



Foundation Investigation and Design Report

*Midland Avenue Overpass Rehabilitation and Northward Widening (Site No. 37-216), 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 ``*

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PART A

**FOUNDATION INVESTIGATION REPORT
MIDLAND AVENUE OVERPASS REHABILITATION AND NORTHWARD
WIDENING (SITE NO. 37-216)
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 Midland Avenue overpass (Site No. 37-216/2 and 37-216/4). This report was developed based on information from the 2018 investigation, supplemented with information from a 1966 foundation investigation completed by Department of Highways - Ontario at the structure site, as follows:

- **MTO GEOCREs No. 30M14-74:** Report titled “Foundation Investigation Report for The Proposed Extension of Hwy. 401 and Midland Ave. Crossing, Metropolitan Toronto, District 6, W.O. 66-F-87 – W.P. 260-61”, prepared by Department of Highways Ontario, Foundation Section – Materials and Testing Division, dated December 8, 1966.

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-Midland Avenue Interchange overpass is located in the City of Toronto, east of Kennedy Road as shown on the Key Plan on Drawing 1. Based on the 1966 Borehole Location and Soil Strata drawing, the natural ground surface at this site varies between approximately Elevations 164 m and 167 m, rising to the east, with the Midland Avenue grade at about Elevation 166.1 m at the structure site. Highway 401 has been constructed on embankment fill, with its grade at approximately between Elevations 171.3 m to 172.2 m at the overpass location. Land use in the area of the interchange is commercial development in the northwest and southern quadrants and residential homes in the northeast quadrant.

The existing Midland Avenue overpass (core and collectors) was constructed in 1969 and consists of a prestressed concrete girder single span structure approximately 30.2 m wide and about 19.4 m long (between the abutments). Based on the available design drawings (dated July 1968), the existing east and west abutments for the westbound core and collector structure are supported on 3.7 m wide strip footings and the northern wingwalls are supported on a 5.0 m wide strip footing, all founded at Elevation 163.4 m. The existing WB core structure (Site No. 37-216/4) is approximately 18.4 m wide, and the WB collector structure (Site No. 37-216/2) is approximately 23.1 m wide.

The Highway 401 approach embankments are up to approximately 8 m high relative to the surrounding grade, with the side slopes inclined at approximately 3 horizontal to 1 vertical (3H:1V) at the steepest locations. At the time of the 2018 investigation, visual observations suggested no evidence of settlement of the WB lanes adjacent to the overpass abutments, nor of global instability of the approach embankment side slopes.

3.0 INVESTIGATION PROCEDURES

3.1 1966 Investigation

A total of 6 boreholes (Borehole Nos 1 to 4, 1A and 2A) were advanced as part of the 1966 investigation (GEOCRE No. 30M14-74) in the immediate vicinity of the Midland Avenue overpass. Two of these boreholes are located within or immediately adjacent to the footprint of the proposed northward widening of the WBL collector lanes and two of these boreholes are located within the WB core lanes, while the other two are located within the eastbound (EB) 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 GEOCRE reference number followed by the original borehole designation. For example, the boreholes from MTO GEOCRE Report No. 30M14-74 have been renumbered as 74-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 1966 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 1966 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)		
74-1	WB Collector East Abutment	4,848,650.4	322,931.3	166.1	36.6
74-1A	WB Core East Approach	4,848,615.6	322,957.3	171.3	14.2
74-2	WB Collector West Abutment	4,848,645.5	322,914.7	165.6	11.1
74-2A	WB Core West Approach	4,848,601.5	322,911.9	170.9	15.7
74-3	EB Collector West Abutment	4,848,561.5	322,923.5	165.2	11.1
74-4	EB Collector East Abutment	4,848,573.7	322,966.5	166.1	11.1

The Standard Penetration Test (SPT) “N”-values presented on the borehole records of the 1966 investigation were obtained using a manual hammer.

3.2 2018 Investigation

The current foundation investigation for the Midland Avenue overpass WB structure was carried out between February 22 to 27, on May 31 and on November 16, 2018, during which time four boreholes (designated as Boreholes MA-01 to MA-04) were drilled adjacent to the east and west abutments in the core lanes from the Highway

401 grade (Boreholes MA-01 and MA-02, respectively), at the toe of the existing Highway 401 embankment slopes at the east and west approaches (Boreholes MA-03 and MA-04, respectively), at the locations shown on Drawing 1.

Borehole MA-01 to MA-03 were advanced using a CME-55 and a CME 75 truck-mounted drill rigs, supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario. Borehole MA-04 was advanced using portable drilling equipment supplied and operated by OGS Inc., of Almonte Ontario. The boreholes drilled with the truck mounted drill rigs were advanced through the overburden using 165 mm or 178 mm outside diameter hollow stem augers to depths between 4.9 m and 17.4 m. Borehole MA-04 was advanced through the overburden using continuous split-spoon sampling to a depth of 5.0 m below 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 on the drill rigs, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)¹. Boreholes advanced by portable equipment were continuously sampled using a full-weight hammer lifted manually and dropped from the SPT height.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole MA-03 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 positioned within the lower 2.5 m section of the borehole. The borehole and annulus surrounding the piezometer pipe above the filter sand pack were backfilled to the ground surface with bentonite pellets. The remaining boreholes were backfilled to ground surface with bentonite, in accordance with Ontario Regulation 903, Wells (as amended).

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, 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 soil sample from each of Boreholes MA-01 and MA-02, 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 established from the digital terrain model for the project. The locations given on the borehole records and shown on Drawings 1 and 2 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.

¹ ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
MA-01	4,848,638.6 (43.777494)	322,954.8 (-79.274470)	172.8	17.4
MA-02	4,848,609.7 (43.777235)	322,893.3 (-79.275236)	172.6	17.4
MA-03	4,848,662.6 (43.777710)	322,955.2 (-79.274464)	167.4	4.9
MA-04	4,848,663.0 (43.777752)	322,875.2 (-79.275457)	165.1	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 South Slope, according to The Physiography of Southern Ontario (Chapman and Putnam, 1984)².

The South Slope region is comprised of calcareous clay till with lacustrine clay and silt reworked by glaciers, with numerous scattered drumlins and deep valley cuts caused by streams flowing towards Lake Ontario. The surface topography slopes down gradually and uniformly southwards towards Lake Ontario. The overburden within the majority of the South Slope area is underlain by shale bedrock of the Queenston and Georgian Bay Formations which contain limestone interlayers.

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 1966 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 2018 investigations (with the exception of Borehole MA-04) 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-sections on Drawings 1 and 2 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

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.)

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 a non-cohesive deposit that varies in composition from silt to sandy silt to silt and sand, underlain in places by deposits of sandy clayey silt and/or sand. Detailed descriptions of the subsurface conditions are provided in the following sections of this report.

4.2.1 Topsoil

An approximately 0.3 m thick layer of topsoil was encountered immediately below ground surface in Borehole MA-04.

4.2.2 Asphalt

An approximately 180 mm thick layer of asphalt pavement was encountered immediately below pavement surface in Boreholes MA-01 and MA-02, which were advanced on the Highway 401 platform.

4.2.3 Fill

A non-cohesive fill deposit between 0.8 m and 6.4 m thick was encountered underlying the pavement in Boreholes MA-01 and MA-02, and immediately below the ground surface in Borehole MA-03. A layer of cohesive fill 5.6 m and 1.1 m thick was encountered underlying the non-cohesive fill in Borehole MA-02 and underlying the topsoil in Borehole MA-04, respectively. The base of the fill in the 2018 investigation extends to between approximately Elevations 166.6 m and 163.7 m. The non-cohesive fill ranges in composition from silt and sand to silty sand to gravelly sand to sand and gravel to sandy gravel. The cohesive fill ranges in composition from sandy clayey silt to clayey silt with sand. Cobbles were inferred to be present within the fill deposit encountered in Borehole MA-02 based on grinding of the augers at a depth of about 2.7 m.

The Standard Penetration Test (SPT) “N”-values measured within the non-cohesive portion of the fill range from 4 blows to 33 blows per 0.3 m of penetration, indicating a very loose to dense level of compactness. The SPT “N”-values measured within the cohesive fill range from 9 blows to 48 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

Grain size distribution testing was carried out on two samples of the non-cohesive fill and one sample of the cohesive fill and the results are shown on Figures C-1A and C1-B, respectively, in Appendix C. Atterberg limits testing was carried out on two samples of the non-cohesive fill and one sample of the cohesive fill and measured liquid limits of 15 per cent to 20 per cent, plastic limits of 12 per cent, and corresponding plasticity indices of between 3 per cent and 8 per cent. These results, which are plotted on a plasticity chart on Figure C-2 in Appendix C, indicate that the fines portion of the fill ranges in composition from silt of slight plasticity to clayey silt of low plasticity. The natural water content measured on selected samples of the non-cohesive fill ranges from about 4 per cent to 16 per cent. The natural water content measured on a selected sample of the cohesive fill range from about 8 per cent to 29 per cent.

4.2.4 Silt to Sand

A silt to sand deposit was encountered underlying the fill deposit in Boreholes MA-01, MA-03 and MA-04, underlying the silty clay deposit in Borehole MA-02 (described in Section 4.2.5) and immediately below ground surface in all of the boreholes drilled as part of the 1966 investigation. The deposit varies in composition from silt to sandy silt to silt and sand to silty sand, trace gravel to gravelly, trace to some clay. In Borehole MA-02 the deposit was noted to

be interlayered with a deposit of silty clay (described in Section 4.2.5). The surface of the silt to sand deposit was encountered between Elevations 171.3 m and 162.4 m. All of the boreholes, except for Borehole 74-1, were terminated within the silt to sand deposit, penetrating it for a thickness ranging from 3.6 m to 15.7 m. The thickness of the deposit is about 22.6 m in Borehole 74-1.

The SPT “N”-values measured within the silt to sand deposit range from 8 blows to 170 blows per 0.3 m of penetration and up to 100 blows for 0.04 m of penetration, indicating a loose, and generally compact, to very dense compactness condition.

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-3A and C-3B in Appendix C. Four Atterberg limits tests carried out on samples of the silt to sand deposit and three tests measured liquid limits between 13 per cent and 15 per cent, plastic limits between 10 per cent and 12 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-4 in Appendix C, indicate that the silt to sand deposit contains portions of silt of slight plasticity; one test on a sample of the silt and sand deposit from Borehole MA-03 indicates a ‘non-plastic’ result. The natural water content measured on selected samples of the silt to sand deposit ranges from about 5 per cent to 36 per cent.

4.2.5 Clayey Silt to Silty Clay

Deposits of sandy clayey silt to clayey silt to silty clay were encountered underlying the fill and interlayered within the silty to sand deposit in Borehole MA-02, and underlying the sand to silty sand deposit in Borehole 74-1. The surface of the sandy clayey silt to silty clay deposit was encountered between approximately Elevations 164.8 m and 143.5 m. In Borehole MA-02 the silty clay layers were found to be between 1.6 m and 2.4 m thick. Borehole 74-1 was terminated within the clayey silt deposit, penetrating it for a thickness of 14.0 m.

The SPT “N”-values measured within the clayey silt to silty clay deposit range from 7 blows to 9 blows per 0.3 m of penetration in Borehole MA-02 and from 91 blows to 106 blows per 0.3 m of penetration in borehole 74-1 with one value of 100 blows for 0.15 m of penetration in Borehole MA-02, suggesting a firm to stiff consistency and hard consistency in the respective boreholes.

An Atterberg limits test was carried out on one selected sample of the silty clay deposit from the 2018 investigation and measured a liquid limit of 43 per cent, a plastic limit of 22 per cent, and a corresponding plasticity index of 21 per cent. The result, which is plotted on a plasticity chart on Figure C-5 in Appendix C, indicate that a portion of the deposit consists of silty clay of medium plasticity. The natural water content measured on selected samples of the clayey silt to silty clay deposit ranges from about 9 per cent to 31 per cent.

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations, and in the piezometer installed in Borehole MA-03 during the 2018 investigation, as summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date	Comments
MA-01	172.8	8.2	164.6	February 27, 2018	Open borehole (borehole caved to 12.8 m depth)
MA-02	172.6	Dry to 11.0	-	February 23, 2018	Open borehole (borehole caved to 11.0 m depth)
MA-03	167.4	3.7	163.7	June 30, 2018	Piezometer screened within silt and sand deposit
MA-04	165.1	1.4	163.7	November 16, 2018	Noted during advancement of borehole, drilling mud used during advancement of borehole.

