferred cobbles between depths of approximately 5.5 m and 6.1 m | | 8 | SS | 40 | | 159 | | | | |
| | | | 9 | SS | 13 | | 158 | | | | |
| 157.2<br>7.6 | SILT and SAND, trace to some clay, trace gravel<br>Very dense<br>Brown<br>Moist | | 10 | SS | 68 | | 157 | | | | 3 30 59 8 |
| | | | | | | | 156 | | | | |
| 155.7<br>9.1 | Sandy CLAYEY SILT<br>Hard<br>Grey<br>Moist | | 11 | SS | 150 | | 155 | | | | |
| | | | 12 | SS | 90 | | 154 | | | | |
| | | | 13 | SS | 82 | | 153<br>152 | | | | |
| | | | 14 | SS | 117 | | 151<br>150 | | | | 0 20 65 15 |

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity  O $^{3\%}$ STRAIN AT FAILURE

# RECORD OF BOREHOLE No MR-03

SHEET 2 OF 2 **METRIC**

PROJECT 1669995

G.W.P. 2219-14-00 LOCATION N 4849545.6; E 326074.8 MTM NAD 83 ZONE 10 (LAT. 43.785591; LONG. -79.235760) ORIGINATED BY AB

DIST Central HWY 401 BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 165 mm O.D. Hollow Stem Augers COMPILED BY KAW

DATUM Geodetic DATE March 4 and 5, 2018 CHECKED BY NK/LCC

| ELEV DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) |
|---|---|---|---|---|---|---|
| | --- CONTINUED FROM PREVIOUS PAGE --- | | | | | |
| | Sandy CLAYEY SILT<br>Hard<br>Grey<br>Moist | 15 | SS | 65 | | |
| | | | | | 149 | |
| | | | | | 148 | |
| | | 16 | SS | 98 | | o |
| | | | | | 147 | |
| | | 17 | SS | 64 | | o |
| 145.9<br>18.9 | END OF BOREHOLE | | | | 146 | |

NOTES:

1. Open borehole dry upon completion of drilling.

2. Borehole caved to a depth of approximately 16.8 m upon removal of augers.

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity  O $^{3\%}$ STRAIN AT FAILURE

GOLDER



# RECORD OF BOREHOLE No MR-04

SHEET 1 OF 1

**METRIC**

PROJECT 1669995

G.W.P. 2219-14-00

LOCATION N 4849610.9; E 326041.6 MTM NAD 83 ZONE 10 (LAT. 43.786164; LONG. -79.236086)

ORIGINATED BY MA

DIST Central HWY 401

BOREHOLE TYPE CME 55 Truck-Mounted Drill Rig, 152 mm O.D. Hollow Stem Augers

COMPILED BY SE

DATUM Geodetic

DATE June 5, 2018

CHECKED BY NK/LCC

| ELEV DEPTH | DESCRIPTION (SOIL PROFILE) | SAMPLE NUMBER | TYPE | "N" VALUES | WATER CONTENT (%) | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 162.3 | GROUND SURFACE | | | | | |
| 0.0 / 0.1 | TOPSOIL, trace organics, Compact, Brown, Moist | | | | | |
| | Sandy CLAYEY SILT, trace gravel, Stiff, Brown, Moist | 1 | SS | 14 | | |
| 160.9 / 1.4 | SILT and SAND, trace to some clay, trace gravel, seams of sand and of silt throughout, Compact to very dense, Brown, Moist | 2 | SS | 22 | o | |
| | | 3 | SS | 20 | o | 8 35 51 6 |
| | | 4A / 4B | SS | 23 | | |
| | | 5 | SS | 38 | o | 0 42 50 8 |
| | | 6 | SS | 62 | | |
| 157.1 / 5.2 | END OF BOREHOLE | | | | | |

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (162, 161, 160, 159, 158); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; STRAT PLOT.

NOTES:

1. Open borehole dry on completion of drilling.

2. Water level measured in piezometer as follow:

| Date | Depth (m) | Elev. (m) |
|---|---|---|
| Jun 05/18 | Dry | - |
| Jun 30/18 | Dry | - |

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

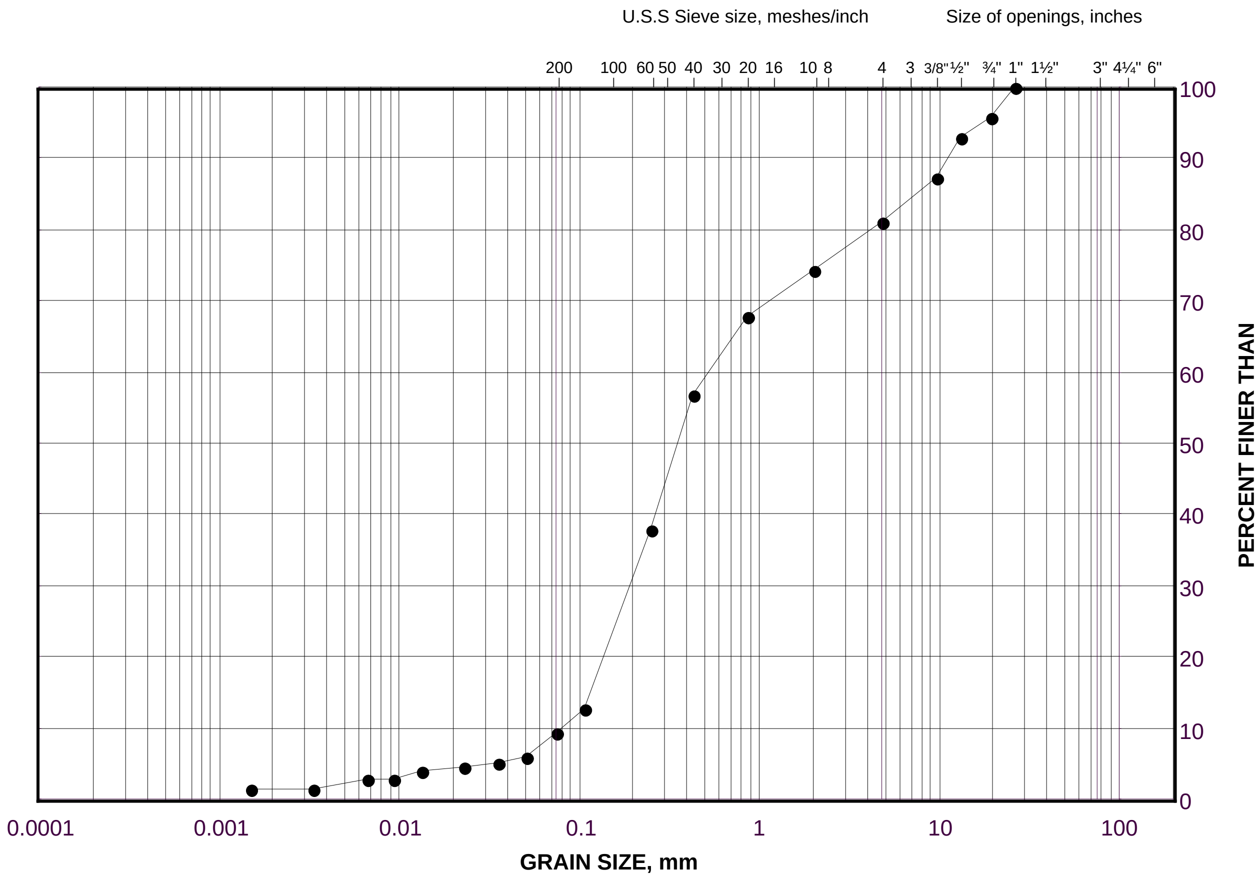
$\circ^{3\%}$ STRAIN AT FAILURE

**APPENDIX C**

# Geotechnical Laboratory Test Results

# GRAIN SIZE DISTRIBUTION
Sand (Fill)

FIGURE C-1




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

## LEGEND

| SYMBOL | Borehole | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | MR-01 | 2 | 162.8 |

Project Number: 1669995

Checked By: NK

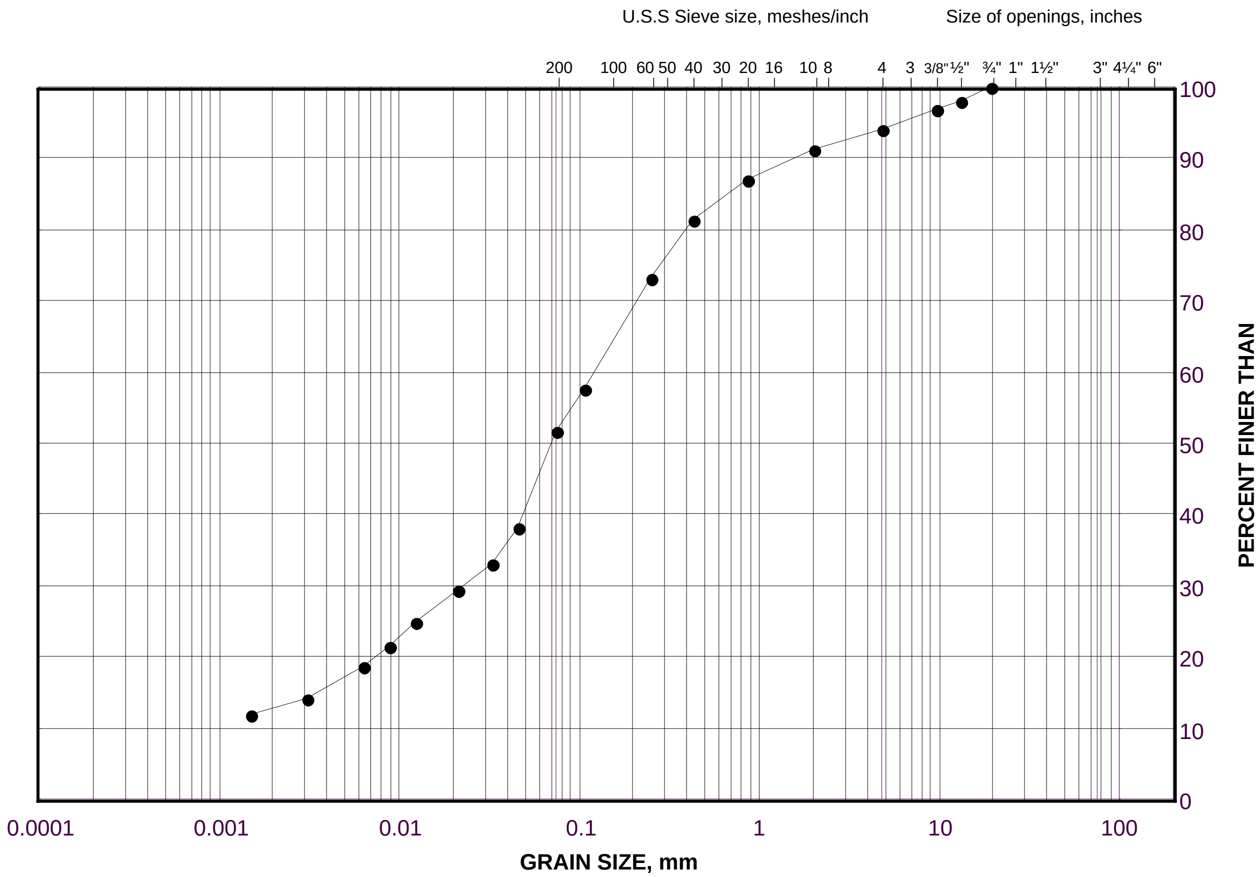
**Golder Associates**

Date: 15-Aug-18

# GRAIN SIZE DISTRIBUTION

Clayey Silt (Fill)

FIGURE C-2




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

## LEGEND

| SYMBOL | Borehole | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | MR-03 | 6 | 160.7 |