The water levels measured immediately after completion of drilling, may not represent the stabilized groundwater level at the site. The 1966 Foundation Investigation Report indicates that the groundwater at the bridge site was established in the open boreholes at an Elevation between 163.1 m and 164.6 m, although this may not be reflective of the stabilized, or current, groundwater level at the site.

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

Two 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)
MA-01 / 11	8.09	1300	797	280	310
MA-02 / 12	7.89	1100	890	430	140

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Matthew Kelly, 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.

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PART B

**FOUNDATION DESIGN REPORT
MIDLAND AVENUE OVERPASS REHABILITATION AND NORTHWARD
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation design recommendations for the proposed Midland Avenue overpass (Site No. 37-216/2 and 37-216/4) 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 a 1966 investigation. 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 Warden Avenue to Brock Road, the existing Midland Avenue WB core and collector structures will be rehabilitated and the collector structure will be widened to the north by about 2.6 m at the east and west abutments. The existing Midland Avenue overpass (core and collectors) was constructed in 1969 and consists of a single span prestressed concrete girder structure with a length of about 18.4 m between abutments. Based on the available design drawings (dated July 1968), the existing east and west abutments for the westbound core and collector structure are supported on 3.7 m wide strip footings and the northern wingwalls are supported on a 5.0 m wide strip footing, all founded at Elevation 163.4 m. The existing WB core structure (Site No. 37-216/4) is approximately 18.4 m wide, and the WB collector structure (Site No. 37-216/2) is approximately 23.1 m wide. Based on visual observations made during the recent subsurface investigation, the existing overpass structure and approach embankments appear to be performing well (no signs of settlement / instability).

The proposed bridge rehabilitation involves the replacement of the superstructure including the approach slabs, existing asphalt 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 3 m below the roadway surface (to approximately Elevation 170 m) to facilitate this conversion. The northward widening will also require construction of new wingwalls to the north of the existing wingwalls. The foundation recommendations for the northwest wingwall are included in this report. The northeast wingwall is connected to a larger retaining structure that will be reconstructed and foundation recommendations for this wingwall/retaining structure are provided in Golder's retaining wall report for this project (issued under separate cover).

The Midland Avenue overpass is planned to be rehabilitated in four stages, with the collector superstructure widened and replaced first, followed by replacement of 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 semi-integral abutment conversion while maintaining traffic along both the core and collector lanes. Although the geometry and design of the temporary protection system is the responsibility of the

contractor, based on the design drawings provided by WSP it is anticipated that the temporary protection systems will extend parallel to Highway 401 between the proposed rehabilitation stages (i.e. between the collector lanes and the widening section, between the collector and core lanes and along the median between the WB/EB core lanes).

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 for support of the widening of the abutments and new northwest wingwall for the Midland Avenue 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 Midland Avenue 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 silt to sand deposit:** Strip or spread footings are feasible for support of the widened abutments and associated wing walls/retaining walls at this site. Up to about 8 m deep excavation will be required through the existing embankment fill adjacent to north end of the existing WB collector structure and 1.5 m into native soil deposits to reach the elevation of the existing abutment footings at the proposed new foundation subgrade level. Temporary protection systems will be required along Highway 401 to permit the staged rehabilitation and widening of the existing structure and constructing new foundations. This excavation would extend through the existing embankment fill and about 1.5 m into native ground potentially through perched groundwater and to about the prevailing groundwater level. 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 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 abutments / 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. A pile foundation option allows for the design / construction of integral or semi-integral abutments, however since the existing shallow foundations of the structure will not be replaced an integral abutment configuration is not feasible nor necessary for the widened abutment foundation elements. It is also assumed that, as the pile caps would need to be founded at a depth of about 1.2 m below the Midland Avenue grade for protection from frost penetration, the required excavation depth is similar to that for shallow foundations. In addition, it may be necessary to pre-auger into the dense/hard 100-blow soils at the pile locations prior to installing the piles.
- **Drilled shafts (caissons):** Drilled shafts foundation are suitable and feasible for support of the widened 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 if 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 structure, 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 relatively shallow depth.

Based on the above considerations, the preferred foundation option from a geotechnical/foundations perspective is to support the new abutment sections and associated wing walls/retaining walls for the proposed northward widening on shallow strip footings founded on the very dense silt to sand deposit.

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 1966 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 Midland Avenue overpass has been assessed as “typical degree of site and prediction model understanding”.

The corresponding consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{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 Seismic Design

6.3.2.1 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 Midland Avenue overpass.

6.3.2.2 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 and as obtained from NCR (2017) website, the peak ground acceleration (PGA), Peak Ground Velocity (PGV) and design spectral acceleration (S_a) 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)	0.040	0.071	0.135
PGV (m/s)	0.031	0.052	0.090
S_a (0.2) (g)	0.068	0.115	0.211

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)
Sa (0.5) (g)	0.043	0.067	0.113
Sa (1.0) (g)	0.024	0.036	0.059
Sa (2.0) (g)	0.011	0.018	0.028
Sa (5.0) (g)	0.0024	0.0040	0.0069
Sa (10.0) (g)	0.0011	0.0017	0.0029

6.3.3 Soil Liquefaction

Given the generally very stiff to hard / compact to very dense compactness condition of the site soils 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.

6.4 Assessment of Existing Foundations

Based on the 1968 design drawings (Drawings D-6132-1 - General Layout and D-6132-3 - Footing and Site Layout Plans), the Midland Avenue overpass is a single-span structure with the abutments 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 wing-/retaining wall foundations are summarized below. Based on Golder's interpretation of the available information in the GEOCRE report and on the above referenced 1968 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 wing-/retaining wall footings are summarized below.

Foundation Element	Existing Footing Width (m)	Existing Founding Elevation (m)	Approximate Existing Founding Depth (m)*	Founding Soil	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance (kPa) (for 25 mm of Settlement)
East and West Abutments	3.7	163.4	3.1	very dense silt to sand deposit	750	425
Northwest Wingwall	5.0	163.4	3.1	very dense silt to sand deposit	850	300

* Based on Midland Avenue grade at Elevation 166.5 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 6.7.4 and C6.7.4 in *CHBDC* (2014).

6.5 Strip Footings

6.5.1 Founding Elevations

Strip footings (shallow foundations) are feasible for the support of the widened portion of the Midland Avenue overpass structure and associated wingwalls/retaining walls. The footings should be founded below any fill and softened/loosened soils on the very dense silt to sand at or below Elevations 163.4 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 163.4 m). The founding level must be deep enough to provide adequate protection against frost penetration, but still minimize the height of the abutment wall.

The strip footings for the widening of the WB lane structure will be constructed in close proximity to the existing footings. In this regard, the new/extended footings should be constructed with the underside either at the founding level of the existing footings, or above / below the elevation of the existing footings positioned outside an area bounded by a line drawn up / down as applicable and away from the base of the existing footings at 1 horizontal:1vertical (1H:1V).

6.5.2 Geotechnical Resistances

Strip footings placed on the native soils at or below the design elevations given in Section 6.5.1, 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 and/or retaining wall footings on native very dense silt to sand deposit – at or below Elevation 163.4 m	2	650	Does not govern ¹
	3	700	550
	3.7 (to match existing abutment foundations)	750	425
	4	800	400
	5.0 (to match existing wingwall foundations)	850	300

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.

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 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.

6.5.3 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 δ 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: $\tan \delta = 0.7$

These represent unfactored values; in accordance with the CHBDC, the appropriate consequence factor and degree of site understanding factor from Table 6.1 and 6.2 in the CHBDC (2014) are to be applied in calculating the horizontal resistance.

6.6 Steel H-Pile or Pipe Pile Foundations

6.6.1 Founding Elevations

Consideration can be given to supporting the widened abutments and wing-/retaining walls 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/through the “100-blow” soils at shallow depths at the pile locations where the pile lengths would otherwise be variable relative to adjacent piles, to allow for installation of the piles to the required tip elevation, 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 165.3 m (i.e. 1.2 m below the Midland Avenue grade for frost protection purposes).

Foundation Element	Surface Elevation of "100-blow" Material (m)	Estimated Design Pile Tip Elevation (m)	Estimated Pile Length (m)
West Abutment and Wing-/Retaining wall	161.5 to 160.1	157	8.3
East Abutment	164.3 to 161.2	158	7.3

Given the variability in the SPT "N"-values with depth, 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 east abutment where "N"-values greater than "100-blows" per 0.3 m of penetration were measured at inconsistent depths in the previous and current borehole investigations.

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 MA-01 and MA-02. 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*).

6.6.2 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 6.6.1, the factored ultimate geotechnical resistance may be taken as 1,400 kN. The factored serviceability geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored ultimate geotechnical resistance and 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 2,800 kN per pile, but must be driven to or below, the following tip Elevations:"

Foundation Element	Pile Tip Elevation (m)
West Abutment and Wing-/Retaining wall	157
East Abutment	158

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.

6.6.3 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:

$$k_h = \frac{n_h z}{B} \quad \text{Where} \quad \begin{array}{l} n_h \text{ is the constant of subgrade reaction (kPa/m);} \\ z \text{ is the depth (m); and} \\ B \text{ is the pile diameter or width (m).} \end{array}$$

For cohesive soils:

$$k_h = \frac{67 s_u}{B} \quad \text{Where} \quad \begin{array}{l} s_u \text{ is the undrained shear strength of the soil (kPa); and} \\ B \text{ is the pile diameter or width (m).} \end{array}$$

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 and cross-sections shown on Drawings 1 and 2. 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	Above Groundwater Table n_h (kPa/m)	Below Groundwater Table n_h (kPa/m)	s_u (kPa)
Existing loose to compact non-cohesive fill	2,500	N/A	-
Existing very stiff to hard cohesive fill	-	N/A	100
Firm/compact silty clay / silt	5,000	4,000	50
Loose to very dense silt to sand	12,000	7,000	-
Compact to very dense silty sand to sand	12,000	7,000	-
Hard clayey silt	-	-	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 $1.5 \times B$ (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.

6.7 Drilled Shafts (Caissons)

6.7.1 Founding Elevations

Drilled shaft foundations could also be considered for support of the widened sections of the abutments and wing-/retaining walls. 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 new wing-/retaining wall foundations are summarized below.

Foundation Element	Surface Elevation of “100-blow” Material (m)	Estimated Design Pile Tip Elevation (m)
West Abutment and Wing-/Retaining wall	161.5 to 160.1	158
East Abutment	164.3 to 161.2	159

6.7.2 Geotechnical Axial Resistance

For drilled shafts socketed approximately 2 m into “100-blow” soil at the elevations given in Section 6.7.1, the factored ultimate geotechnical resistance and factored serviceability geotechnical resistance may be taken as follows, based on a caisson length relative to the Midland Avenue grade equal to 8.1 m for the west abutment and 7.1 m for the east abutment:

Foundation Element	Drilled Shaft Diameter (m)	Factored Ultimate Geotechnical Resistance (kN)	Factored Serviceability Geotechnical Resistance (kN) (for 25 mm of settlement)
West Abutment and Wing-/Retaining wall	0.9	1,300	1,100
	1.2	2,200	1,600
	1.5	3,400	1,900
East Abutment	0.9	1,500	Does not govern ¹
	1.2	2,400	2,000
	1.5	3,600	2,400

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.

6.7.3 Resistance to Lateral Loads

The geotechnical resistance to lateral loading for the caissons should be calculated in accordance with Section 6.6.3, using the horizontal subgrade formulas and parameter values presented therein.

6.8 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*), as amended by SP105S10 (*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).

6.8.1 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/m ³
Coefficients of static lateral earth pressure:	
Active, K_a	0.33
At rest, K_o	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/m ³	21 kN/m ³
Coefficients of static lateral earth pressure:		
Active, K_a	0.27	0.27
At rest, K_o	0.43	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).