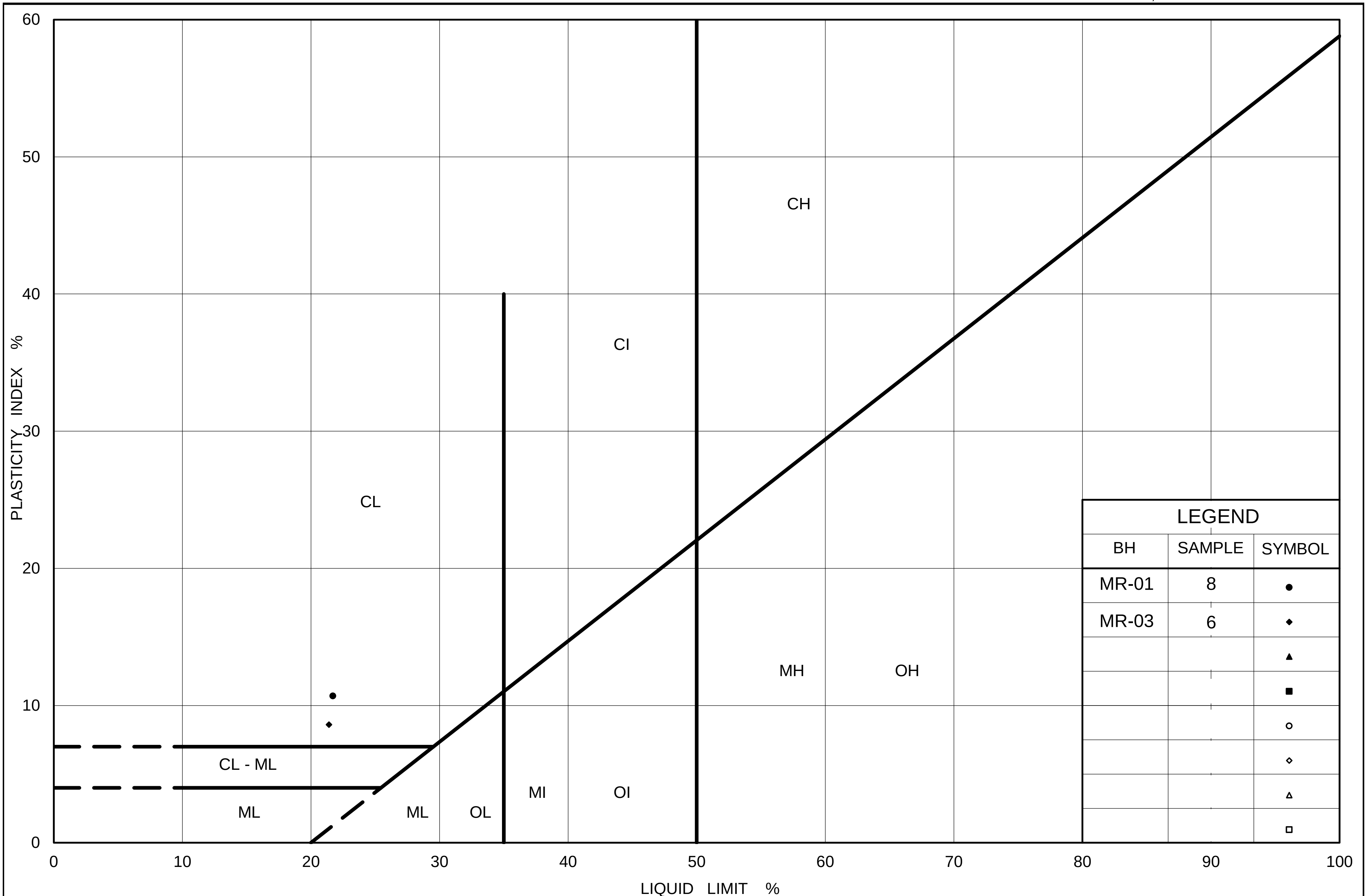
Project Number: 1669995

Checked By: NK

**Golder Associates**

Date: 15-Aug-18

Oct 75, FF-S-21




Ministry of Transportation

Ontario

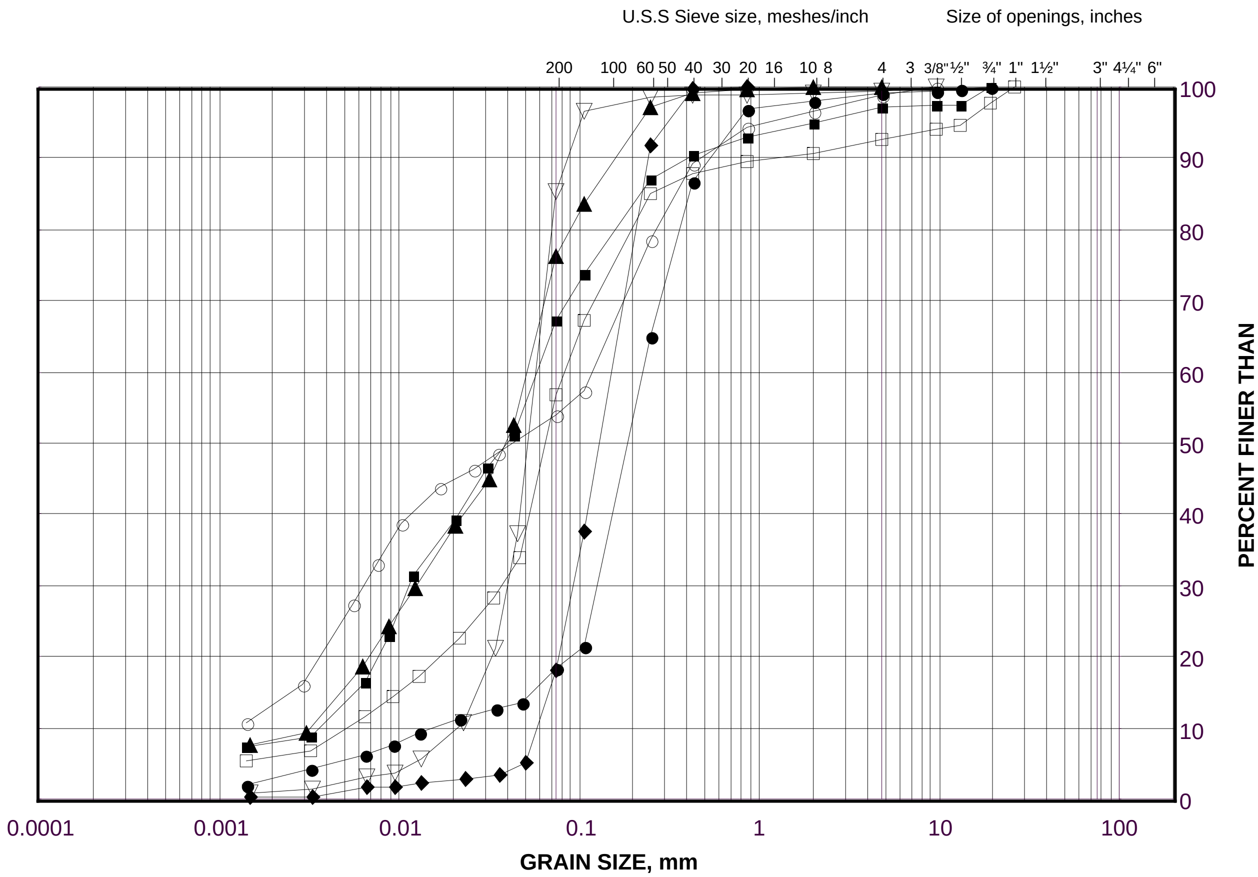
# PLASTICITY CHART
## Clayey Silt (Fill)

Figure No. C-3

Project No. 1669995

Checked By: NK

| GRAIN SIZE DISTRIBUTION<br>Silt to Sandy Silt to Silt and Sand to Sand | FIGURE C-4A |
|---|---|




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

## LEGEND

| SYMBOL | Borehole | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | MR-02 | 10 | 149.0 |
| ■ | MR-03 | 10 | 156.9 |
| ◆ | MR-01 | 11 | 154.7 |
| ▲ | MR-01 | 12 | 153.3 |
| ▽ | MR-02 | 15 | 141.5 |
| ❍ | MR-01 | 15 | 148.6 |
| ☐ | MR-04 | 3 | 159.8 |

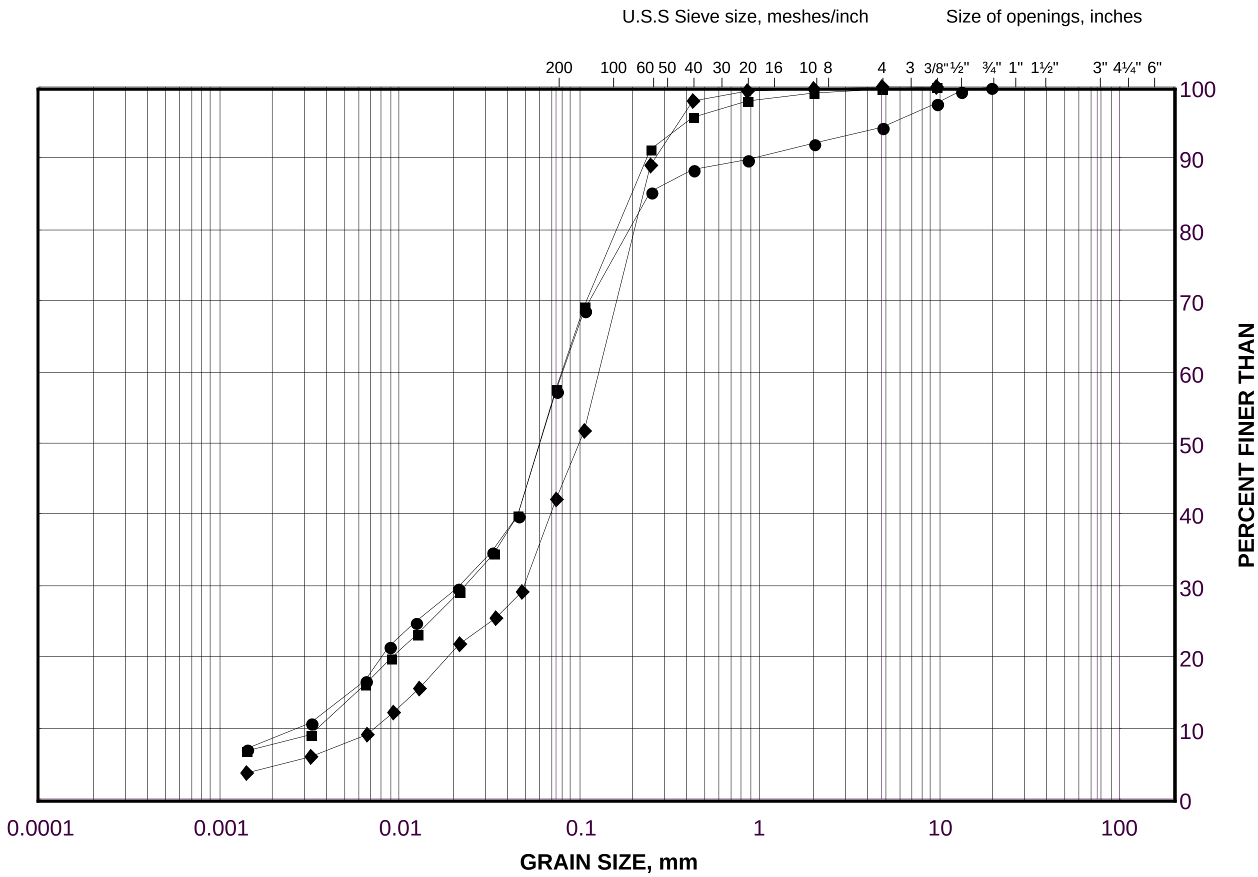
Project Number: 1669995

Checked By: NK

**Golder Associates**

Date: 15-Aug-18

| GRAIN SIZE DISTRIBUTION<br>Silt and Sand | FIGURE C-4B |
|---|---|




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

## LEGEND

| SYMBOL | Borehole | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | MR-02 | 3 | 156.7 |
| ■ | MR-04 | 5 | 158.3 |
| ◆ | MR-02 | 6 | 154.4 |