6.8.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must also 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	0.040g	0.26	0.26	0.31
	975-Yr	0.071g	0.27	0.27	0.32
	2,475 Yr	0.135g	0.29	0.29	0.35

	Design Earthquake	Site PGA	Seismic Active Pressure Coefficients, K_{AE}		
			Granular A	Granular B Type II	Earth Fill
Non-Yielding Wall (Restrained)	475-Yr	0.040g	0.27	0.27	0.33
	975-Yr	0.071g	0.29	0.29	0.34
	2,475 Yr	0.135g	0.32	0.32	0.39

- 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)*.

6.9 Approach Embankment Design and Construction

It is our understanding that the existing Midland Avenue structure will be widened by about 2.6 m to the north and new wing walls / retaining walls will be constructed at the northeast and northwest corners of the new structure. The retaining wall at the northeast corner of the structure is addressed in Golder's Foundation Investigation and Design Report for the Retaining walls for this project (issued under separate cover). Approach embankment widening at this site will require placement of fill on / along the north side of the existing embankment up to about 8 m thick relative to the toe of the existing side slopes.

Along the north side of the west approach embankment, Borehole MA-04 was advanced to the north of the northerly widening footprint and encountered a 0.3 m thick layer of topsoil underlain by a 1.1 m thick layer of very stiff clayey silt fill, which is underlain by a compact to very dense sandy silt to silty sand deposit to a depth of about 3.6 m below ground surface and silt deposit to a depth of about 5.0 m below ground surface.

Along the north side of the east approach embankment, Borehole MA-03 was advanced near the northerly widening footprint and encountered a 0.8 m thick layer of silty sand fill which is underlain by a deposit of dense to very dense sandy silt to silt and sand to silty sand deposit to a depth of 4.9 m below ground surface where the borehole was terminated.

6.9.1 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 OPSS 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.

6.9.2 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 FoS for the widened embankment side slopes, constructed in accordance with the recommendations contained in Section 6.9.1, for the short-term (undrained) and long-term (drained) cases are greater than 1.3 and 1.5, respectively. The result of the analysis for the long-term (drained) case is presented on Figure 1.

6.9.3 Settlement

Settlement of the subgrade soils beneath the widened approach embankment areas, assuming that all topsoil/organic materials have been removed from the footprint of the widening 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 MA-04 and MA-03, respectively, are summarized below.

Borehole/Approach	Soil Type	Approximate Thickness (m)	Bulk Unit Weight (kN/m ³)	Elastic Modulus (MPa)
Borehole MA-04 at West Approach Embankment Toe	Firm to very stiff clayey silt (Fill)	1.1	19	15
	Compact to very dense sandy silt to silty sand	2.2	20	40
	Compact to very dense Silt	>1.4	20	15

Borehole/Approach	Soil Type	Approximate Thickness (m)	Bulk Unit Weight (kN/m ³)	Elastic Modulus (MPa)
Borehole MA-03 at East Approach Embankment Toe	Silty sand (Fill)	0.8	19	10
	Dense to very dense silt and sand	>4.1	20	50

6.9.3.1 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 (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.

6.9.3.2 Results of Analysis

Based on the analysis using the parameters presented in Section 6.9.3, 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.

6.10 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.

6.10.1 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 two tested samples (0.014 per cent and 0.031 per cent) are below the exposure class of S-3

(Moderate). Therefore, based on the two 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.

6.10.2 Potential for Corrosion

The test results indicate pH value of about 7.9 to 8.1 and a resistivity of 1,100 ohm-cm and 1,300 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 elements / 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.

6.11 Construction Considerations

6.11.1 Excavation and Control of Groundwater and Surface Water

The foundation excavations at the abutments for new sections of strip / spread footings or pile cap construction will extend to depths of about 3.0 m below the Midland Avenue grade and up to about 9.5 m below the Highway 401 grade, through the existing fill the firm silty clay and into compact to very dense zone of the sandy silt to silt and sand deposits.

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 and firm silty clay native deposit are classified as Type 3 soils, while the remaining native deposits are classified as Type 2 soils above the water groundwater level and may be classified as Type 3 soils below the groundwater level, 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 in soils above the groundwater level and 3H:1V in soils below the groundwater level.

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 Midland Avenue overpass structure. Recommendations for temporary protection systems are provided in Section 6.11.2 below.

Excavations for construction of the structure foundations are anticipated to extend to about the level of the groundwater table, which is interpreted to be at approximately Elevation 163.7 m. The groundwater level should be lowered to not less than 0.3 m below the base of the excavation(s) prior to the excavation reaching the base level. 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 (Excavation 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.

6.11.2 Temporary Protection Systems

To facilitate the staged rehabilitation and widening of the Midland Avenue overpass, including for construction of foundation units, temporary protection systems are expected to be required between the WB and EB core lanes, between the WB core and collector lanes and potentially between the WB collector lanes and the widening construction limit. Temporary protection systems may also be required in front of the existing/new abutment foundations to protect Midland Avenue.

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 Midland Avenue 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 fill deposits. 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.

6.11.3 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.

6.11.4 Obstructions

Cobbles and/or boulders were encountered and are inferred present due to the difficulty to augering and grinding of the augers 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 as noted in Section 6.6.1. In addition it is recommended that a Notice to Contractor 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 is presented in Appendix F.

6.11.5 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 and 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 homes are located about 50 m to 75 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 100 m radius of any deep foundation or protection system installation, however, it should be noted that in some cases other agencies (such as Municipal or Rail) may choose to expand the radius beyond that anticipated for attenuation of construction-induced vibrations, to mitigate potential claims from property owners. For this site, because the buildings are located at least 150 m from the construction site, pre- and post-construction condition surveys are not strictly required, although MTO may consider such surveys to be desirable.

An NSSP describing the requirements for vibration monitoring is presented in Appendix F.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Matthew Kelly, 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.



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MWK/JMAC/nk/rb

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<https://golderassociates.sharepoint.com/sites/16003g/6.deliverables/3.midlandavenue/4.final/1669995fidr042019jan21hwy401wbmidlandaveoverpass.docx>

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ASTM International:

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

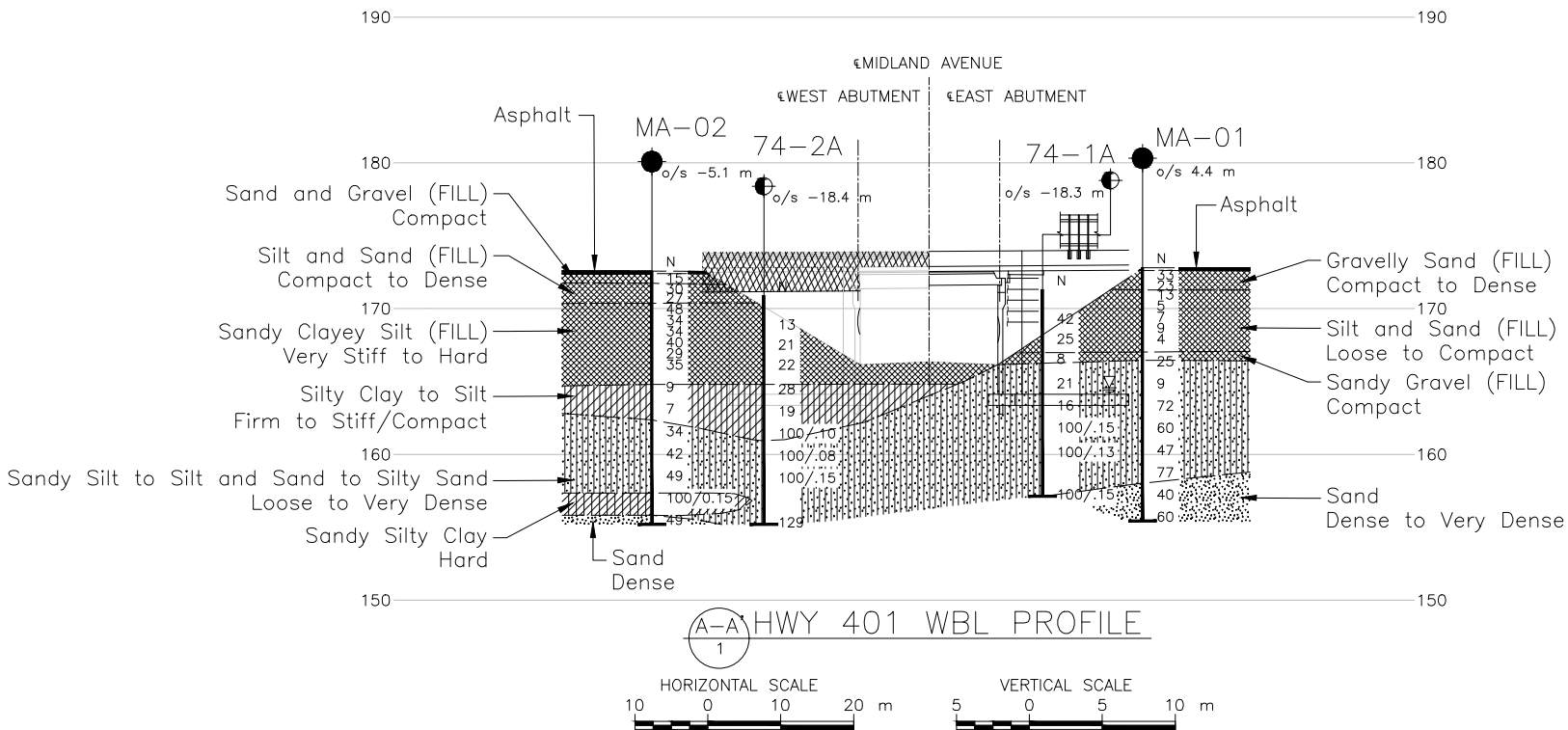
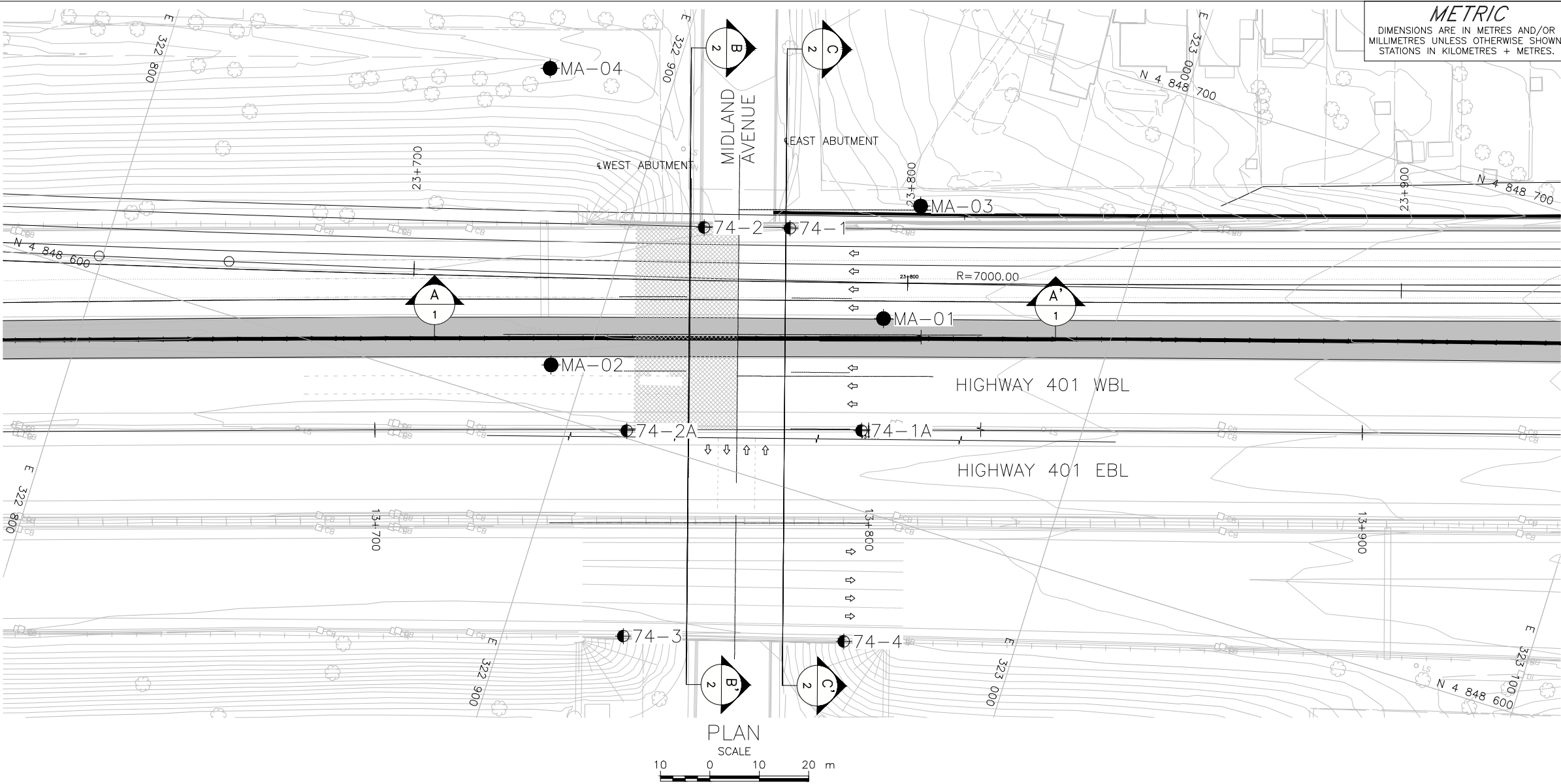
Standard Drawing SS103-11. Pile Driving Control, April 2008.