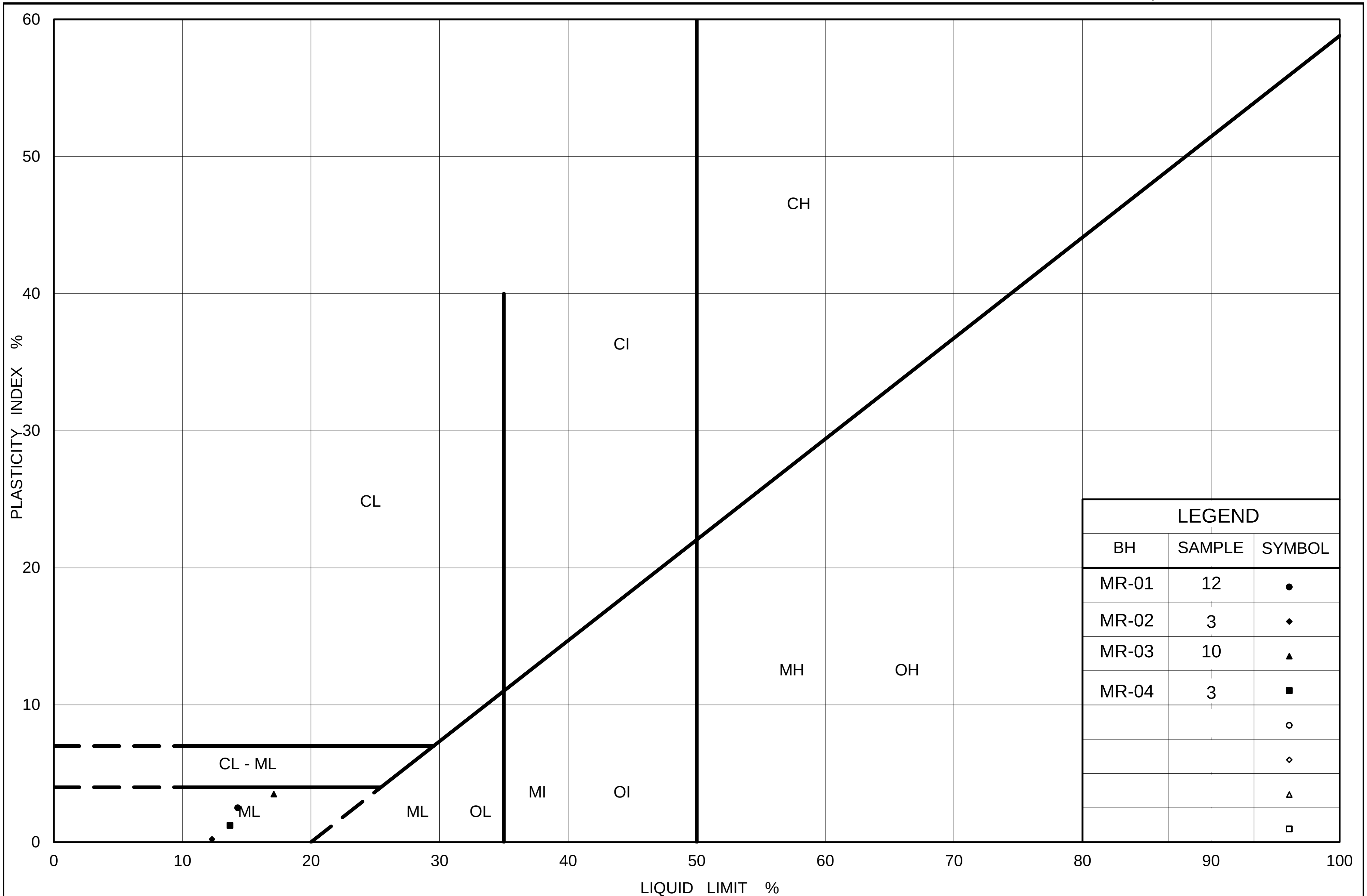
Project Number: 1669995

Checked By: NK

**Golder Associates**

Date: 15-Aug-18

Oct 75, FF-S-21




Ministry of Transportation

Ontario

# PLASTICITY CHART
## Sandy Silt to Silt and Sand

Figure No. C-5

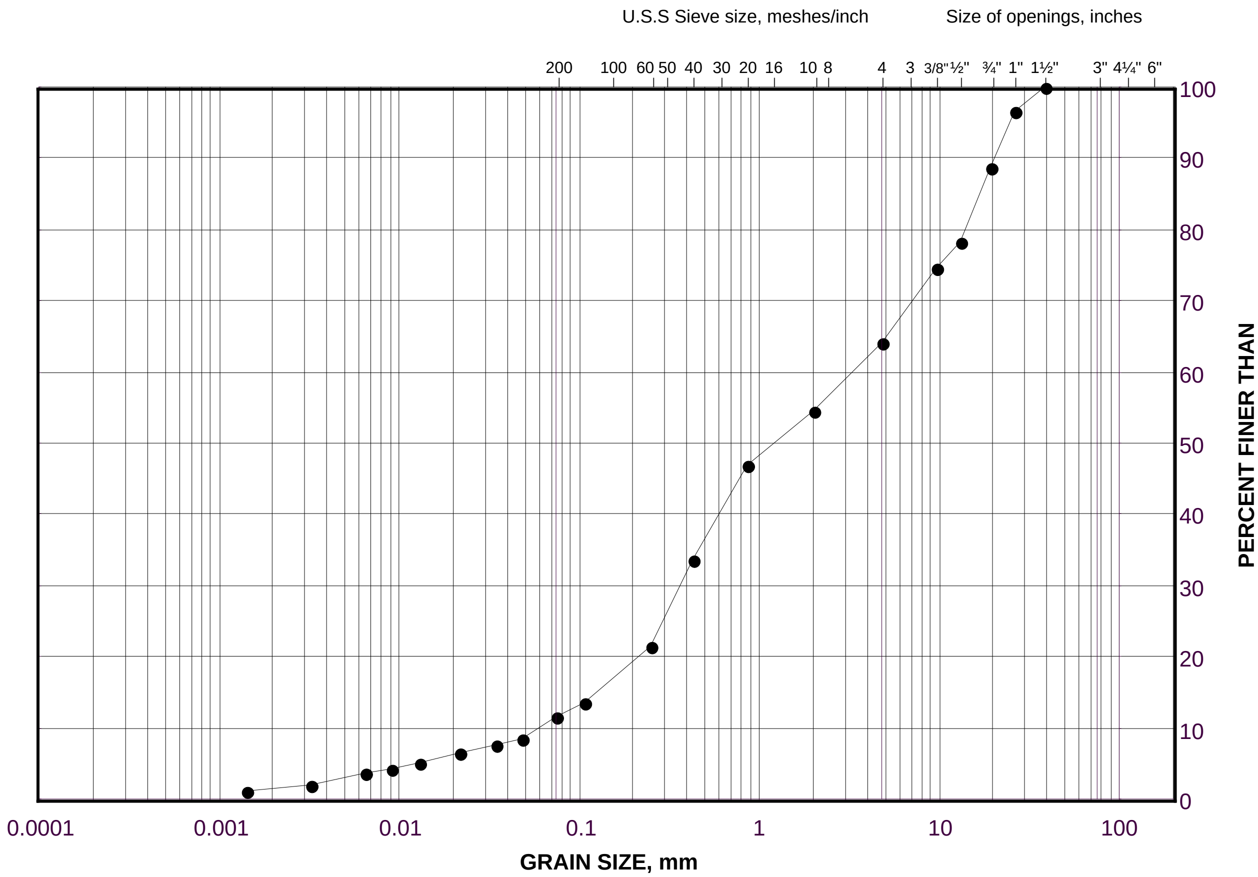
Project No. 1669995

Checked By: NK

# GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE C-6




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

## LEGEND

| SYMBOL | Borehole | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | MR-02 | 13 | 144.5 |

Project Number: 1669995

Checked By: NK

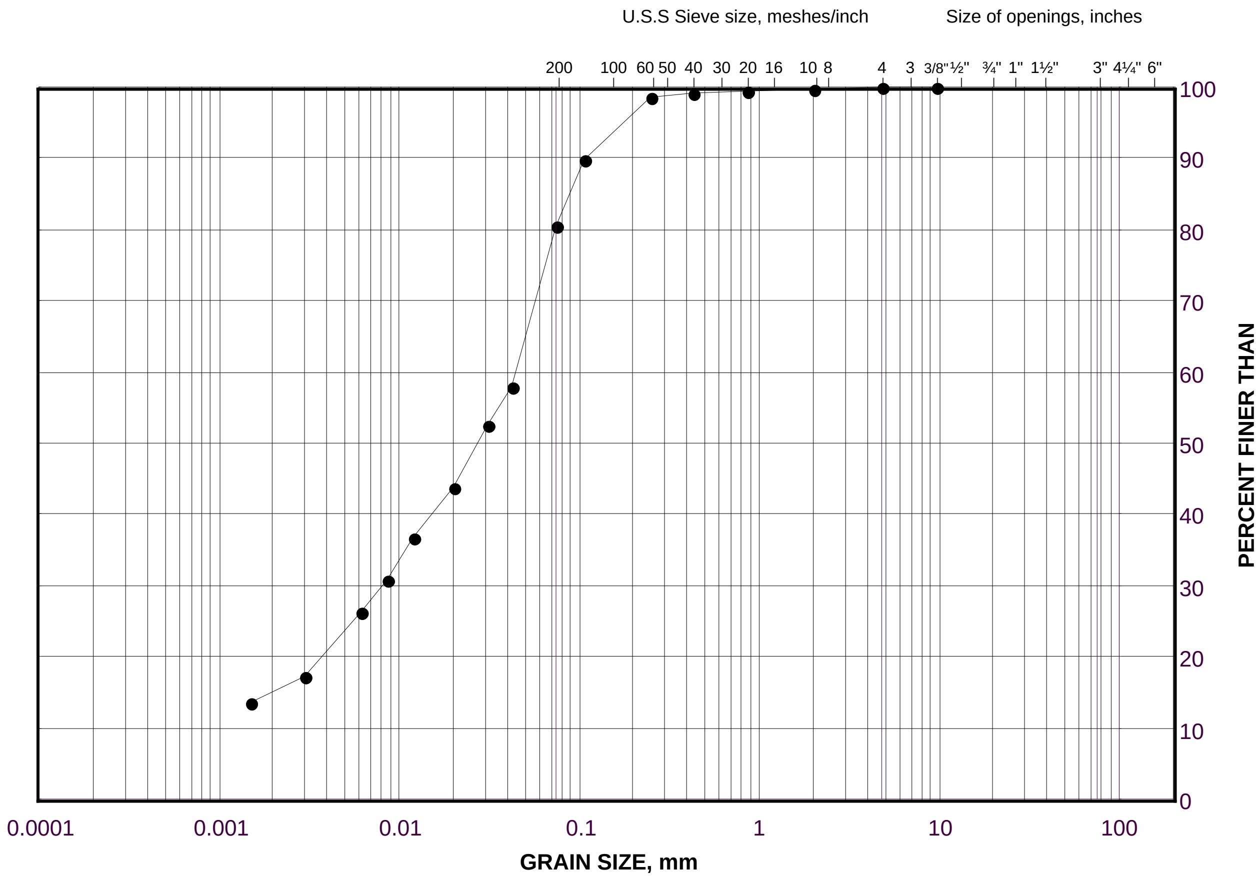
**Golder Associates**

Date: 15-Aug-18

# GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt

FIGURE C-7




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

## LEGEND

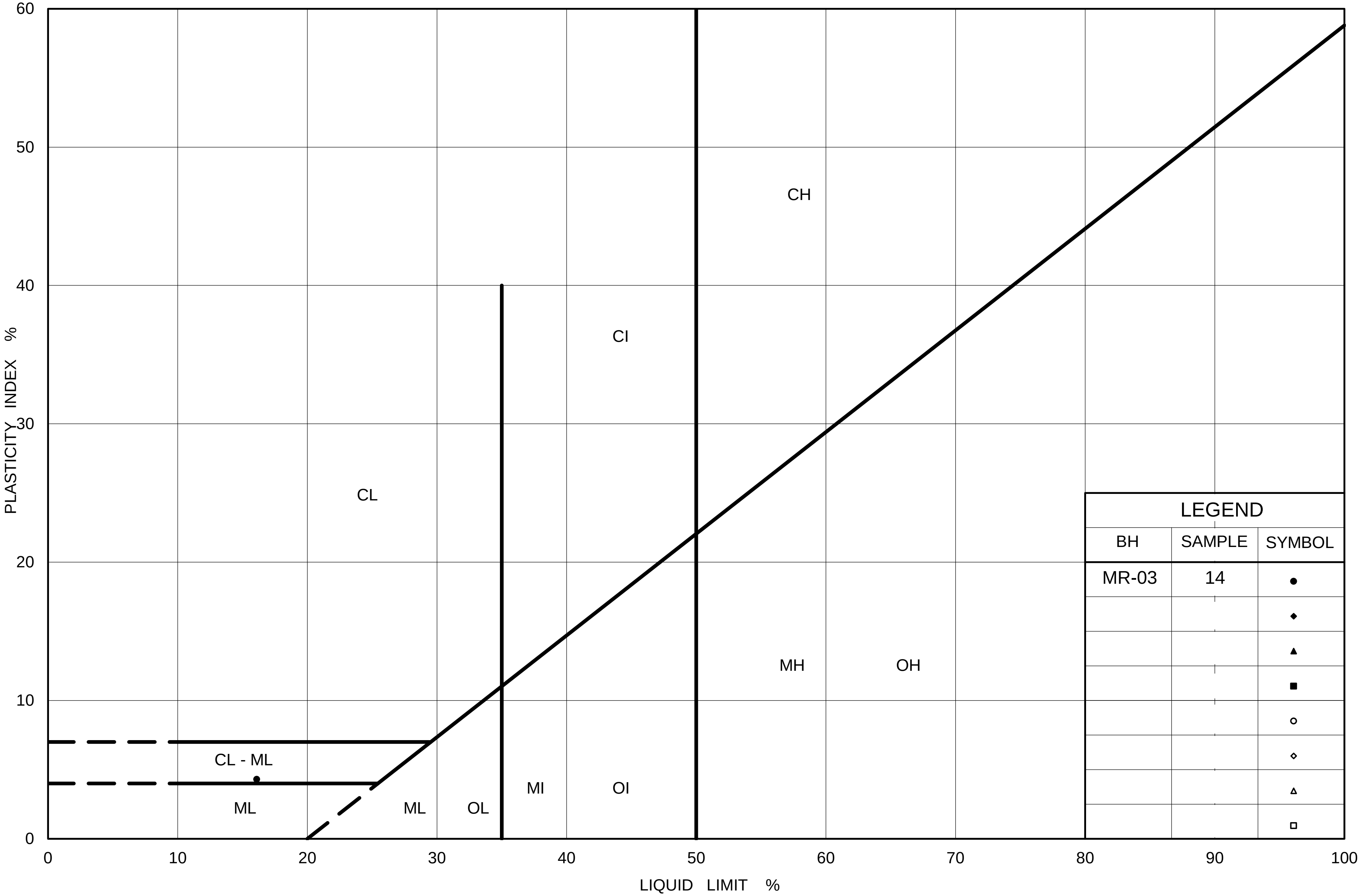
| SYMBOL | Borehole | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | MR-03 | 14 | 150.8 |

Project Number: 1669995

Checked By: NK

**Golder Associates**

Date: 15-Aug-18




Ministry of Transportation

Ontario

# PLASTICITY CHART
## Sandy Clayey Silt

Figure No. C-8

Project No. 1669995

Checked By: NK

**APPENDIX D**

# Analytical Laboratory Test Results

Your Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Your C.O.C. #: 105772

**Attention: Nikol Kochmanova**

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

**Report Date: 2018/03/26**
Report #: R5054991
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B862090**
**Received: 2018/03/20, 12:06**

Sample Matrix: Soil
# Samples Received: 4

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Reference |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | 4 | N/A | 2018/03/26 | CAM SOP-00463 | EPA 325.2 m |
| Conductivity | 4 | N/A | 2018/03/26 | CAM SOP-00414 | OMOE E3530 v1 m |
| pH CaCl2 EXTRACT | 4 | 2018/03/23 | 2018/03/23 | CAM SOP-00413 | EPA 9045 D m |
| Resistivity of Soil | 4 | 2018/03/20 | 2018/03/26 | CAM SOP-00414 | SM 23 2510 m |
| Sulphate (20:1 Extract) | 4 | N/A | 2018/03/26 | CAM SOP-00464 | EPA 375.4 m |

**Remarks:**

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Your Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Your C.O.C. #: 105772

**Attention: Nikol Kochmanova**

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

**Report Date: 2018/03/26**
Report #: R5054991
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B862090**
**Received: 2018/03/20, 12:06**

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
====================================================================
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B862090
Report Date: 2018/03/26

Golder Associates Ltd
Client Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Sampler Initials: AB

## SOIL CORROSIVITY PACKAGE (SOIL)

| **Maxxam ID** | | GHG238 | GHG239 | GHG240 | GHG241 | | | GHG241 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2018/02/21 | 2018/02/22 | 2018/02/13 | 2018/02/09 | | | 2018/02/09 | | |
| **COC Number** | | 105772 | 105772 | 105772 | 105772 | | | 105772 | | |
| | **UNITS** | **BR-02 SA#11** | **MA-02 SA#12** | **CP-02 SA#11** | **MR-03 SA#11** | **RDL** | **QC Batch** | **MR-03 SA#11 Lab-Dup** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | |
| Resistivity | ohm-cm | 1600 | 1100 | 1300 | 1200 | | 5448848 | | | |
| **Inorganics** | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 330 | 430 | 400 | 340 | 20 | 5453941 | 360 | 20 | 5453941 |
| Conductivity | umho/cm | 644 | 890 | 745 | 848 | 2 | 5454237 | | | |
| Available (CaCl2) pH | pH | 7.73 | 7.89 | 7.94 | 7.79 | | 5452380 | 7.86 | | 5452380 |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 140 | <20 | 260 | 20 | 5453942 | 270 | 20 | 5453942 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Maxxam Job #: B862090
Report Date: 2018/03/26

Golder Associates Ltd
Client Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Sampler Initials: AB

## TEST SUMMARY

**Maxxam ID:** GHG238
**Sample ID:** BR-02 SA#11
**Matrix:** Soil

**Collected:** 2018/02/21
**Shipped:**
**Received:** 2018/03/20

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5453941 | N/A | 2018/03/26 | Deonarine Ramnarine |
| Conductivity | AT | 5454237 | N/A | 2018/03/26 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5452380 | 2018/03/23 | 2018/03/23 | Neil Dassanayake |
| Resistivity of Soil | | 5448848 | 2018/03/26 | 2018/03/26 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5453942 | N/A | 2018/03/26 | Deonarine Ramnarine |