Embankment Settlement Criteria for Design. July 2, 2010.

TABLE 1 – COMPARISON OF FOUNDATION ALTERNATIVES – MIDLAND AVENUE OVERPASS WIDENING

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability	Estimated Costs
Spread/strip footings founded on native soils	Feasible for support of the abutments; requires temporary protection for staged construction.	<ul style="list-style-type: none">• Suitable founding strata at shallow depths which reduces depth of excavation and temporary excavation support requirements.• Existing structure is supported on shallow foundations, and has performed well; compatible with existing foundations which are to remain.• Permits semi-integral abutment configuration as also proposed for the rehabilitation (conversion) of the existing foundations.	<ul style="list-style-type: none">• Temporary protection systems required along north edge of Highway 401 WB collector, between WB and EB core lanes, between WB Core and Collector lanes, and may be required along Midland Avenue.• Lower bearing geotechnical resistances compared to deep foundation options.• Excavations will extend to about 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.	<ul style="list-style-type: none">• Conventional excavation and construction techniques.	<ul style="list-style-type: none">• Lower relative cost than deep foundations.
Steel H-piles founded within “100-blow” material	Feasible for support of the abutments; requires temporary protection for staged construction.	<ul style="list-style-type: none">• Abutment pile caps could be maintained slightly higher than footings founded on native soils, thus reducing excavation depth and associated protection system requirements.• Allows for integral or semi-integral abutment construction; could be made compatible with the existing shallow foundations (will not be replaced), upon rehabilitation to a semi-integral abutment configuration.• Potentially only one location of TPS required.	<ul style="list-style-type: none">• Temporary protection systems will be required along the north edge of Highway 401 WB Collector lanes to facilitate excavation to pile cap level and may be required along Midland Avenue.• Pre-augering into the “100-blow” soils may be required to achieve the required pile lengths.• Risk of encountering obstructions that could impact pile installation.• Larger/specialized equipment required for installation of piles than for construction of shallow foundations.• May not be compatible with existing shallow foundations to remain.	<ul style="list-style-type: none">• Conventional construction methods for driven piles; augering into the “100-blow” material may be required to achieve minimum pile lengths (5 m).	<ul style="list-style-type: none">• 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.• 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 the abutments; requires temporary protection for staged construction.	<ul style="list-style-type: none">• Higher bearing resistances than for shallow foundation or steel H-pile foundations, requiring fewer elements.• Can be made compatible with existing foundations allowing for semi-integral abutment configuration.• Pile cap could be constructed at the underside of the superstructure – little to no TPS required.	<ul style="list-style-type: none">• Temporary liners would be required during construction to control potential ground losses in the non-cohesive soils and to mitigate for groundwater seepage.• Cleaning of the base below the water table could be difficult.• Concrete would have to be placed by tremie methods below the water level.• Risk of encountering obstructions that could impact pile installation.• May not be compatible with existing shallow foundations to remain.	<ul style="list-style-type: none">• Conventional construction methods for drilled shaft foundations; temporary liners required for ground and groundwater control.	<ul style="list-style-type: none">• 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.
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METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.2162-11-00

MIDLAND AVENUE OVERPASS
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS
BOREHOLE LOCATIONS PLAN AND
SOIL STRATA



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- Borehole - 1966 Investigation (GEOCREs No. 30M14-74)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
74-1	166.1	4848650.4	322931.3
74-1A	171.3	4848615.6	322957.3
74-2	165.6	4848645.5	322914.7
74-2A	170.9	4848601.5	322911.9
74-3	165.2	4848561.5	322923.5
74-4	166.2	4848573.7	322966.5
MA-01	172.8	4848638.6	322954.8
MA-02	172.6	4848609.7	322893.3
MA-03	167.4	4848662.6	322955.2
MA-04	164.6	4848667.0	322875.3

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.
General Arrangement provided in digital format by WSP, drawing file no. S17M-01449-00-305-001GA.dwg, received June 5, 2018.
Existing ground provided in digital format by WSP, drawing file no. Contours Sept. 12, 2019.dwg, received September 12, 2018.



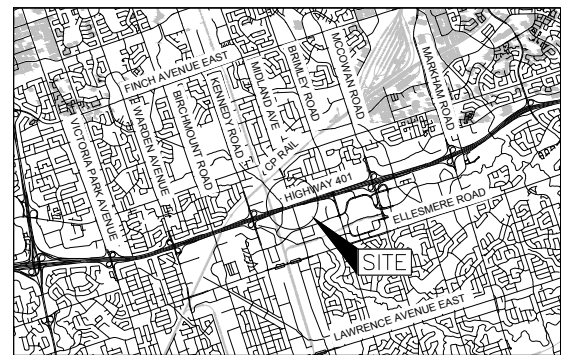
NO.	DATE	BY	REVISION
Geocres No. 30M14-495			
HWY. 401	PROJECT NO. 1669995	DIST. .	
SUBM'D. NK	CHKD. MWK	DATE: 01/18/2019	SITE: 37-216
DRAWN: DD	CHKD. MWK	APPD. JMAC	DWG. 1

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

CONT No.
WP No.2162-11-00

MIDLAND AVENUE OVERPASS
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS

SHEET



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- Borehole - 1966 Investigation (GEOCREs No. 30M14-74)
- ⊥ Seal
- ⊥ Piezometer
- 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

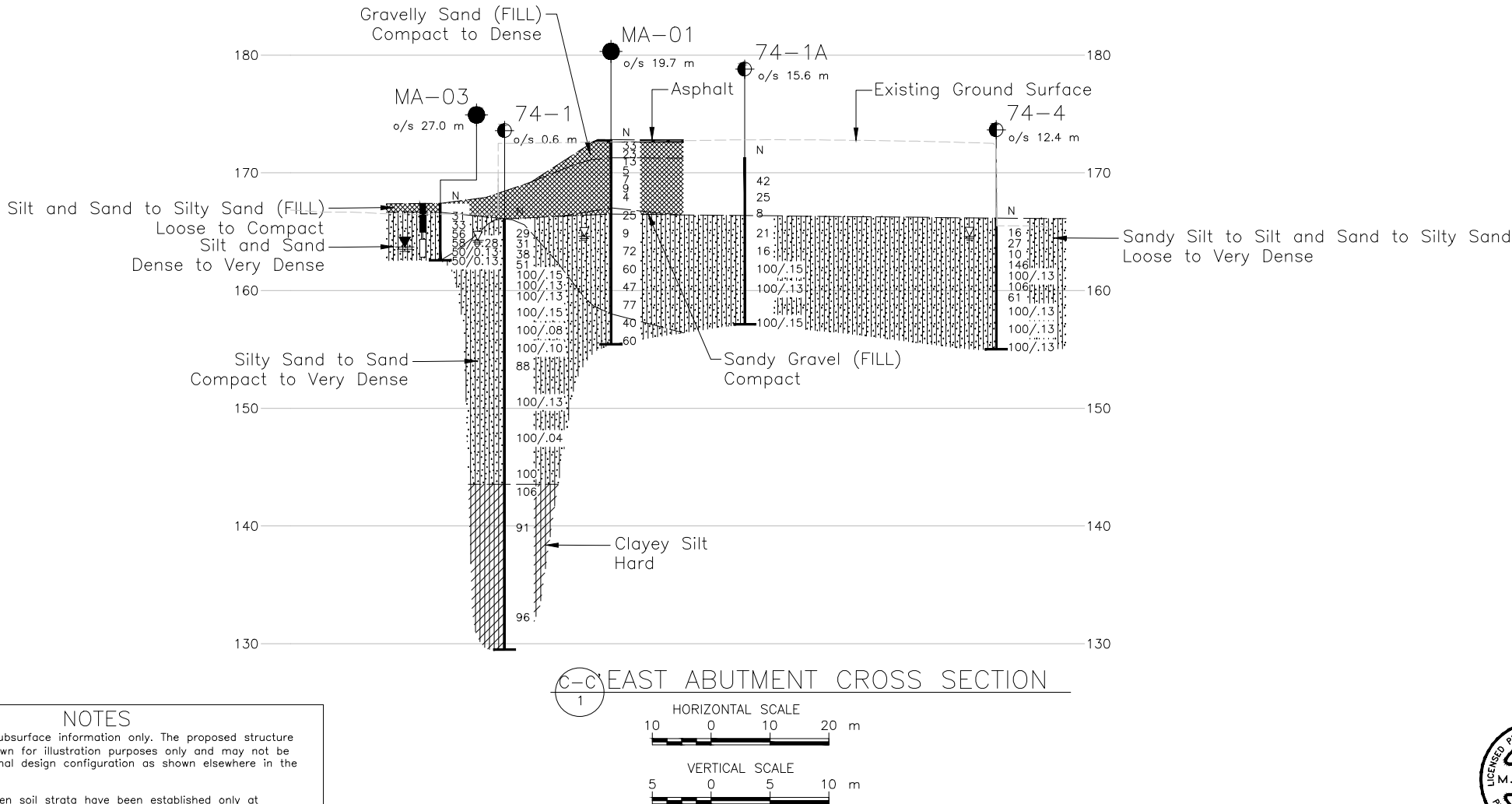
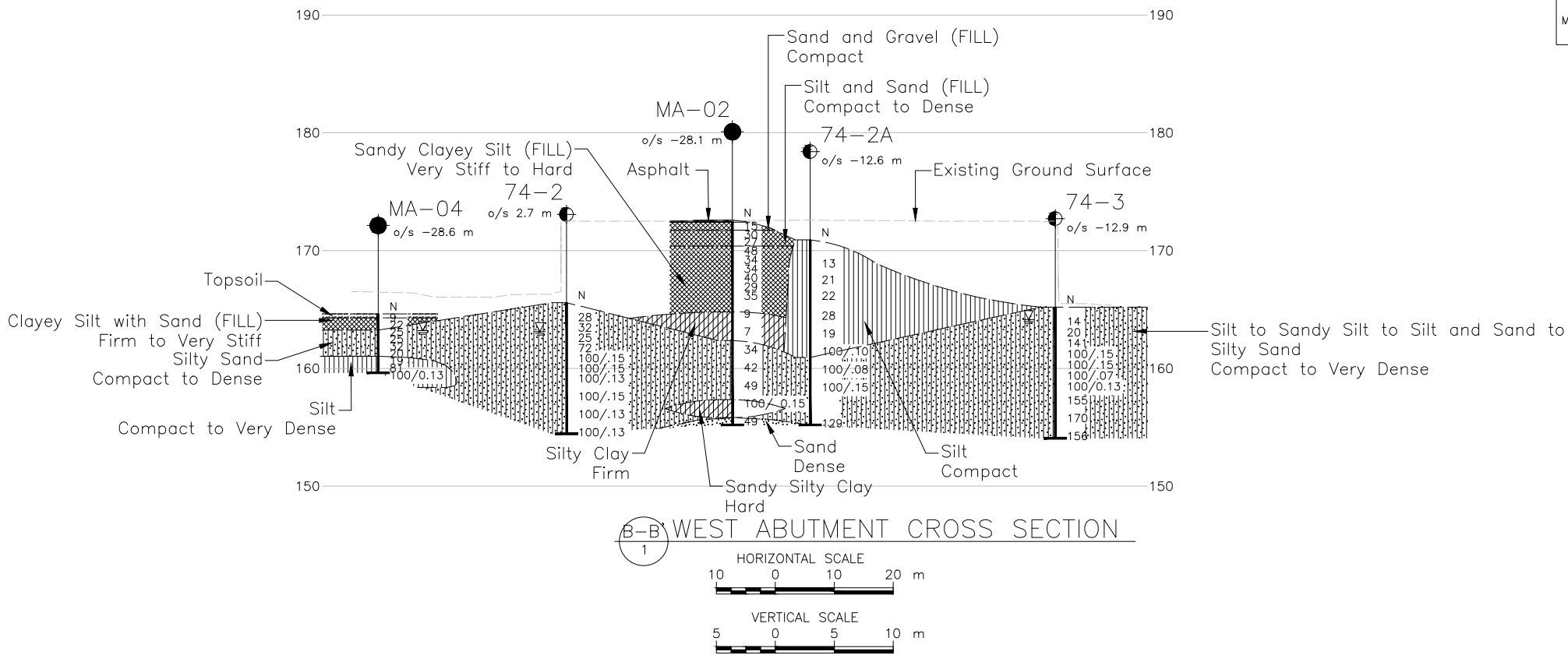
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74-3	165.2	4848561.5	322923.5
74-4	166.2	4848573.7	322966.5
MA-01	172.8	4848638.6	322954.8
MA-02	172.6	4848609.7	322893.3
MA-03	167.4	4848662.6	322955.2
MA-04	164.6	4848667.0	322875.3