**Maxxam ID:** GHG239
**Sample ID:** MA-02 SA#12
**Matrix:** Soil

**Collected:** 2018/02/22
**Shipped:**
**Received:** 2018/03/20

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5453941 | N/A | 2018/03/26 | Deonarine Ramnarine |
| Conductivity | AT | 5454237 | N/A | 2018/03/26 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5452380 | 2018/03/23 | 2018/03/23 | Neil Dassanayake |
| Resistivity of Soil | | 5448848 | 2018/03/26 | 2018/03/26 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5453942 | N/A | 2018/03/26 | Deonarine Ramnarine |

**Maxxam ID:** GHG240
**Sample ID:** CP-02 SA#11
**Matrix:** Soil

**Collected:** 2018/02/13
**Shipped:**
**Received:** 2018/03/20

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5453941 | N/A | 2018/03/26 | Deonarine Ramnarine |
| Conductivity | AT | 5454237 | N/A | 2018/03/26 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5452380 | 2018/03/23 | 2018/03/23 | Neil Dassanayake |
| Resistivity of Soil | | 5448848 | 2018/03/26 | 2018/03/26 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5453942 | N/A | 2018/03/26 | Deonarine Ramnarine |

**Maxxam ID:** GHG241
**Sample ID:** MR-03 SA#11
**Matrix:** Soil

**Collected:** 2018/02/09
**Shipped:**
**Received:** 2018/03/20

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5453941 | N/A | 2018/03/26 | Deonarine Ramnarine |
| Conductivity | AT | 5454237 | N/A | 2018/03/26 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5452380 | 2018/03/23 | 2018/03/23 | Neil Dassanayake |
| Resistivity of Soil | | 5448848 | 2018/03/26 | 2018/03/26 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5453942 | N/A | 2018/03/26 | Deonarine Ramnarine |

**Maxxam ID:** GHG241 Dup
**Sample ID:** MR-03 SA#11
**Matrix:** Soil

**Collected:** 2018/02/09
**Shipped:**
**Received:** 2018/03/20

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5453941 | N/A | 2018/03/26 | Deonarine Ramnarine |



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B862090
Report Date: 2018/03/26

Golder Associates Ltd
Client Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Sampler Initials: AB

## TEST SUMMARY

**Maxxam ID:** GHG241 Dup
**Sample ID:** MR-03 SA#11
**Matrix:** Soil

**Collected:** 2018/02/09
**Shipped:**
**Received:** 2018/03/20

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| pH CaCl2 EXTRACT | AT | 5452380 | 2018/03/23 | 2018/03/23 | Neil Dassanayake |
| Sulphate (20:1 Extract) | KONE/EC | 5453942 | N/A | 2018/03/26 | Deonarine Ramnarine |

Maxxam Job #: B862090
Report Date: 2018/03/26

Golder Associates Ltd
Client Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Sampler Initials: AB

## GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

| | |
|---|---|
| Package 1 | 15.0°C |

**Results relate only to the items tested.**


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B862090
Report Date: 2018/03/26

# QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1669995
Site Location: HWY 401 W SCARBOROUGH
Sampler Initials: AB

| | | | Matrix Spike | | SPIKED BLANK | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | UNITS | Value (%) | QC Limits |
| 5452380 | Available (CaCl2) pH | 2018/03/23 | | | 100 | 97 - 103 | | | 0.86 | N/A |
| 5453941 | Soluble (20:1) Chloride (Cl) | 2018/03/26 | NC | 70 - 130 | 105 | 70 - 130 | <20 | ug/g | 7.9 | 35 |
| 5453942 | Soluble (20:1) Sulphate (SO4) | 2018/03/26 | NC | 70 - 130 | 100 | 70 - 130 | <20 | ug/g | 3.5 | 35 |
| 5454237 | Conductivity | 2018/03/26 | | | 98 | 90 - 110 | <2 | umho/cm | 0.099 | 10 |

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

## VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

CHARTERED
Eva Pranjic
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/3

# CHAIN OF CUSTODY RECORD 105772

Page 1 of 1

| Invoice Information | | Report Information (if differs from invoice) | | Project Information (where applicable) | | Turnaround Time (TAT) Required |
|---|---|---|---|---|---|---|
| Company Name: | Golder Associates Ltd. | Company Name: | | Quotation #: | | [X] Regular TAT (5-7 days) Most analyses |
| Contact Name: | Nikol Kochmanova | Contact Name: | | P.O. #/ AFE#: | | PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS |
| Address: | 6925 Century Ave. #100 Mississauga ON | Address: | | Project #: | 1669995 | Rush TAT (Surcharges will be applied) [ ] 1 Day [ ] 2 Days [ ] 3-4 Days |
| | | | | Site Location: | Hwy 401 W Scarborough | |
| Phone: | 905-567-4444 Fax: | Phone: | Fax: | Site #: | | |
| Email: | Nikol_Kochmanova@golder.com | Email: | | Sampled By: | AB | Date Required: |

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Rush Confirmation #:

**Regulation 153:** [ ] Table 1 [ ] Res/Park [ ] Med/ Fine [ ] Table 2 [ ] Ind/Comm [ ] Coarse [ ] Table 3 [ ] Agri/ Other [ ] Table ___
FOR RSC (PLEASE CIRCLE) Y / N

**Other Regulations:** [ ] CCME [ ] Sanitary Sewer Bylaw [ ] MISA [ ] Storm Sewer Bylaw [ ] PWQO Region ___ [ ] Other (Specify) [ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL ( < 10 °C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

**LABORATORY USE ONLY**

| CUSTODY SEAL Y / N Present | Intact | COOLER TEMPERATURES |
|---|---|---|
| N | N | 9/17/19 |

COOLING MEDIA PRESENT: Y / N

| | SAMPLE IDENTIFICATION | DATE SAMPLED (YYYY/MM/DD) | TIME SAMPLED (HH:MM) | MATRIX | # OF CONTAINERS SUBMITTED | FIELD FILTERED (CIRCLE) Metals / Hg / CrVI | BTEX/ PHC F1 | PHCs F2 - F4 | VOCs | REG 153 METALS & INORGANICS | REG 153 ICPMS METALS | REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) | Corrosivity Package | | | | | | | HOLD- DO NOT ANALYZE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BR-02 SA#11 | 2018/02/21 | AM | Soil | | | | | | | | | X | | | | | | | | |
| 2 | MA-08 SA#12 | 2018/02/27 | AM | Soil | | | | | | | | | X | | | | | | | | |
| 3 | CP-02 SA#11 | 2018/02/13 | AM | Soil | | | | | | | | | X | | | | | | | | |
| 4 | MR-03 SA#11 | 2018/03/04 | AM | Soil | | | | | | | | | X | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |

| RELINQUISHED BY: (Signature/Print) | DATE: (YYYY/MM/DD) | TIME: (HH:MM) | RECEIVED BY: (Signature/Print) | DATE: (YYYY/MM/DD) | TIME: (HH:MM) |
|---|---|---|---|---|---|
| Katie Nero | 2018/03/20 | 12:05PM | Pardeep / Pardeep K Purewal | 2018/03/20 | 12:06 |
| | | | | | |

20-Mar-18 12:06
Emà Gitej
B862090
URE ENV-1226

*Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Maxxam's standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgment and acceptance of our terms which are available for viewing at www.maxxam.ca/terms. Sample container, preservation, hold time and packages information can be viewed at http://maxxam.ca/wp-content/uploads/Ontario-COC.pdf.*

COC-1004 (03/17)

White: Maxxam ~ Yellow: Client

Maxxam
A Bureau Veritas Group Company

Your Project #: 1669995
Site Location: 401W

**Attention: Nikol Kochmanova**

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Your C.O.C. #: 668025-02-01, 668025-03-01, 668025-04-01, 668025-05-01

**Report Date: 2018/06/08**
Report #: R5226716
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B8D5245**
**Received: 2018/06/05, 16:46**

Sample Matrix: Soil
# Samples Received: 31

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Reference |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | 31 | N/A | 2018/06/08 | CAM SOP-00463 | EPA 325.2 m |
| Conductivity | 20 | N/A | 2018/06/07 | CAM SOP-00414 | OMOE E3530 v1 m |
| Conductivity | 11 | N/A | 2018/06/08 | CAM SOP-00414 | OMOE E3530 v1 m |
| pH CaCl2 EXTRACT | 20 | 2018/06/07 | 2018/06/07 | CAM SOP-00413 | EPA 9045 D m |
| pH CaCl2 EXTRACT | 11 | 2018/06/08 | 2018/06/08 | CAM SOP-00413 | EPA 9045 D m |
| Resistivity of Soil | 20 | 2018/06/06 | 2018/06/07 | CAM SOP-00414 | SM 23 2510 m |
| Resistivity of Soil | 11 | 2018/06/06 | 2018/06/08 | CAM SOP-00414 | SM 23 2510 m |
| Sulphate (20:1 Extract) | 31 | N/A | 2018/06/08 | CAM SOP-00464 | EPA 375.4 m |

**Remarks:**

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Maxxam
A Bureau Veritas Group Company

Your Project #: 1669995
Site Location: 401W

**Attention: Nikol Kochmanova**

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Your C.O.C. #: 668025-02-01, 668025-03-01, 668025-04-01, 668025-05-01

**Report Date: 2018/06/08**
Report #: R5226716
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B8D5245**
**Received: 2018/06/05, 16:46**

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
====================================================================
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## RESULTS OF ANALYSES OF SOIL

| Maxxam ID | | GWL599 | GWL600 | GWL601 | | GWL601 | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2018/02/14 | 2018/04/09 | 2018/02/28 | | 2018/02/28 | | |
| COC Number | | 668025-02-01 | 668025-02-01 | 668025-02-01 | | 668025-02-01 | | |
| | **UNITS** | **BR-03 SA#14** | **RW-02 SA#9** | **MR-01 SA#10** | **QC Batch** | **MR-01 SA#10 Lab-Dup** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | |
| Resistivity | ohm-cm | 680 | 6300 | 1400 | 5567331 | | | |
| **Inorganics** | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 730 | <20 | 390 | 5569372 | 420 | 20 | 5569372 |
| Conductivity | umho/cm | 1480 | 160 | 718 | 5568916 | 708 | 2 | 5568916 |
| Available (CaCl2) pH | pH | 8.02 | 8.28 | 8.08 | 5568601 | | | |
| Soluble (20:1) Sulphate (SO4) | ug/g | 270 | 68 | 50 | 5569377 | 51 | 20 | 5569377 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

| Maxxam ID | | GWL602 | | GWL603 | | GWL604 | | GWL605 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2018/04/11 | | 2018/04/12 | | 2018/03/19 | | 2018/03/21 | | |
| COC Number | | 668025-02-01 | | 668025-02-01 | | 668025-02-01 | | 668025-02-01 | | |
| | **UNITS** | **OH-7 SA#5** | **QC Batch** | **OH-4 SA#4** | **RDL** | **MRU-01 SA#4** | **RDL** | **BRU-01 SA#6** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | |
| Resistivity | ohm-cm | 710 | 5567331 | 1300 | | 330 | | 990 | | 5567331 |
| **Inorganics** | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 680 | 5569369 | 220 | 20 | 1700 | 60 | 620 | 20 | 5569369 |
| Conductivity | umho/cm | 1410 | 5570740 | 764 | 2 | 3050 | 2 | 1010 | 2 | 5570740 |
| Available (CaCl2) pH | pH | 7.99 | 5568601 | 8.01 | | 8.07 | | 8.07 | | 5569005 |
| Soluble (20:1) Sulphate (SO4) | ug/g | 280 | 5569370 | 370 | 20 | <20 | 20 | <20 | 20 | 5569370 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## RESULTS OF ANALYSES OF SOIL

| Maxxam ID | | GWL606 | | | GWL606 | | | GWL607 | GWL608 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2018/03/14 | | | 2018/03/14 | | | 2018/03/22 | 2018/04/05 | | |
| COC Number | | 668025-02-01 | | | 668025-02-01 | | | 668025-02-01 | 668025-02-01 | | |
| | **UNITS** | **CN-02 SA#23B** | **RDL** | **QC Batch** | **CN-02 SA#23B Lab-Dup** | **RDL** | **QC Batch** | **KR-01 SA#9** | **NW1-04 SA#6** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | | |
| Resistivity | ohm-cm | 3200 | | 5567331 | | | | 940 | 2000 | | 5567331 |
| **Inorganics** | | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | <20 | 20 | 5569369 | | | | 580 | 230 | 20 | 5569372 |
| Conductivity | umho/cm | 312 | 2 | 5570740 | 314 | 2 | 5570740 | 1070 | 508 | 2 | 5568916 |
| Available (CaCl2) pH | pH | 8.12 | | 5568601 | | | | 8.01 | 8.26 | | 5568601 |
| Soluble (20:1) Sulphate (SO4) | ug/g | 200 | 20 | 5569370 | | | | <20 | <20 | 20 | 5569377 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

| Maxxam ID | | GWL609 | GWL610 | GWL611 | GWL612 | GWL613 | GWL614 | | |
|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2018/02/25 | 2018/04/11 | 2018/02/26 | 2018/04/11 | 2018/04/06 | 2018/04/10 | | |
| COC Number | | 668025-03-01 | 668025-03-01 | 668025-03-01 | 668025-03-01 | 668025-03-01 | 668025-03-01 | | |
| | **UNITS** | **KR-03S SA#10** | **NW-05 SA#7B** | **MA-01 SA#11** | **NW-04 SA#4** | **NW-03S SA#7** | **NW-08 SA#7** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | |
| Resistivity | ohm-cm | 2300 | 620 | 1300 | 1000 | 1600 | 1300 | | 5567331 |
| **Inorganics** | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 210 | 820 | 280 | 510 | 340 | 350 | 20 | 5569372 |
| Conductivity | umho/cm | 437 | 1620 | 797 | 979 | 643 | 778 | 2 | 5568916 |
| Available (CaCl2) pH | pH | 8.21 | 8.11 | 8.09 | 8.16 | 8.08 | 8.13 | | 5568601 |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 24 | 310 | <20 | 23 | 77 | 20 | 5569377 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## RESULTS OF ANALYSES OF SOIL