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NO.	DATE	BY	REVISION
Geocres No. 30M14-495			
HWY. 401	PROJECT NO. 1669995		DIST. .
SUBM'D. NK	CHKD. MWK	DATE: 01/08/2019	SITE: 37-216
DRAWN: DD	CHKD. MWK	APPD. JMAC	DWG. 2



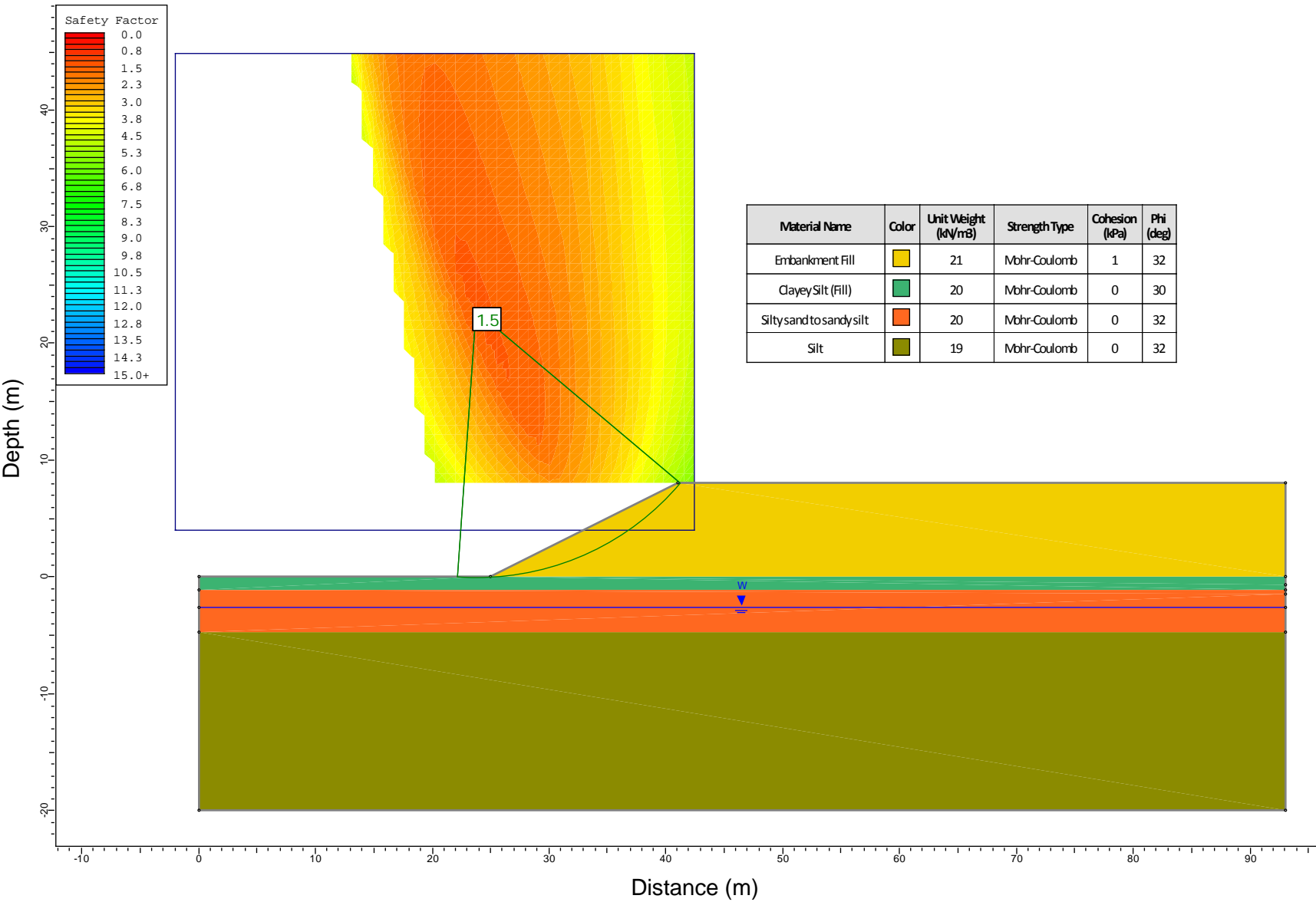
NOTES

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

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

Static Slope Stability Analysis – West Approach Embankment

Figure 1



APPENDIX A

**Borehole Records from 1966
Investigation (GEOCRES No.
30M14-074)**

BH 74-1

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 371 #10; 134' Lt. of E

ORIGINATED BY A.K.B.

W.P. 250-61

BORING DATE Sept. 29-Oct. 5, 1966

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Washboring, BX & NX Casing

CHECKED BY *AKB*

SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS				
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	20	40	60			80	100	WP	W
544.9	GROUND LEVEL														
0.0															
			1	SS	29	540									
			2	SS	31										
			3	SS	38										
			4	SS	51										
	Grey and Brown		5	SS	100/6"	530									
	Sand to Silty Sand		6	SS	100/5"										
	Traces of Gravel & clay.		7	SS	100/5"										
			8	SS	100/6"	520									
	Compact to very dense.		9	SS	100/3"										
			10	SS	100/4"	510									
			11	SS	88										
						500									
			12	SS	100/5"										
						490									
			13	SS	100/1.5"										
						480									
			14	SS	100										
						470									
			15	SS	106										
	Grey Clayey Silt		16	SS	91										
	Hard					450									
			17	SS	96										
						440									
						430									
						420									
424.9	End of Borehole														

W.L.
El. 538.9Sa. 91%
Si. & Cl. 9%

BH 74-1A

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1A

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 371 459.5; 1.5' Lt. 2

ORIGINATED BY A.K.B.

W.P. 260-61

BOHRING DATE Oct. 31, 1966

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Washboring, BX Casing

CHECKED BY AK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WP	W	WL		
171.3	562.0	GROUND LEVEL														
	0.0					560										
			1	SS	42											
	Brown & Grey															
			2	SS	25	550										
	Sandy Silt with traces of clay															
			3	SS	8									NP		
			4	SS	21	540										
	Loose to very dense															
			5	SS	16											
			6	SS	100/6"	530										
			7	SS	100/5"											
						520										
157.1	515.5		8	SS	100/5"											
14.2	46.5	End of Borehole														

Gr. 3%
Sa. 44%
Sl. 42%
Cl. 11%

Gr. 4%
Sa. 39%
Sl. & Cl. 57%

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2A

FOUNDATION SECTION

JOB 66-F-87

LOCATION

Sta. 370 +03.5; 1' Rt. of E

ORIGINATED BY AKB

W.P. 260-61

BORING DATE

November 2, 1966

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE

Washboring, BX Casing

CHECKED BY

AKB

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	wp	w	wL		
(w) 170.9	560.7	GROUND LEVEL														
0.0						560										
	Brown & Grey		1	SS	13											
	Silt with occ. layers of clayey silt.		2	SS	21	550										
			3	SS	22											
	Compact		4	SS	28	540										
			5	SS	19											
			6	SS	100/4"	530										
			7	SS	100/3"											
	Silty Sand to Sand.		8	SS	100/6"	520										
	Very Dense															
ISS.2 15.7	509.2		9	SS	129	510										
	51.5	End of Borehole														

Org. 2.6%

BH 74-4

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 66-F-87 LOCATION Sta. 371 + 50; 139' Rt. of C ORIGINATED BY AKB
W.P. 260-61 BORING DATE Oct. 12, 1966 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Washboring, BX Casing CHECKED BY AKR

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					WATER CONTENT %					
							20	40	60	80	100	WP	WL	W			
							SHEAR STRENGTH P.S.F.										
545.1	GROUND LEVEL																
0.0	Brown & Grey Silty sand with traces of clay Compact to very dense	•••••	1	SS	16	540										▼ W.L. = El. 540.0 Gr. 1% Sa. 70% Si. & Cl. 29%	
			2	SS	27												
			3	SS	10												
			4	SS	14.6												
			5	SS	100/5"	530											
			6	SS	106												
			7	SS	61												
			8	SS	100/5"	520											
			9	SS	100/5"												
			10	SS	100/5"	510											
508.6	End of Borehole	•••••															
36.5																	

APPENDIX B

**Borehole Records from 2018
Investigation**

LIST OF SYMBOLS

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

I. GENERAL

π	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

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	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
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_{α}	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
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² 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	N
Condition	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test 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)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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

PROJECT 1669995		RECORD OF BOREHOLE No MA-01		SHEET 1 OF 2		METRIC	
G.W.P. 2219-14-00		LOCATION N 4848638.6; E 322954.8 MTM NAD 83 ZONE 10 (LAT. 43.777494; LONG. -79.274470)		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 26 and 27, 2018		CHECKED BY NK/LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _P	W	W _L					
172.8	GROUND SURFACE																			
0.0	ASPHALT (178 mm)																			
0.2	Gravelly sand, some silt (FILL) Compact to dense Brown Moist		1	SS	33															
			2	SS	23															
171.3	Silt and sand, trace to some clay, trace gravel (FILL) Loose to compact Brown Moist to wet		3	SS	13															
			4	SS	5															
			5	SS	7															
			6	SS	9															
			7	SS	4															
167.0	Sandy gravel, some silt (FILL) Brown to grey Moist		8A	SS	25															
166.5	SILT and SAND, trace to some clay, trace gravel, trace organics Loose to compact Grey Moist to wet		8B	SS	25															
6.4			9	SS	9															
164.1	SILT and SAND, trace to some gravel, trace clay Dense to very dense Brown to grey Moist to wet		10	SS	72															
8.7			11	SS	60															
	- Grinding on inferred cobble between depths of approximately 10.7 m and 11.3 m		12	SS	47															
	- Grinding on inferred cobble between depths of approximately 11.6 m and 11.9 m		13	SS	77															
158.0																				
14.8																				

Continued Next Page

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

GTA-MTO 001 S:\CLIENTS\MTOWHY_401\02_DATA\GINT\HWY_401.GPJ GAL-GTA-GDT 01/18/19

PROJECT		1669995		RECORD OF BOREHOLE No MA-01				SHEET 2 OF 2		METRIC							
G.W.P.		2219-14-00		LOCATION		N 4848638.6; E 322954.8 MTM NAD 83 ZONE 10 (LAT. 43.777494; LONG. -79.274470)		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 26 and 27, 2018		CHECKED BY		NK/LCC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
	SAND, trace to some silt, trace clay Dense to very dense Brown Wet		14	SS	40		157										0 87 12 1
							156										
155.4 17.4	END OF BOREHOLE		15	SS	60												
NOTES:																	
1. Borehole caved to a depth of approximately 12.8 m upon removal of augers.																	
2. Water level measured in open borehole at a depth of about 8.2 m below ground surface (Elev. 164.6 m) upon completion of drilling.																	