| **Maxxam ID** | | GWL615 | | GWL616 | | GWL617 | | GWL618 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2018/04/10 | | 2018/03/25 | | 2018/03/28 | | 2018/03/26 | | |
| **COC Number** | | 668025-03-01 | | 668025-03-01 | | 668025-03-01 | | 668025-03-01 | | |
| | **UNITS** | **NW-07 SA#5A** | **QC Batch** | **NBP1-3 SA#6** | **QC Batch** | **RW-01 SA#3** | **QC Batch** | **NW1-02 SA#3** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | |
| Resistivity | ohm-cm | 610 | 5567331 | 1600 | 5567331 | 1300 | 5567331 | 2300 | | 5567331 |
| **Inorganics** | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 810 | 5569372 | 320 | 5569369 | 370 | 5569372 | 170 | 20 | 5569372 |
| Conductivity | umho/cm | 1630 | 5568916 | 627 | 5568916 | 743 | 5568916 | 429 | 2 | 5570740 |
| Available (CaCl2) pH | pH | 8.10 | 5568601 | 8.00 | 5568601 | 8.07 | 5568601 | 8.13 | | 5568601 |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 5569377 | <20 | 5569370 | <20 | 5569377 | <20 | 20 | 5569377 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

| **Maxxam ID** | | GWL618 | | GWL619 | | GWL620 | | GWL621 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2018/03/26 | | 2018/03/26 | | 2018/04/09 | | 2018/03/06 | | |
| **COC Number** | | 668025-03-01 | | 668025-04-01 | | 668025-04-01 | | 668025-04-01 | | |
| | **UNITS** | **NW1-02 SA#3 Lab-Dup** | **QC Batch** | **NW1-01 SA#4** | **QC Batch** | **NBP1-01 SA#9** | **QC Batch** | **CN-01 SA#20A** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | |
| Resistivity | ohm-cm | | | 4200 | 5567331 | 1200 | 5567331 | 2900 | | 5567331 |
| **Inorganics** | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | | | 78 | 5569372 | 460 | 5569369 | 120 | 20 | 5569372 |
| Conductivity | umho/cm | | | 238 | 5568916 | 835 | 5570740 | 343 | 2 | 5568916 |
| Available (CaCl2) pH | pH | 8.09 | 5568601 | 8.24 | 5568601 | 8.13 | 5569005 | 8.34 | | 5568601 |
| Soluble (20:1) Sulphate (SO4) | ug/g | | | <20 | 5569377 | <20 | 5569370 | 92 | 20 | 5569377 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## RESULTS OF ANALYSES OF SOIL

| Maxxam ID | | GWL622 | | GWL623 | | GWL624 | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2018/02/25 | | 2018/04/12 | | 2018/04/13 | | |
| COC Number | | 668025-04-01 | | 668025-04-01 | | 668025-04-01 | | |
| | **UNITS** | **CP-01 SA#12** | **QC Batch** | **OH-5 SA#7** | **QC Batch** | **OH-9 SA#5** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | |
| Resistivity | ohm-cm | 1500 | 5567331 | 1000 | 5567331 | 1400 | | 5567331 |
| **Inorganics** | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 340 | 5569369 | 490 | 5569372 | 330 | 20 | 5569369 |
| Conductivity | umho/cm | 649 | 5570740 | 974 | 5568916 | 733 | 2 | 5570740 |
| Available (CaCl2) pH | pH | 8.10 | 5569005 | 8.14 | 5568601 | 8.16 | | 5569005 |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 5569370 | 29 | 5569377 | <20 | 20 | 5569370 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

| Maxxam ID | | GWL624 | | | GWL625 | | | GWL626 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2018/04/13 | | | 2018/05/29 | | | 2018/04/12 | | |
| COC Number | | 668025-04-01 | | | 668025-04-01 | | | 668025-04-01 | | |
| | **UNITS** | **OH-9 SA#5 Lab-Dup** | **RDL** | **QC Batch** | **NB-02 SA#4** | **RDL** | **QC Batch** | **OH-01 SA#7** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | |
| Resistivity | ohm-cm | | | | 870 | | 5567331 | 300 | | 5567331 |
| **Inorganics** | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 330 | 20 | 5569369 | 670 | 20 | 5569372 | 1700 | 60 | 5569369 |
| Conductivity | umho/cm | | | | 1150 | 2 | 5568916 | 3300 | 2 | 5570740 |
| Available (CaCl2) pH | pH | | | | 8.24 | | 5569005 | 7.47 | | 5569005 |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 20 | 5569370 | 62 | 20 | 5569377 | 250 | 20 | 5569370 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## RESULTS OF ANALYSES OF SOIL

| **Maxxam ID** | | GWL627 | | | GWL628 | | | GWL629 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sampling Date** | | 2018/05/09 | | | 2018/05/07 | | | 2018/05/30 | | |
| **COC Number** | | 668025-04-01 | | | 668025-04-01 | | | 668025-05-01 | | |
| | **UNITS** | **KR-02 SA#3** | **RDL** | **QC Batch** | **MR-02 SA#7** | **RDL** | **QC Batch** | **BR-01 SA#4** | **RDL** | **QC Batch** |
| **Calculated Parameters** | | | | | | | | | | |
| Resistivity | ohm-cm | 470 | | 5567331 | 760 | | 5567331 | 400 | | 5567331 |
| **Inorganics** | | | | | | | | | | |
| Soluble (20:1) Chloride (Cl) | ug/g | 1100 | 40 | 5569369 | 670 | 20 | 5569372 | 1300 | 60 | 5569369 |
| Conductivity | umho/cm | 2140 | 2 | 5568916 | 1310 | 2 | 5568916 | 2490 | 2 | 5570740 |
| Available (CaCl2) pH | pH | 8.24 | | 5569005 | 8.08 | | 5569005 | 8.04 | | 5569005 |
| Soluble (20:1) Sulphate (SO4) | ug/g | 26 | 20 | 5569370 | 70 | 20 | 5569377 | 130 | 20 | 5569370 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL599
**Sample ID:** BR-03 SA#14
**Matrix:** Soil

**Collected:** 2018/02/14
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL600
**Sample ID:** RW-02 SA#9
**Matrix:** Soil

**Collected:** 2018/04/09
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL601
**Sample ID:** MR-01 SA#10
**Matrix:** Soil

**Collected:** 2018/02/28
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL601 Dup
**Sample ID:** MR-01 SA#10
**Matrix:** Soil

**Collected:** 2018/02/28
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL602
**Sample ID:** OH-7 SA#5
**Matrix:** Soil

**Collected:** 2018/04/11
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL602
**Sample ID:** OH-7 SA#5
**Matrix:** Soil

**Collected:** 2018/04/11
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL603
**Sample ID:** OH-4 SA#4
**Matrix:** Soil

**Collected:** 2018/04/12
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL604
**Sample ID:** MRU-01 SA#4
**Matrix:** Soil

**Collected:** 2018/03/19
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL605
**Sample ID:** BRU-01 SA#6
**Matrix:** Soil

**Collected:** 2018/03/21
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL606
**Sample ID:** CN-02 SA#23B
**Matrix:** Soil

**Collected:** 2018/03/14
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL606
**Sample ID:** CN-02 SA#23B
**Matrix:** Soil

**Collected:** 2018/03/14
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL606 Dup
**Sample ID:** CN-02 SA#23B
**Matrix:** Soil

**Collected:** 2018/03/14
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |

**Maxxam ID:** GWL607
**Sample ID:** KR-01 SA#9
**Matrix:** Soil

**Collected:** 2018/03/22
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL608
**Sample ID:** NW1-04 SA#6
**Matrix:** Soil

**Collected:** 2018/04/05
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL609
**Sample ID:** KR-03S SA#10
**Matrix:** Soil

**Collected:** 2018/02/25
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL610
**Sample ID:** NW-05 SA#7B
**Matrix:** Soil

**Collected:** 2018/04/11
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL611
**Sample ID:** MA-01 SA#11
**Matrix:** Soil

**Collected:** 2018/02/26
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL612
**Sample ID:** NW-04 SA#4
**Matrix:** Soil

**Collected:** 2018/04/11
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL613
**Sample ID:** NW-03S SA#7
**Matrix:** Soil

**Collected:** 2018/04/06
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL614
**Sample ID:** NW-08 SA#7
**Matrix:** Soil

**Collected:** 2018/04/10
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL614
**Sample ID:** NW-08 SA#7
**Matrix:** Soil

**Collected:** 2018/04/10
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL615
**Sample ID:** NW-07 SA#5A
**Matrix:** Soil

**Collected:** 2018/04/10
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL616
**Sample ID:** NBP1-3 SA#6
**Matrix:** Soil

**Collected:** 2018/03/25
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL617
**Sample ID:** RW-01 SA#3
**Matrix:** Soil

**Collected:** 2018/03/28
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL618
**Sample ID:** NW1-02 SA#3
**Matrix:** Soil

**Collected:** 2018/03/26
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL618
**Sample ID:** NW1-02 SA#3
**Matrix:** Soil

**Collected:** 2018/03/26
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL618 Dup
**Sample ID:** NW1-02 SA#3
**Matrix:** Soil

**Collected:** 2018/03/26
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |

**Maxxam ID:** GWL619
**Sample ID:** NW1-01 SA#4
**Matrix:** Soil

**Collected:** 2018/03/26
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL620
**Sample ID:** NBP1-01 SA#9
**Matrix:** Soil

**Collected:** 2018/04/09
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL621
**Sample ID:** CN-01 SA#20A
**Matrix:** Soil

**Collected:** 2018/03/06
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

## TEST SUMMARY

**Maxxam ID:** GWL622
**Sample ID:** CP-01 SA#12
**Matrix:** Soil

**Collected:** 2018/02/25
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL623
**Sample ID:** OH-5 SA#7
**Matrix:** Soil

**Collected:** 2018/04/12
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5568601 | 2018/06/07 | 2018/06/07 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL624
**Sample ID:** OH-9 SA#5
**Matrix:** Soil

**Collected:** 2018/04/13
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL624 Dup
**Sample ID:** OH-9 SA#5
**Matrix:** Soil

**Collected:** 2018/04/13
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL625
**Sample ID:** NB-02 SA#4
**Matrix:** Soil

**Collected:** 2018/05/29
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## TEST SUMMARY

**Maxxam ID:** GWL625
**Sample ID:** NB-02 SA#4
**Matrix:** Soil

**Collected:** 2018/05/29
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL626
**Sample ID:** OH-01 SA#7
**Matrix:** Soil

**Collected:** 2018/04/12
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL627
**Sample ID:** KR-02 SA#3
**Matrix:** Soil

**Collected:** 2018/05/09
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL628
**Sample ID:** MR-02 SA#7
**Matrix:** Soil

**Collected:** 2018/05/07
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569372 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5568916 | N/A | 2018/06/07 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/07 | 2018/06/07 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569377 | N/A | 2018/06/08 | Alina Dobreanu |

**Maxxam ID:** GWL629
**Sample ID:** BR-01 SA#4
**Matrix:** Soil

**Collected:** 2018/05/30
**Shipped:**
**Received:** 2018/06/05

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 5569369 | N/A | 2018/06/08 | Deonarine Ramnarine |
| Conductivity | AT | 5570740 | N/A | 2018/06/08 | Tahir Anwar |
| pH CaCl2 EXTRACT | AT | 5569005 | 2018/06/08 | 2018/06/08 | Gnana Thomas |
| Resistivity of Soil | | 5567331 | 2018/06/08 | 2018/06/08 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 5569370 | N/A | 2018/06/08 | Alina Dobreanu |


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

| | |
|---|---|
| Package 1 | 20.0°C |

Most samples have been received and analyzed past the recommended hold time of 30 days as per client request.

**Results relate only to the items tested.**


Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8D5245
Report Date: 2018/06/08

# QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1669995

Site Location: 401W
Sampler Initials: AM

| | | | Matrix Spike | | SPIKED BLANK | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | UNITS | Value (%) | QC Limits |
| 5568601 | Available (CaCl2) pH | 2018/06/07 | | | 100 | 97 - 103 | | | 0.50 | N/A |
| 5568916 | Conductivity | 2018/06/07 | | | 98 | 90 - 110 | <2 | umho/cm | 1.4 | 10 |
| 5569005 | Available (CaCl2) pH | 2018/06/08 | | | 101 | 97 - 103 | | | 0.13 | N/A |
| 5569369 | Soluble (20:1) Chloride (Cl) | 2018/06/08 | NC | 70 - 130 | 108 | 70 - 130 | <20 | ug/g | 0.23 | 35 |
| 5569370 | Soluble (20:1) Sulphate (SO4) | 2018/06/08 | 114 | 70 - 130 | 107 | 70 - 130 | <20 | ug/g | NC | 35 |
| 5569372 | Soluble (20:1) Chloride (Cl) | 2018/06/08 | NC | 70 - 130 | 107 | 70 - 130 | <20 | ug/g | 7.2 | 35 |
| 5569377 | Soluble (20:1) Sulphate (SO4) | 2018/06/08 | NC | 70 - 130 | 102 | 70 - 130 | <20 | ug/g | 2.5 | 35 |
| 5570740 | Conductivity | 2018/06/08 | | | 98 | 90 - 110 | <2 | umho/cm | 0.64 | 10 |

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8D5245
Report Date: 2018/06/08

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

## VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam A Bureau Veritas Group Company

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.maxxam.ca

1 of 4

# CHAIN OF CUSTODY RECORD

Page 1 of 5

| INVOICE TO: | | REPORT TO: | | PROJECT INFORMATION: | | Laboratory Use Only: | |
|---|---|---|---|---|---|---|---|
| Company Name: | #1326 Golder Associates Ltd | Company Name: | | Quotation #: | B80683 | Maxxam Job #: | Bottle Order #: |
| Attention: | Accounts Payable | Attention: | Nikol Kochmanova | P.O. #: | | | 668025 |
| Address: | 6925 Century Ave Suite 100 | Address: | | Project: | 1669995 | COC #: | Project Manager: |
| | Mississauga ON L5N 7K2 | | | Project Name: | 401 W | C#668025-02-01 | Ema Gitej |
| Tel: | (905) 567-4444 Fax: (905) 567-6561 | Tel: | (905) 567-6100 Ext: 1459 Fax: | Site #: | | | |
| Email: | AP_CustomerService@golder.com | Email: | Nikol_Kochmanova@golder.com | Sampled By: | | | |

**MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY**

| Regulation 153 (2011) | Other Regulations | Special Instructions |
|---|---|---|
| ☐ Table 1 ☐ Res/Park ☐ Medium/Fine<br>☐ Table 2 ☐ Ind/Comm ☐ Coarse<br>☐ Table 3 ☐ Agri/Other ☐ For RSC<br>☐ Table ___ | ☐ CCME ☐ Sanitary Sewer Bylaw<br>☐ Reg 558 ☐ Storm Sewer Bylaw<br>☐ MISA Municipality ___<br>☐ PWQO<br>☐ Other ___ | |

*Include Criteria on Certificate of Analysis (Y/N)?* ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

**Regular (Standard) TAT:** ☒
*(will be applied if Rush TAT is not specified):*
*Standard TAT = 5-7 Working days for most tests.*
*Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.*

**Job Specific Rush TAT (if applies to entire submission)**
Date Required: ___ Time Required: ___
Rush Confirmation Number: ___ *(call lab for #)*

| # | Sample Barcode Label | Sample (Location) Identification | Date Sampled | Time Sampled | Matrix | Field Filtered (please circle): | Metals / Hg / Cr VI | Corrosivity pkg (Cl, SO4, pH, Resistivity/EC - no Sulphide and Redox Potential) | # of Bottles | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | BR-03 SA#14 | Feb14/18 | AM | Soil | | | X | | |
| 2 | | RW-02 SA#9 | April 9/18 | AM | Soil | | | X | | |
| 3 | | MR-01 SA#10 | Feb28/18 | AM | Soil | | | X | | |
| 4 | | OH-7 SA#5 | Apr 11/18 | AM | Soil | | | X | | |
| 5 | | OH-4 SA#4 | Apr 12/18 | AM | Soil | | | X | | |
| 6 | | MRU-01 SA#4 | Mar 19/18 | AM | Soil | | | X | | |
| 7 | | BRU-01 SA#6 | Mar 21/18 | AM | Soil | | | X | | |
| 8 | | CN-02 SA#23b | Mar 14/18 | AM | Soil | | | X | | |
| 9 | | KR-01 SA#9 | Mar 22/18 | AM | Soil | | | X | | |
| 10 | | NWI-04 SA#6 | Apr 5/18 | AM | Soil | | | X | | |

05-Jun-18 16:46
Ema Gitej
B8D5245
GK1 ENV-1309

| * RELINQUISHED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | RECEIVED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | # jars used and not submitted |
|---|---|---|---|---|---|---|
| Alex MacMillan | 18/06/05 | 16:45 | Junaid | 18/06/05 | 16:46 | |

| Laboratory Use Only | | | | |
|---|---|---|---|---|
| Time Sensitive | Temperature (°C) on Recei | Custody Seal | Yes | No |
| | 20/20/20 | Present | | ✓ |
| | | Intact | | ✓ |

White: Maxxa Yellow: Client

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL ( < 10° C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

NO ICE

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam A Bureau Veritas Group Company

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free 800-563-6266 Fax:(905) 817-5777 www.maxxam.ca

**CHAIN OF CUSTODY RECORD** Page 2 of 4

**INVOICE TO:**
Company Name: #1326 Golder Associates Ltd
Attention: Accounts Payable
Address: 6925 Century Ave Suite 100, Mississauga ON L5N 7K2
Tel: (905) 567-4444 Fax: (905) 567-6561
Email: AP_CustomerService@golder.com

**REPORT TO:**
Company Name:
Attention: Nikol Kochmanova
Address:
Tel: (905) 567-6100 Ext: 1459 Fax:
Email: Nikol_Kochmanova@golder.com

**PROJECT INFORMATION:**
Quotation #: B80683
P.O. #:
Project: 1669995
Project Name: 401 W
Site #:
Sampled By:

**Laboratory Use Only:**
Maxxam Job #:
Bottle Order #: 668025
COC #: C#668025-03-01
Project Manager: Ema Gitej

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

**Regulation 153 (2011):** ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ____

**Other Regulations:** ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ____ ☐ PWQO ☐ Other

**Special Instructions**

*Include Criteria on Certificate of Analysis (Y/N)?* ____

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; Corrosivity pkg (Cl, SO4, pH, Resistivity/EC - no Sulphide and Redox Potential)

**Turnaround Time (TAT) Required:**
Please provide advance notice for rush projects

**Regular (Standard) TAT:** ☐
*(will be applied if Rush TAT is not specified):*
*Standard TAT = 5-7 Working days for most tests.*
*Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.*

**Job Specific Rush TAT (if applies to entire submission)**
Date Required: ____ Time Required: ____ ☐
Rush Confirmation Number: ____ *(call lab for #)*

| | Sample Barcode Label | Sample (Location) Identification | Date Sampled | Time Sampled | Matrix | Field Filtered / Metals / Hg / Cr VI | Corrosivity pkg | | | | | | | | | # of Bottles | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | KR-03 SA#10 | Feb 25/18 | AM | SOIL | | X | | | | | | | | | | |
| 2 | | NW-05 SA#7B | Apr 11/18 | AM | SOIL | | X | | | | | | | | | | |
| 3 | | MA-01 SA#11 | Feb 26/18 | AM | SOIL | | X | | | | | | | | | | |
| 4 | | NW-04 SA#4 | Apr 11/18 | AM | SOIL | | X | | | | | | | | | | |
| 5 | | NW-03 SA#7 | Apr 6/18 | AM | SOIL | | X | | | | | | | | | | |
| 6 | | NW-08 SA#7 | Apr 10/18 | AM | SOIL | | X | | | | | | | | | | |
| 7 | | NW-07 SA#5A | Apr 10/18 | AM | SOIL | | X | | | | | | | | | | |
| 8 | | NBP1-3 SA#6 | Mar 25/18 | AM | SOIL | | X | | | | | | | | | | |
| 9 | | RW-01 SA#3 | Mar 28/18 | AM | SOIL | | X | | | | | | | | | | |
| 10 | | NWL02 SA#3 | Mar 26/18 | AM | SOIL | | X | | | | | | | | | | |

| * RELINQUISHED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | RECEIVED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | # jars used and not submitted |
|---|---|---|---|---|---|---|
| See pg. 1 | | | See page one | | | |

**Laboratory Use Only:** Time Sensitive | Temperature (°C) on Recei | Custody Seal: Present / Intact | Yes | No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL ( < 10° C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam A Bureau Veritas Group Company

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.maxxam.ca

# CHAIN OF CUSTODY RECORD

3 of 4

Page [illegible]

| INVOICE TO: | | REPORT TO: | | PROJECT INFORMATION: | | Laboratory Use Only: | |
|---|---|---|---|---|---|---|---|
| Company Name: | #1326 Golder Associates Ltd | Company Name: | | Quotation #: | B80683 | Maxxam Job #: | Bottle Order #: 668025 |
| Attention: | Accounts Payable | Attention: | Nikol Kochmanova | P.O. #: | | | |
| Address: | 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 | Address: | | Project: | 1669995 | COC #: C#668025-04-01 | Project Manager: Ema Gitej |
| Tel: | (905) 567-4444 Fax: (905) 567-6561 | Tel: | (905) 567-6100 Ext: 1459 Fax: | Project Name: | 401W | | |
| Email: | AP_CustomerService@golder.com | Email: | Nikol_Kochmanova@golder.com | Site #: | | | |
| | | | | Sampled By: | | | |

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

| Regulation 153 (2011) | Other Regulations | Special Instructions |
|---|---|---|
| ☐ Table 1 ☐ Res/Park ☐ Medium/Fine | ☐ CCME ☐ Sanitary Sewer Bylaw | |
| ☐ Table 2 ☐ Ind/Comm ☐ Coarse | ☐ Reg 558: ☐ Storm Sewer Bylaw | |
| ☐ Table 3 ☐ Agri/Other ☐ For RSC | ☐ MISA Municipality | |
| ☐ Table | ☐ PWQO | |
| | ☐ Other | |

*Include Criteria on Certificate of Analysis (Y/N)?*

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

| | Sample Barcode Label | Sample (Location) Identification | Date Sampled | Time Sampled | Matrix | Field Filtered (please circle): Metals / Hg / Cr VI | Corrosivity pkg (Cl, SO4, pH, Resistivity/EC - no Sulphide and Redox Potential) | # of Bottles | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | NW1-01 SA#4 | Mar 26/18 | AM | SOIL | | X | | |
| 2 | | NBP1-1 SA#9 | Apr 9/18 | AM | SOIL | | X | | |
| 3 | | CN-01 SA#20A | Mar 6/18 | AM | SOIL | | X | | |
| 4 | | CP-01 SA#12 | Feb 25/18 | AM | SOIL | | X | | |
| 5 | | OH-5 SA#7 | Apr 12/18 | AM | SOIL | | X | | |
| 6 | | OH-9 SA#5 | Apr 13/18 | AM | SOIL | | X | | |
| 7 | | NB-02 SA#4 | May 29/18 | AM | SOIL | | X | | |
| 8 | | OH-1 SA#7 | Apr 12/18 | AM | SOIL | | X | | |
| 9 | | KR-02 SA#3 | May 9/18 | AM | SOIL | | X | | |
| 10 | | MR-02 SA#7 | May 7/18 | AM | SOIL | | X | | |

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

**Regular (Standard) TAT:** ☐
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

**Job Specific Rush TAT (if applies to entire submission)**
Date Required: Time Required: ☐
Rush Confirmation Number: (call lab for #)

| * RELINQUISHED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | RECEIVED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | # jars used and not submitted |
|---|---|---|---|---|---|---|
| See Page 1 | | | See page one | | | |

| Laboratory Use Only | | | | |
|---|---|---|---|---|
| Time Sensitive | Temperature (°C) on Recei | Custody Seal | Yes | No |
| | | Present | | |
| | | Intact | | |

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL ( < 10° C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam A Bureau Veritas Group Company

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.maxxam.ca

# CHAIN OF CUSTODY RECORD

4 of 4

| INVOICE TO: | | REPORT TO: | | PROJECT INFORMATION: | | Laboratory Use Only: | |
|---|---|---|---|---|---|---|---|
| Company Name: | #1326 Golder Associates Ltd | Company Name: | | Quotation #: | B80683 | Maxxam Job #: | Bottle Order #: |
| Attention: | Accounts Payable | Attention: | Nikol Kochmanova | P.O. #: | | | 668025 |
| Address: | 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 | Address: | | Project: | 1669995 | COC #: | Project Manager: |
| Tel: | (905) 567-4444 Fax: (905) 567-6561 | Tel: | (905) 567-6100 Ext: 1459 Fax: | Project Name: | | C#668025-05-01 | Ema Gitej |
| Email: | AP_CustomerService@golder.com | Email: | Nikol_Kochmanova@golder.com | Site #: / Sampled By: | | | |

**MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY**

**Regulation 153 (2011)**: ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

**Other Regulations**: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ☐ PWQO ☐ Other

**Special Instructions**

*Include Criteria on Certificate of Analysis (Y/N)?*

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; Corrosivity pkg (Cl, SO4, pH, Resistivity/EC - no Sulphide and Redox Potential)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

**Regular (Standard) TAT:** ☐
*(will be applied if Rush TAT is not specified):*
*Standard TAT = 5-7 Working days for most tests.*
*Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.*

**Job Specific Rush TAT (if applies to entire submission)**
Date Required: ____ Time Required: ____ ☐
Rush Confirmation Number: ____ *(call lab for #)*

| | Sample Barcode Label | Sample (Location) Identification | Date Sampled | Time Sampled | Matrix | Field Filtered / Metals / Hg / Cr VI | Corrosivity pkg | # of Bottles | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | BR-01 SA#4 | May 30/18 | AM | SOIL | | X | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |

| * RELINQUISHED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | RECEIVED BY: (Signature/Print) | Date: (YY/MM/DD) | Time | # jars used and not submitted | Time Sensitive | Laboratory Use Only: Temperature (°C) on Recei | Custody Seal | Yes | No |
|---|---|---|---|---|---|---|---|---|---|---|---|
| See page 1 | | | See page one | | | | | | Present | | |
| | | | | | | | | | Intact | | |

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

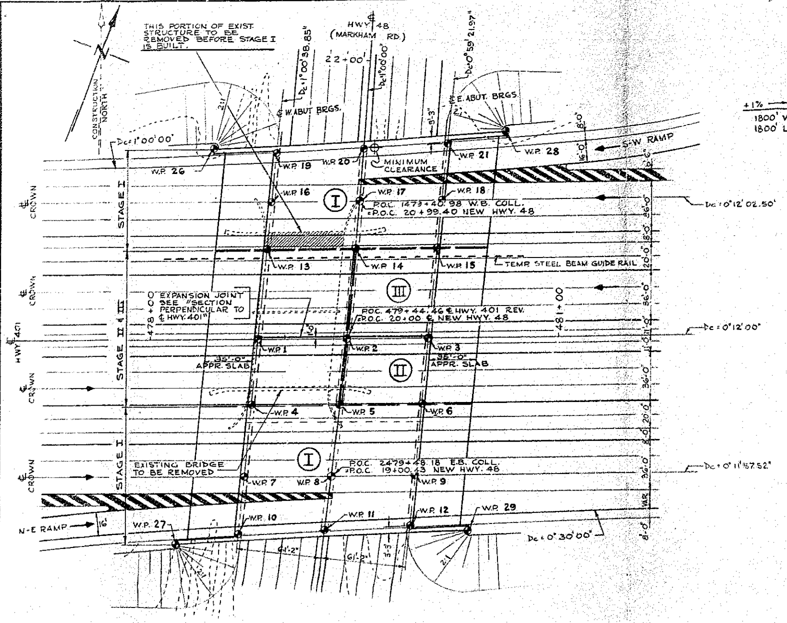
SAMPLES MUST BE KEPT COOL ( < 10° C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxa Yellow: Client

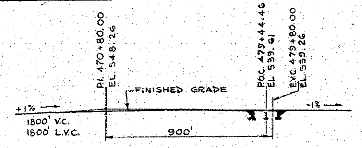
Maxxam Analytics International Corporation o/a Maxxam Analytics

**APPENDIX E**

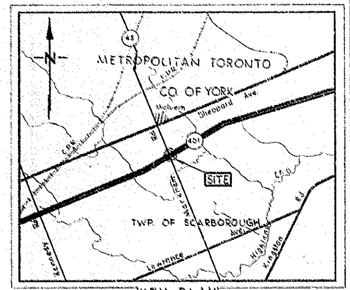
# Drawing Nos. D-6298-1, D-6298-5 and D-6298-6



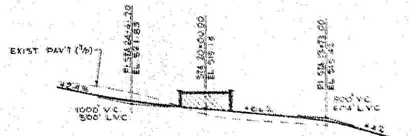
PLAN
SCALE: 1" = 40'-0"



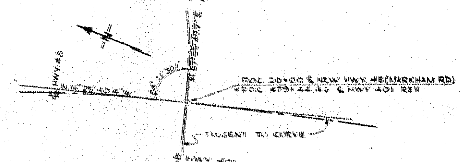
PROFILE OF HWY. 401
(AT PROFILE CONTROL)
N.T.S.