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PROJECT		1669995		RECORD OF BOREHOLE				No MA-02		SHEET 1 OF 2		METRIC		
G.W.P.		2219-14-00		LOCATION		N 4848609.7; E 322893.3 MTM NAD 83 ZONE 10 (LAT. 43.777235; LONG. -79.275236)				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 22 and 23, 2018				CHECKED BY		NK/LCC		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
								20 40 60 80 100		W _P W W _L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED		WATER CONTENT (%)				
172.6	GROUND SURFACE													
0.0	ASPHALT (178 mm)													
0.2	Sand and gravel, some silt (FILL) Compact Brown Moist		1	SS	15									
171.8														
0.8	Silt and sand, trace to some gravel, trace to some clay (FILL) Compact to dense Brown Moist		2	SS	30									
			3	SS	27									
170.4														
2.2	Sandy clayey silt, trace to some gravel (FILL) Very stiff to hard Brown Moist - Grinding on inferred cobble at depth of approximately 2.7 m		4	SS	48									
			5	SS	34									
			6	SS	34									
			7	SS	40									
			8	SS	29									
			9	SS	35									
164.8			10A											
7.8	SILTY CLAY, trace to some gravel, trace sand, trace organics Firm to stiff Dark grey Wet		10B	SS	9									
			11	SS	7									
162.4														
10.2	SILT and SAND to SILTY SAND, trace to some gravel, trace to some clay Dense Grey Moist		12	SS	34									
			13	SS	42									
			14	SS	49									

Continued Next Page

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

GTA-MTO 001 S:\CLIENTS\MTOWHY_401\02_DATA\GINT\HWY_401.GPJ GAL-GTA.GDT 01/18/19

PROJECT 1669995		RECORD OF BOREHOLE No MA-02				SHEET 2 OF 2		METRIC								
G.W.P. 2219-14-00		LOCATION N 4848609.7; E 322893.3 MTM NAD 83 ZONE 10 (LAT. 43.777235; LONG. -79.275236)				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 22 and 23, 2018				CHECKED BY NK/LCC										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100					
157.4																
15.2	Sandy SILTY CLAY, some gravel Hard Grey Wet		15	SS	100/ 0.15											
155.8																
16.8	SAND, trace gravel, trace silt Dense Brown Wet		16	SS	49											
155.2																
17.4	END OF BOREHOLE															
	NOTES: 1. Borehole caved to a depth of approximately 11.0 m upon removal of augers. 2. Open borehole dry above 11.0 m depth (Elev. 161.6 m) upon completion of drilling.															

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PROJECT		1669995		RECORD OF BOREHOLE No MA-03		SHEET 1 OF 1		METRIC					
G.W.P.		2219-14-00		LOCATION		N 4848662.6; E 322955.2 MTM NAD 83 ZONE 10 (LAT. 43.777710; LONG. -79.274464)		ORIGINATED BY DS					
DIST		Central HWY 401		BOREHOLE TYPE		CME 55 Truck-Mounted Drill Rig, 178 mm O.D. Hollow Stem Augers		COMPILED BY SE					
DATUM		Geodetic		DATE		May 31, 2018		CHECKED BY NK/LCC					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)		
167.4	GROUND SURFACE												
0.0	Silty sand, trace gravel (FILL) Brown Moist						167						
166.6	SILT and SAND, trace to some clay, trace gravel Dense to very dense Brown to grey below 3.0 m Moist		1	SS	31		166						
0.8			2	SS	33								
			3	SS	56		165						
			4	SS	58/0.28		164						
			5	SS	50/0.13		163						
162.5			6	SS	50/0.13								
4.9	END OF BOREHOLE												
NOTES: 1. Piezometer dry on completion of installation. 2. Water level measured in piezometer as follow: Date Depth (m) Elev. (m) Jul 30/18 3.7 163.7													

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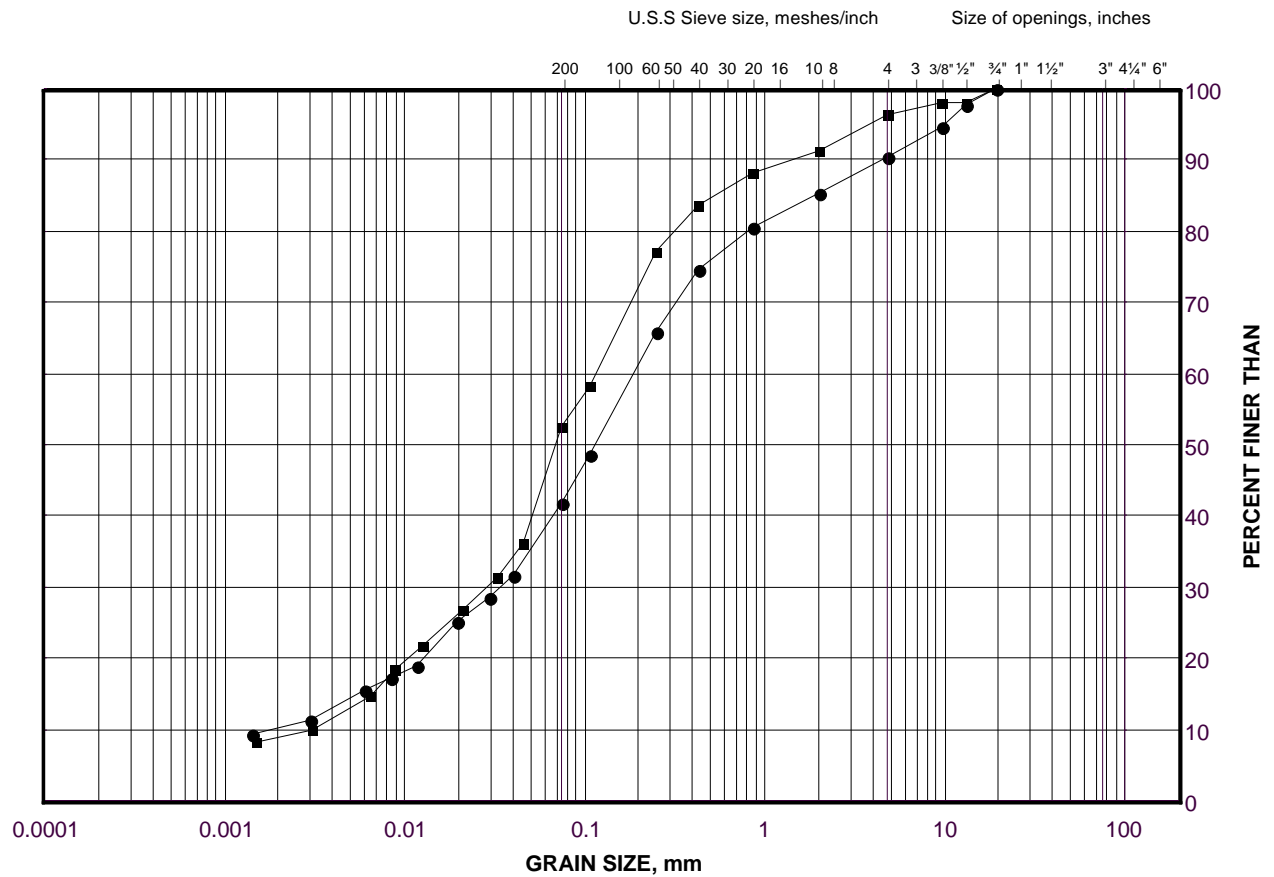
PROJECT		1669995		RECORD OF BOREHOLE No MA-04				SHEET 1 OF 1		METRIC							
G.W.P.		2219-14-00		LOCATION		N 4848667.0; E 322875.3 MTM NAD 83 ZONE 10 (LAT. 43.777752; LONG. -79.275457)		ORIGINATED BY		LK							
DIST		Central HWY 401		BOREHOLE TYPE		Portable Tripod, Mud Rotary		COMPILED BY		CC							
DATUM		Geodetic		DATE		November 16, 2018		CHECKED BY		MWK							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
164.6	GROUND SURFACE																
0.0	TOPSOIL (330 mm)		1	SS	9												
164.3			2A	SS	22												
0.3	Clayey silt with sand (FILL) Firm to very stiff Greyish brown Wet		2B	SS	22												
163.2			3	SS	25												
1.4	Silty SAND, trace to some clay Compact to dense Brown grey to grey below 2.4 m Wet		4	SS	25												
			5	SS	32												
			6	SS	20												
161.0			7	SS	19												
3.6	SILT, trace to some sand, trace to some clay Compact to very dense Grey Wet		8	SS	81												
			9	SS	100/0.1												
159.6																	
5.0	END OF BOREHOLE																
	NOTE: 1. Water level at a depth of 1.4 m below ground surface (Elev. 163.2 m) during advancement of borehole.																

APPENDIX C

Geotechnical Laboratory Test Results

Silt and Sand (Fill)

FIGURE C-1A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	MA-02	3	170.8
■	MA-01	5	169.4