KEY PLAN
SCALE: 1"=1 MILE



PROFILE OF HWY 48
(AT PROFILE CONTROL)
N.T.S.



INTERSECTION OF HWY 48 & HWY. 401
N.T.S.

## GENERAL NOTES:

1. CLASS OF CONCRETE

PRECAST MEMBERS ——— 6000 P.S.I.
DECK SLAB, DIAPHRAGMS, CURBS AND PARAPET WALL ON DECK ——— 4000 P.S.I.
PIER ——— 4000 P.S.I.
REMAINDER ——— 3000 P.S.I.

2. CLEAR COVER ON REINFORCING STEEL

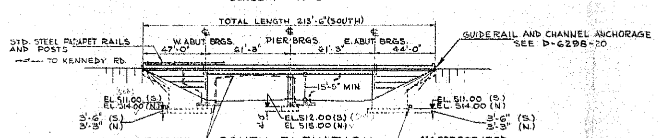
FOOTINGS & ABUTMENTS ——— 3"
PIER ——— 2½"
DECK SLAB ——— TOP ——— 2"
BOT. ——— 1½"
CURBS ——— 2"
PARAPET WALLS & END POSTS ——— 1½"
APPROACH SLABS ——— 2"
AND / OR AS NOTED ON DRAWINGS

3. CONSTRUCTION NOTES

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 1/8".

PLACE BACKFILL TO JUST BELOW THE CONSTRUCTION JOINT AT EL. 581.12 OR EL. 582.50 BEFORE PLACING THE GIRDERS.

PLACE BACKFILL TO JUST BELOW THE UNDERSIDE OF APPROACH SLABS BEFORE PLACING THE DECK SLAB.



SOUTH ELEVATION
SCALE: 1" = 40'-0

## DRAWING LIST

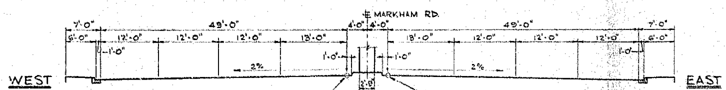
D-6298-1 GENERAL LAYOUT
-2 BORE HOLE LOCATIONS & SOIL STRATA
-3 ROADWAY PROTECTION
-4 SITE LAYOUT PLAN
-5 FOOTING LAYOUT
-6 PIER FOOTING
-7 WEST ABUTMENT
-8 EAST ABUTMENT
-9 WEST ABUTMENT DETAILS
-10 EAST ABUTMENT DETAILS
-11 PIER
-12 PRESTRESSED GIRDER & BEARINGS
-13 DECK DETAILS - STAGE I SOUTH
-14 DECK DETAILS - STAGE I NORTH
-15 DECK DETAILS - STAGES II & III
-16 DECK LAYOUT AND SCREED ELEVATIONS
-17 APPROACH SLABS
-18 STANDARD DETAILS
-19 STANDARD STEEL PARAPET RAIL
-20 PARAPET WALL DETAILS

## BENCH MARK

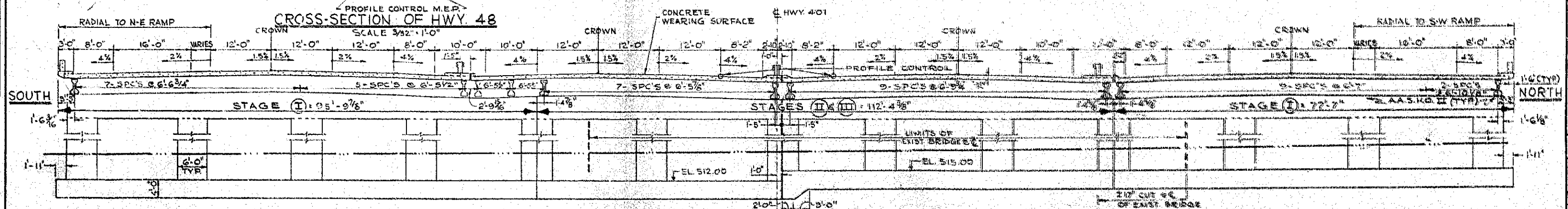
HIGHWAY Nº 401 OVERPASS AT MARKHAM ROAD (HIGHWAY Nº 48) I TABLET IN TOP OF 2ND GUARD RAIL POST FROM SOUTHWEST END OF BRIDGE AND ON SOUTHEAST SIDE. Nº T-25. ELEVATION 540.435.

CIVIL
K. Z. STOLANSKI

| PRINT RECORD | | |
|---|---|---|
| No. | FOR | DATE |



CROSS-SECTION OF HWY. 48
SCALE 3/32" = 1'-0"



SECTION PERPENDICULAR TO ℄ HWY 401 @ PIER
SCALE: 3/32" = 1'-0"

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

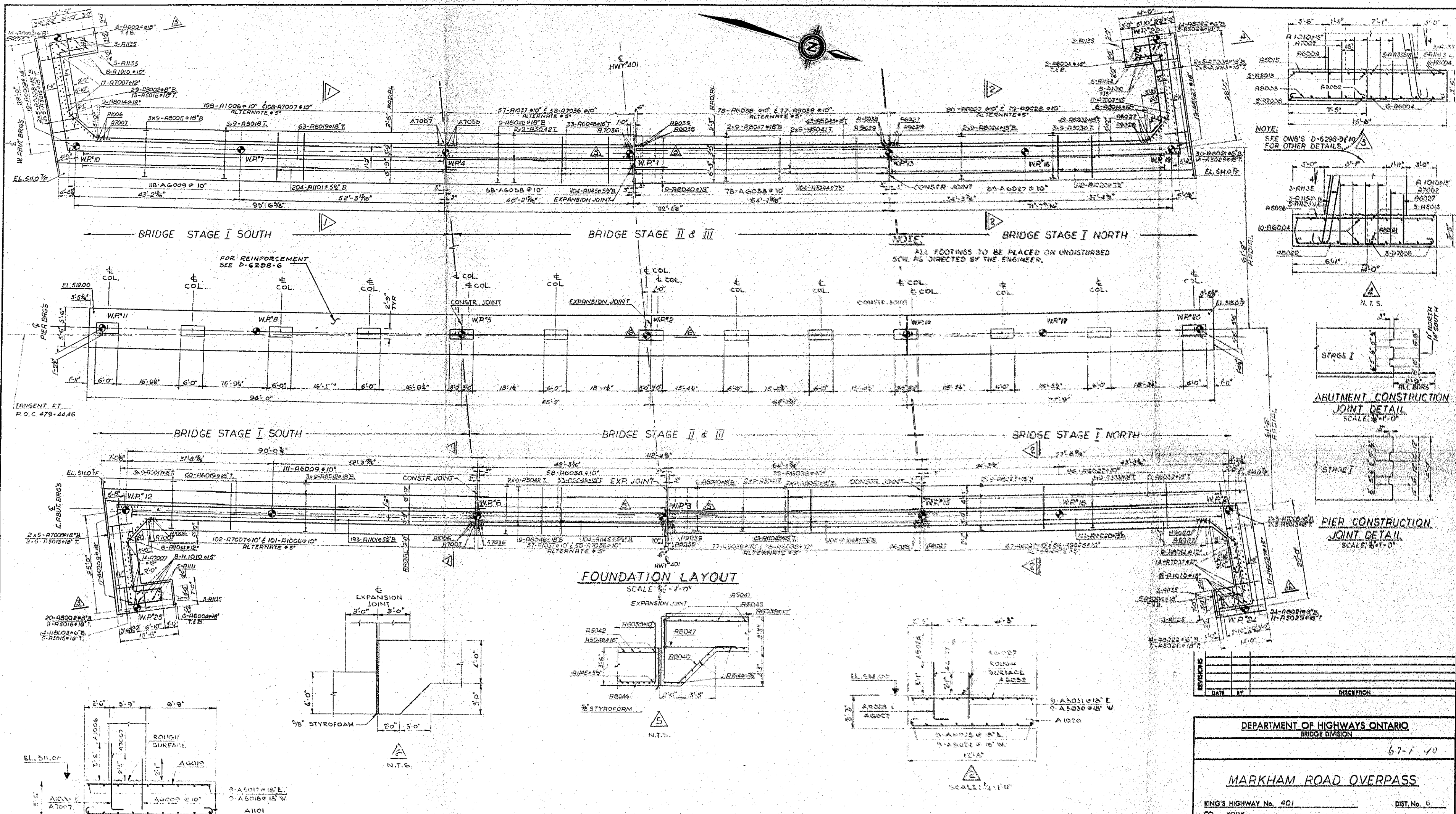
69-F-40

# MARKHAM ROAD OVERPASS

KING'S HIGHWAY No. 401 DIST. No. 6
CO. YORK
BOROUGH OF SCARBOROUGH LOT CON.

## GENERAL LAYOUT

| | | | |
|---|---|---|---|
| APPROVED ___ BRIDGE ENGINEER | | SITE No. 37-218 | W.P. No. 262-61 |
| DESIGN K.Z.S. | CHECK M.G. | CONTRACT No. | |
| DRAWING G.F. M^C | CHECK M.G. | DRAWING No. | D-6298-1 |
| DATE AUG 1969 | LOADING HS 20-44 | | |




| W.P. | STATIONS | CO-ORD'S NORTH | CO-ORD'S EAST |
|---|---|---|---|
| 22 | +P.O.C. 2+62.59 S-W RAMP (7'-9" LT) | 62336.66 | 102606.66 |
| 23 | +P.O.C. 5+16.76 N-E RAMP (7'-9" LT) | 62087.95 | 102685.46 |
| 24 | +P.O.C. 4+29.39 S-W RAMP (7'-9" LT) | 62430.33 | 102766.64 |
| 25 | +P.O.C. 5+77.88 N-E RAMP (7'-9" LT) | 62161.58 | 102816.48 |

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |

**DEPARTMENT OF HIGHWAYS ONTARIO**
BRIDGE DIVISION

67-F-40

# MARKHAM ROAD OVERPASS

KING'S HIGHWAY No. 401 DIST. No. 6
CO. YORK
[redacted]BOROUGH OF SCARBOROUGH LOT CON.

## FOOTING LAYOUT

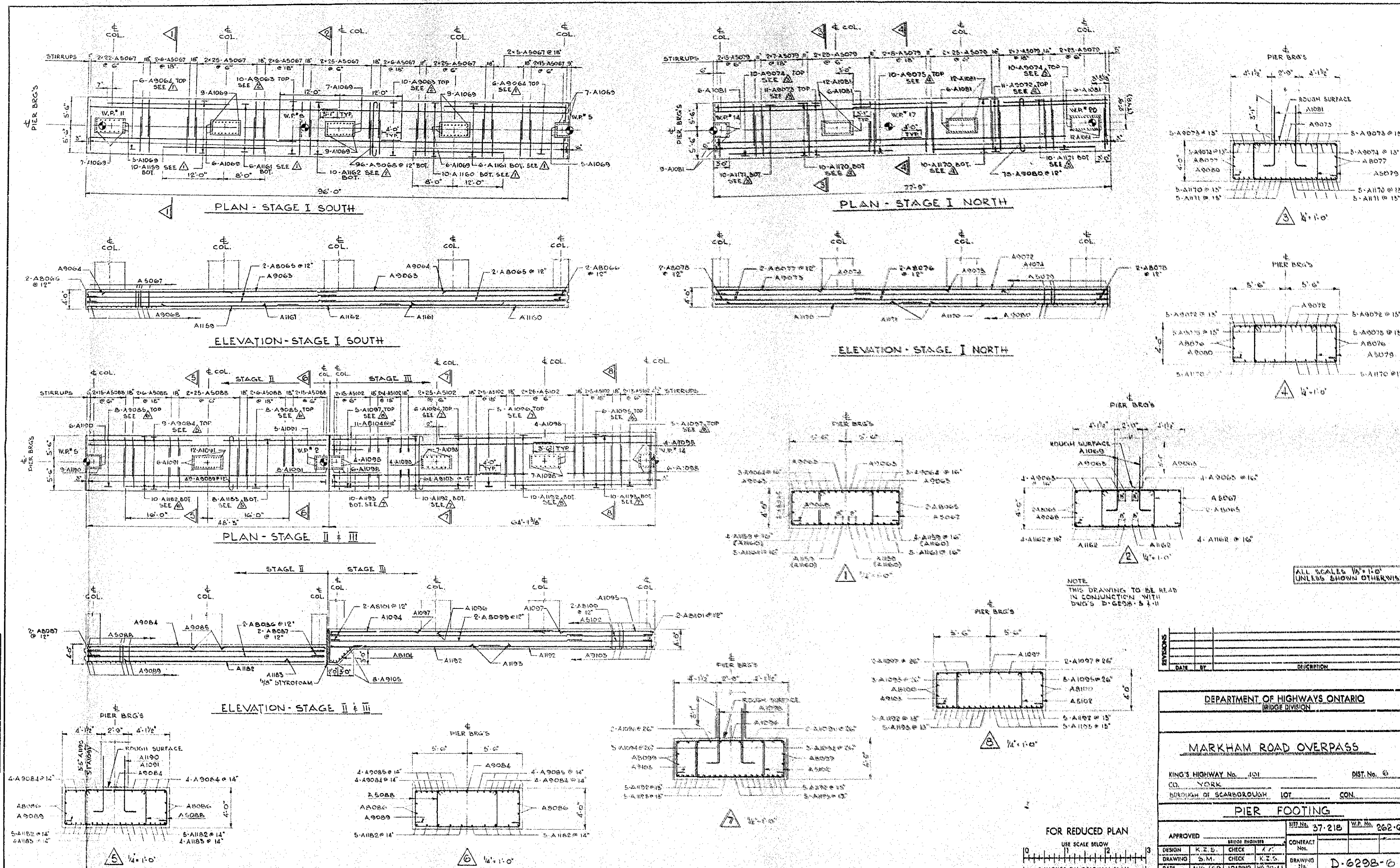
SITE No. 37-218 W.P. No. 262-61

APPROVED
BRIDGE ENGINEER

| DESIGN | K.Z.S. | CHECK | K.R. |
|---|---|---|---|
| DRAWING | Z.K. | CHECK | K.Z.S. |
| DATE | AUG.1969 | LOADING | HS20-44 |

CONTRACT Nos.

DRAWING No. D-6298-5




PRINT RECORD

| No. | FOR | DATE |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**APPENDIX F**

# Non-Standard Special Provisions

**CONCRETE WORKING SLAB - Item No.**

Non-Standard Special Provision

**1.0 Scope**

This Special Provision covers the requirements for the supply and placement of a concrete working slab for the base of the foundations associated with the Highway 401/Markham Road structure foundation widening.

**2.0 References**

This Special Provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction
OPSS 902 Excavating and Backfilling - Structures

**3.0 Definitions - Not Used**

**4.0 Design and Submission Requirements - Not Used**

**5.0 Materials**

Concrete for working slabs shall have a minimum 28 day strength of 20 MPa.

**6.0 EQUIPMENT - Not Used**

**7.0 CONSTRUCTION**

**7.01 Excavation**

Excavation for the working slab shall be according to OPSS 902.

**7.03 Protection of Subgrade**

The native subgrade for the Highway 401/Markham Road structure will be susceptible to disturbance and softening/loosening from construction traffic and ponded water. Following inspection and approval of the prepared subgrade, a concrete working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade within four hours.

The concrete shall have a compressive strength of at least 20 MPa, and be placed in accordance with OPSS.PROV 904.

**7.04 Dewatering**

Dewatering shall be carried out according to OPSS 902.

**8.0 Quality Assurance - Not Used**

**9.0 Measurement for Payment - Not Used**

**10.0 Basis of Payment**

**10.01 Working Slab - Item**

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work.

**END OF SECTION**

**VIBRATION MONITORING - Item No.**

Non-Standard Special Provision

**Scope**

This special provision describes requirements for vibration monitoring during piling / caisson installation works for the remediation and widening of the Highway 401/Markham Road overpass and installation of the temporary protection systems.

**References**

The subsurface conditions at the site are described in the following Foundation Investigation Report for WP 2162-11-00:

Markham Road Overpass (Site No. 37-218)
Highway 401 Westbound Core and Collector Lanes, Neilson Road to Warden Avenue, City of Toronto, Ontario,
Ministry of Transportation, Ontario
G.W.P. No. 2162-11-00

**Definitions**

Contractor's Engineer: An Engineer with a minimum of five (5) years of experience in the field of installation of piling and vibration monitoring or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the contract. The Contractor's Engineer shall be retained by the Contractor to ensure general conformance with the contract documents and issue certificate(s) of conformance.

**Submission Requirements**

The Contractor/Contractor's Engineer shall submit details of the vibration monitoring plan to the Contract Administrator for review. The submittals shall satisfy the specifications and at a minimum contain the following specific information:

- Qualifications of vibration monitoring specialist.
- Details regarding proposed instrumentation.
- Proposed location of instruments.
- Proposed frequency of readings.
- Proposed methods for adjusting piling methods if readings show vibrations exceeding tolerable levels.

**Monitoring**

The vibration monitoring equipment shall be placed as close as possible to the works. The Contractor/ Contractor's Engineer shall take readings on the existing structures located within 200 m of the works during installation of any deep foundation elements (including piles for temporary protection systems), starting with the pile furthest away for each foundation element.

The vibrations measured at the site shall not exceed 50 mm/s (peak particle velocity).
The results shall be submitted to the Contract Administrator after each pile installation, prior to continuing with the subsequent piles. As a minimum, the pile number, location, set criteria and driving/drilling log must be submitted with vibration monitoring results.

If the vibration monitoring results are acceptable, the Contractor may continue with the next pile(s) with readings taken during driving of each pile. The results of subsequent piles should be submitted to the Contract Administrator after each pile has been driven.

If the readings are not within the limits stated above, the Contractor must alter the driving procedures until the vibrations at the existing structures are within acceptable levels. The above process must be repeated for each pile.

**Certificate of Conformance (CoC)**

Upon completion of the work in each area of pile driving, the Contractor shall submit to the Contract Administrator a CoC sealed and signed by the Contractor's Engineer. The certificate shall state that the vibrations on the existing structure were below the limits stated above, and where the levels were exceeded, what procedures were used to reduce the vibrations to below the limits stated above.

**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**

**EARTH EXCAVATION FOR STRUCTURE (Obstructions) – Item No.**

Special Provision

**Amendment to OPSS 902, November 2010**

**Excavating and Backfilling – Structures**

**902.07 CONSTRUCTION**

Section 902.07 of OPSS 902 shall be amended by the addition of the following:

The Contactor is alerted to the potential presence of cobbles and boulders within the fill and native soils. Consideration of the presence of these obstructions shall be made in the selection of appropriate equipment and procedures for excavations, pile driving, caisson drilling and installation of temporary protection systems.

**AMENDMENT TO OPSS 903, APRIL 2016**

Special Provision No. 109F57 (Modified) April 2018

**903.03 DEFINITIONS**

Section 903.03 of OPSS 903 is amended by the deletion of the definitions for Certificate of Conformance and Quality Verification Engineer.

**903.04 DESIGN AND SUBMISSION REQUIREMENTS**

**903.04.02.04.02.01 Milestone Inspections**

Clause 903.04.02.04.02.01 of OPSS 903 is deleted in its entirety.

**903.04.02.06 Review of Splice Test Results and Permission to Proceed**

Clause 903.04.02.06 of OPSS 903 is deleted in its entirety.

**903.07 CONSTRUCTION**

**903.07.02.07.01 General**

Clause 903.07.02.07.01 of OPSS 903 is amended by deleting the first paragraph in its entirety and replacing it with the following:

The driving of piles shall be carefully monitored and controlled and pile driving records produced for each pile under the direction of the Contractor. A pile driving record shall be submitted to the Contract Administrator.

**903.07.02.07.03 Driving to a Specified Ultimate Resistance**

**903.07.02.07.03.01 General**

Clause 903.07.02.07.03.01 of OPSS 903 is deleted in its entirety and replaced with the following:

When piles are specified to be driven to a specified ultimate resistance, the specified ultimate resistance shall be determined using the Hiley Dynamic Formula on all piles, and Pile Dynamic Analyzer (PDA) testing on a minimum of 10% of piles or two piles per foundation element (whichever is greater), in each stage, at end of initial driving as specified in the Contract Documents. If the specified ultimate resistance is not achieved, retap/restrike shall be conducted after initial driving as specified in the Contract Documents, also using both Hiley Dynamic Formula on all retapped piles, and PDA testing on the minimum number of piles as noted above.

A Request to Proceed shall be submitted to the Contract Administrator after the design ultimate resistance is achieved.

The next operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

**903.07.02.07.03.03 Driving to Bedrock**

Clause 903.07.02.07.03.03 of OPSS 903 is amended by deleting the last sentence in its entirety.

**903.07.02.07.04 Wave Equation Analysis**

Clause 903.07.02.07.04 of OPSS 903 is deleted in its entirety and replaced with the following:

All equipment, material, and personnel shall be supplied to assist the Contract Administrator in installing the require instrumentation and carrying out the wave equation analysis procedure in accordance with Special Provision 903S06.

**903.07.03.07 Concrete**

**903.07.03.07.01 General**

Clause 903.07.03.07.01 of OPSS 903 is deleted in its entirety and replaced with the following:

A Request to Proceed shall be submitted to the Contract Administrator before the concrete placement.

The reinforcement shall not be displaced or distorted during the construction of the caisson.

The placement of concrete shall not proceed until the Contract Administrator has inspected the caisson hole and issued to the Contractor a Notice to Proceed.

Concrete shall be placed immediately after the Notice to Proceed has been received and shall be placed in the caisson according to OPSS 904 and as specified herein.

Arching of concrete during casing withdrawal shall be prevented.

**903.07.03.07.05 Founding Elevation**

Clause 903.07.03.07.05 of OPSS 903 is amended by deleting the last paragraph in its entirety and replacing it with the following:

Complete access to inspect the bearing area of the caisson pile prior to the placement of concrete shall be given to the Contract Administrator.

**903.07.06 Load Test**

Subsection 903.07.06 of OPSS 903 is amended by deleting the first paragraph in its entirety and replacing it with the following:

When a load test is specified in the Contract Documents, the testing shall be according to ASTM D 1143M for piles under vertical static load, ASTM D 3689 for piles under tensile load, and ASTM D 3966 for piles under lateral loads. The Contract Administrator shall witness the pile load test. All records and results of the pile load test shall be submitted to the Contract Administrator.

### 903.07.08.01.02 Visual Inspection of Welds

Clause 903.07.08.01.02 of OPSS 903 is deleted in its entirety and replaced with the following:

Complete access to visually inspect the welds shall be given to the Contract Administrator.

A representative sample of not less than 30% of the welds, as determined by the Contract Administrator, shall be visually inspected for conformance to the requirements of CSA W59 and the Contract Documents.

### 903.07.08.01.03 Non-Destructive Testing of Welds

Clause 903.07.08.01.03 of OPSS 903 is deleted in its entirety and replaced with the following:

Radiographic or ultrasonic testing shall be carried out using procedures according to CSA W59.

Ultrasonic or radiographic testing shall be carried out on the entire length of selected splice welds chosen at random by the Contractor's welding inspector assigned to carry out visual inspections.

Selection shall be based on the following criteria:

a) For pile groups other than at integral abutments, 10% of the splice welds, rounded to the next highest number, but no fewer than two.

b) For pile groups at integral abutments, 10% of the splice welds, rounded to the next highest number, but no fewer than two of when the welds are below 6 m of the pile cut-off elevation.

c) For pile groups at integral abutments, all splice welds within 6 m of the pile cut-off elevation.

### 903.07.08.03 Certificate of Conformance

Clause 903.07.08.03 of OPSS 903 is deleted in its entirety.

## 903.10 BASIS FOR PAYMENT

### 903.10.01 Supply Equipment for Installing Driven Piles - Item<br>Supply Equipment for Installing Caisson Piles - Item<br>Supply Equipment for Installing Displacement Caisson Piles - Item

Subsection 903.10.01 of OPSS 903 is amended by deleting the second paragraph in its entirety and replacing it with the following:

For payment purposes, 50% of the work under this item shall be paid when the satisfactory performance of the equipment has been demonstrated to the Contract Administrator by the installation of 1% of piles.

Another 40% shall be paid by progress payments proportional to the work completed. The remaining 10% shall be paid on the satisfactory completion of the installation of piles.

WARRANT: Always with OPSS 903, Construction Specification for Deep Foundations.

**DEWATERING STRUCTURE EXCAVATIONS - Item No.**

Special Provision No. FOUN0003 March 8, 2018

**Amendment to OPSS 902, November 2010**

OPSS 902, November 2010, Construction Specification for Excavating and Backfilling - Structures is amended as follows:

**902.02 REFERENCES**

Section 902.02 of OPSS 902 is amended by the addition of the following:

**Ontario Provincial Standard Specifications, Construction**

OPSS 517 Dewatering
OPSS 805 Temporary Erosion and Sediment Control Measures

**902.03 DEFINITIONS**

Section 903.03 of OPSS 902 is amended by the addition of the following:

**Automatic Transfer Switch** means as defined in OPSS 517.

**Cofferdam** means as defined in OPSS 539.

**Cut-Off Wall** means as defined in OPSS 517.

**Design Storm Return Period** means as defined in OPSS 517.

**Dewatering System** means as defined in OPSS 517.

**Groundwater Control System** means as defined in OPSS 517.

**Plug** means as defined in OPSS 517.

**Sediment** means as defined in OPSS 517.

**Sediment Control Measure** means as defined in OPSS 517.

**Temporary Flow Passage System** means as defined in OPSS 517.

**Unwatering** means as defined in OPSS 517.

**Vegetated Discharge Area** means as defined in OPSS 517.

**Waterbody** means as defined in OPSS 517.

**Watercourse** means as defined in OPSS 517.

**902.04 DESIGN AND SUBMISSION REQUIREMENTS**

**902.04.01 Design Requirements**

**902.04.01.01 Dewatering**

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a [* Designer Fill-In, See Notes to Designer] year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

**902.04.02 Submission Requirements**

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

**902.04.02.01 Working Drawings**

Working Drawings for the dewatering system shall be according to OPSS 517.

**902.04.02.02 Preconstruction Survey**

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of [** Designer Fill-In, See Notes to Designer] metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website https://www.ontario.ca/environment-and-energy/map-well-records or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

**902.04.02.03 Milestone Inspections**

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

**902.07 CONSTRUCTION**

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

### 902.07.04 Dewatering Structure Excavation

#### 902.07.04.01 General

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

#### 902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

#### 902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

#### 902.07.04.04 System Amendments

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

#### 902.07.04.05 Removal

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTES TO DESIGNER:

Designer Fill-Ins

* Fill in the design storm return period according to MTO Drainage Design Standard TW-1.

** Fill in the preconstruction survey distance as recommended by the foundation engineer.

WARRANT: Include with this standard tender item **only** on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.

**PROTECTION SYSTEM - Item No.**

Special Provision

**Amendment to OPSS 539, November 2014**

**593.07.02Removal of Protection Systems**

Subsection 539.07.02 of OPSS 539 is deleted in its entirety and replaced with the following:

Protection systems shall be removed from the right-of-way unless it is specified in the Contract Documents that the protection system may be left in place.

Where piles are left in place, the top shall be removed to at least 1.2 m below the finished grade or ground level.

The method and sequence of removal shall be such that there shall be no damage to the new work, existing work and facility being protected.

All disturbed areas shall be restored to an equivalent or better condition than existing prior to the commencement of construction.

GOLDER

golder.com