Project Number: 1669995

Checked By: MWK

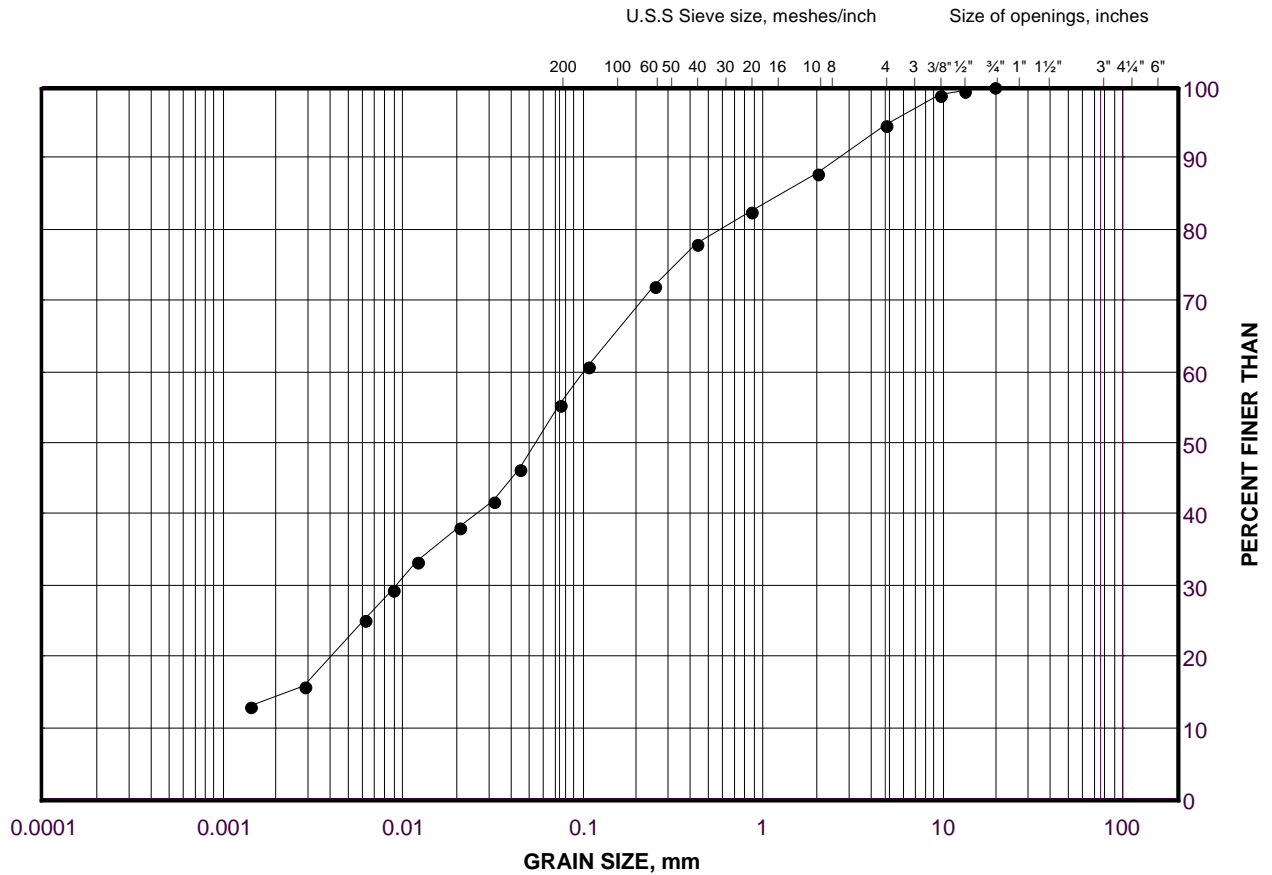
Golder Associates

Date: 27-Nov-18

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE C-1B



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

LEGEND

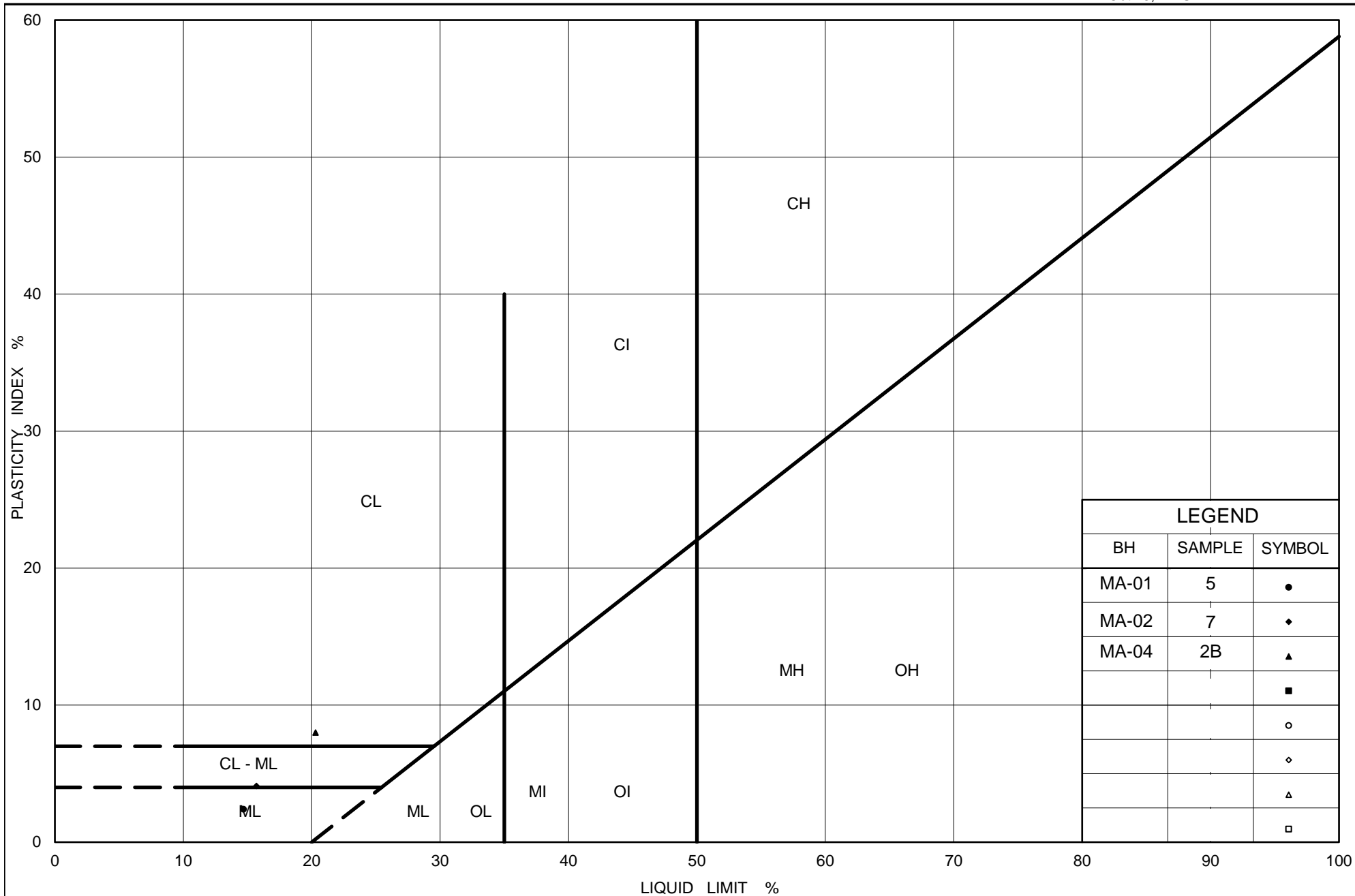
SYMBOL	Borehole	SAMPLE	ELEVATION
•	MA-04	2B	164.1

Project Number: 1669995

Checked By: MWK

Golder Associates

Date: 14-Dec-18



Ministry of Transportation

Ontario

PLASTICITY CHART Silt to Clayey Silt (Fill)

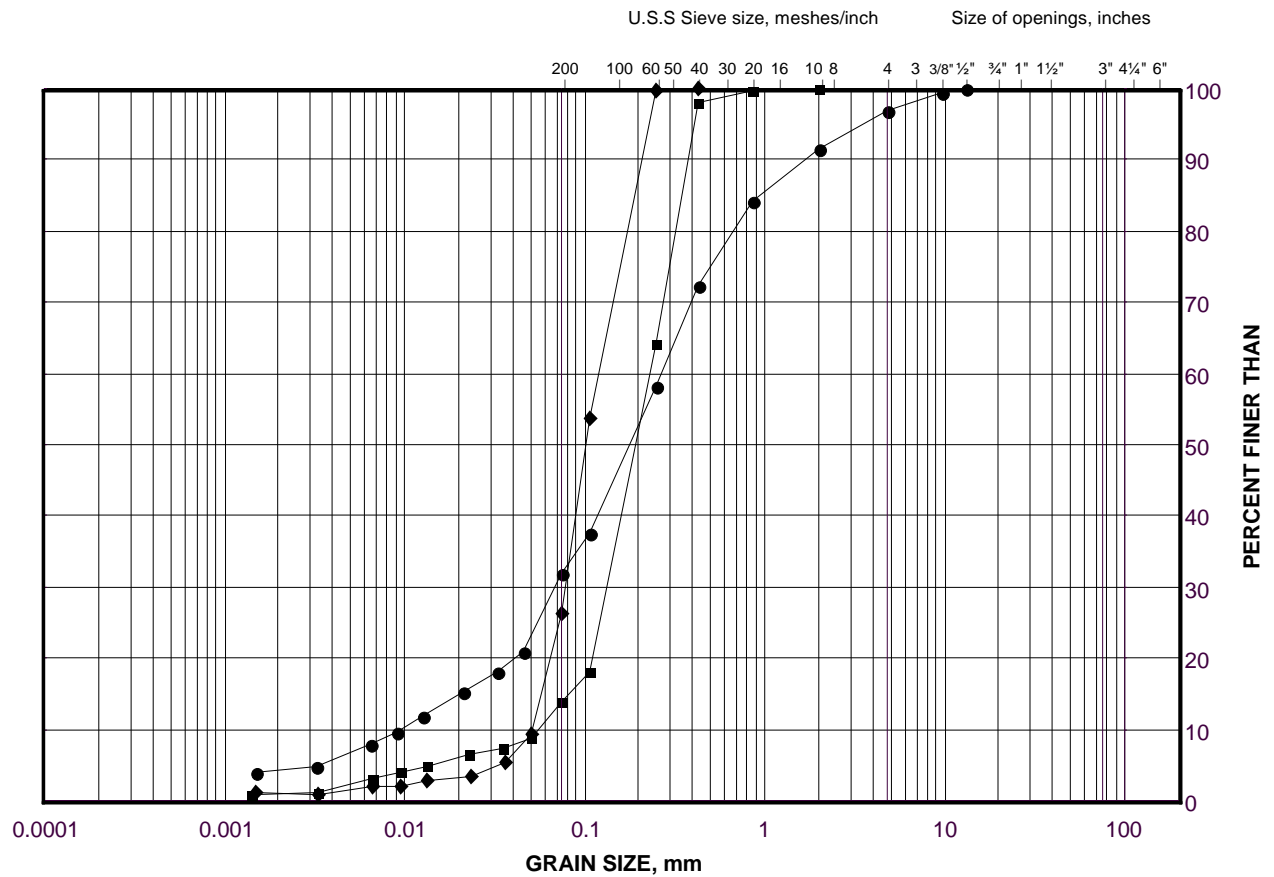
Figure No. C-2

Project No. 1669995

Checked By: MWK

Silty Sand to Sand

FIGURE C-3A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION
●	MA-02	14	158.5
■	MA-01	14	157.3
◆	MA-04	4	163.0

Project Number: 1669995

Checked By: MWK

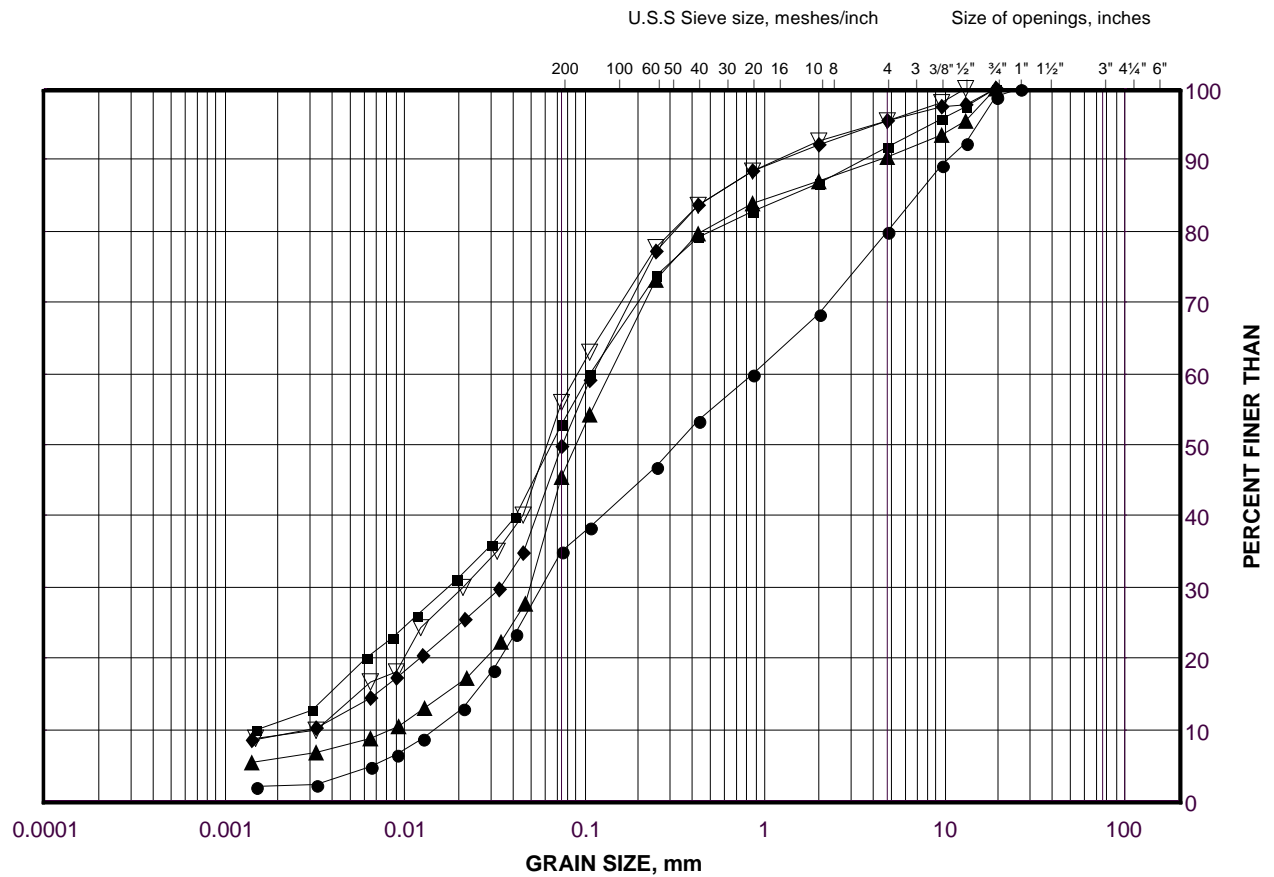
Golder Associates

Date: 14-Dec-18

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE C-3B



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION
●	MA-01	12	160.3
■	MA-02	13	160.1
◆	MA-03	2	165.6
▲	MA-03	6	162.7
▽	MA-01	9	164.9

Project Number: 1669995

Checked By: MWK

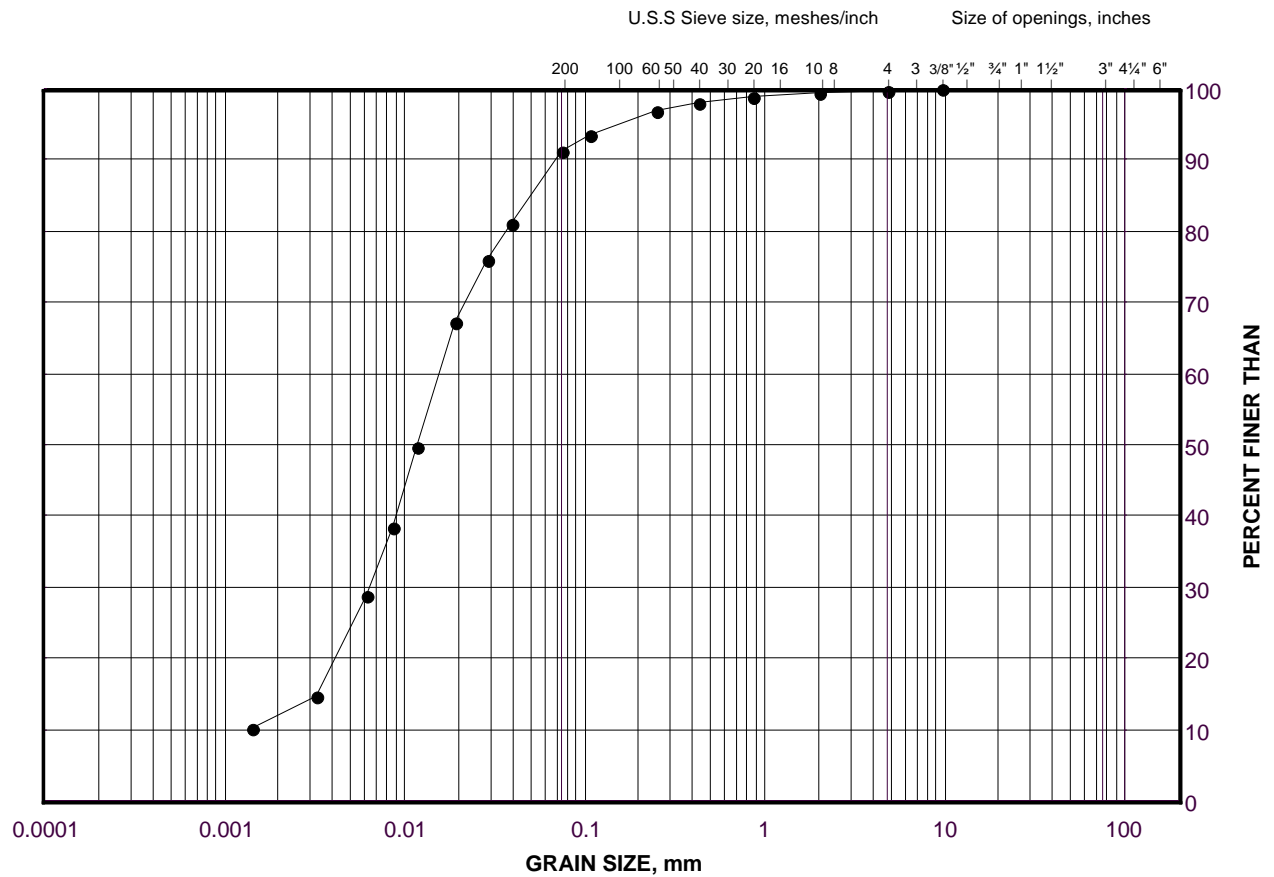
Golder Associates

Date: 14-Dec-18

GRAIN SIZE DISTRIBUTION

Silt

FIGURE C-3C



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

LEGEND

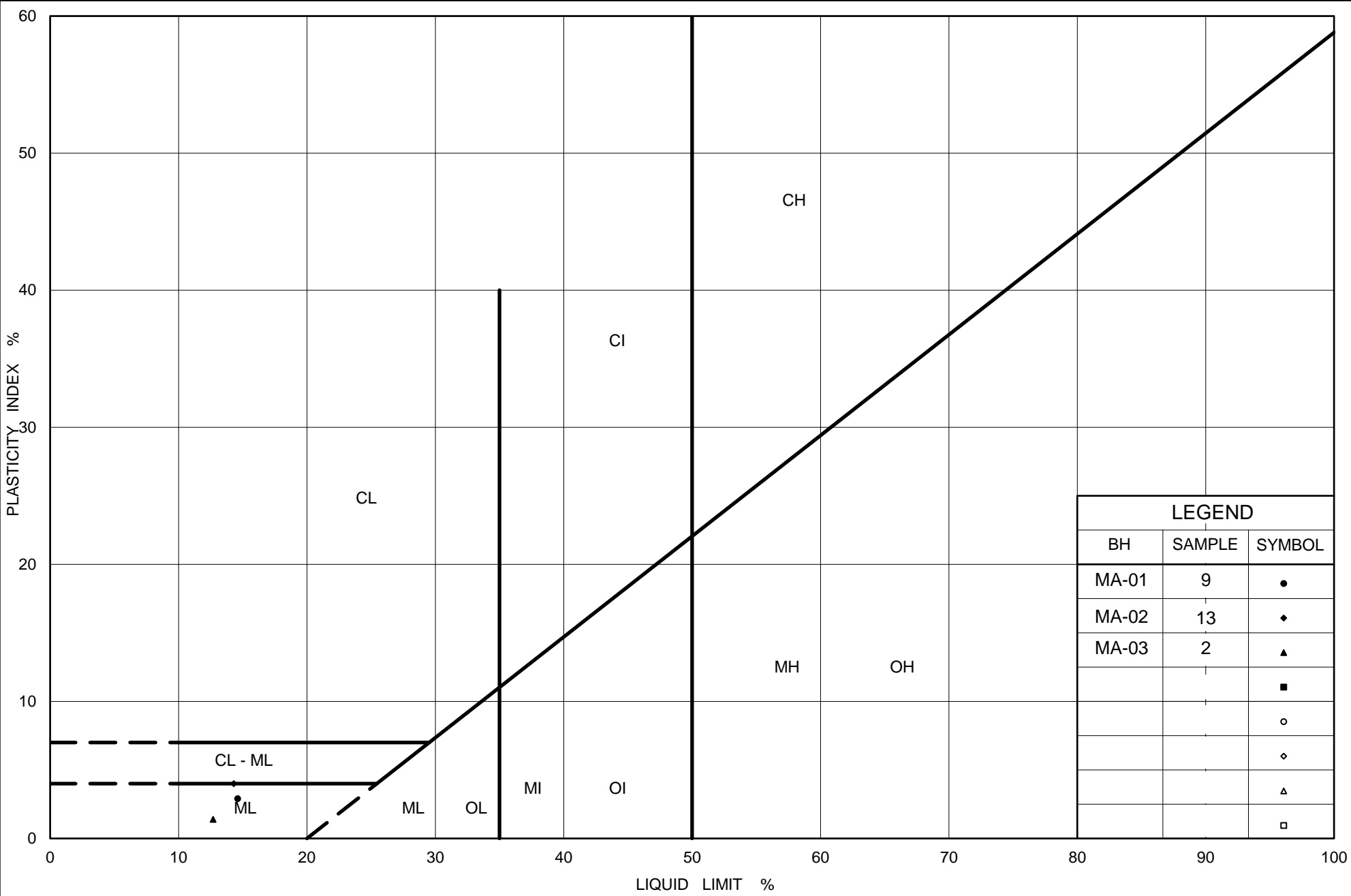
SYMBOL	Borehole	SAMPLE	ELEVATION
•	MA-04	7	161.1

Project Number: 1669995

Checked By: MWK

Golder Associates

Date: 14-Dec-18



Ministry of Transportation

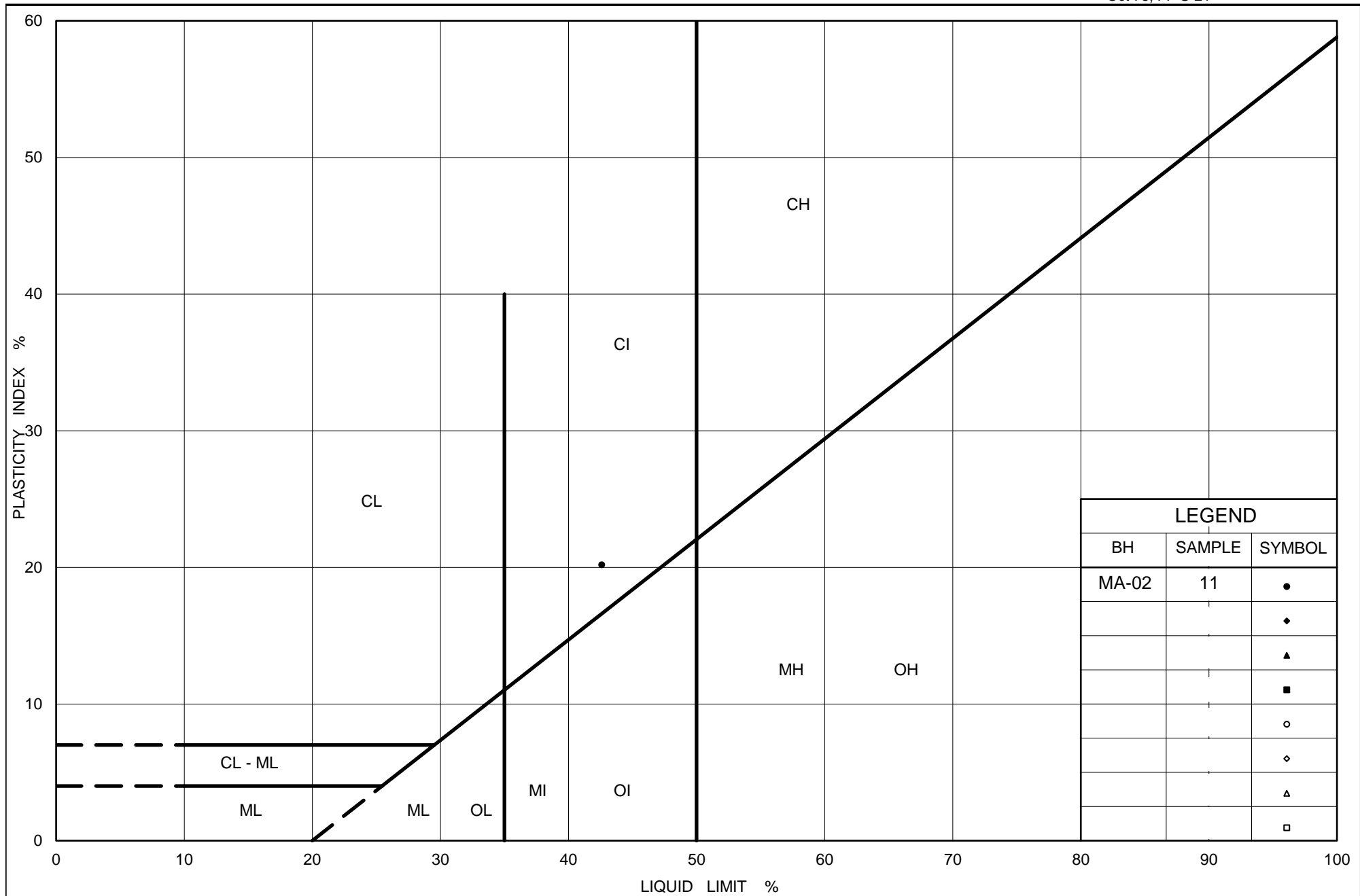
Ontario

PLASTICITY CHART
Silt

Figure No. C-4

Project No. 1669995

Checked By: MWK



Ministry of Transportation

Ontario

PLASTICITY CHART Silty Clay

Figure No. C-5

Project No. 1669995

Checked By: MWK

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 CaCl ₂ 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.

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.

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										

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 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

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.

QUALITY ASSURANCE REPORT

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

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5452380	Available (CaCl ₂) 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 (SO ₄)	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)

VALIDATION SIGNATURE PAGE

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



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

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CHAIN OF CUSTODY RECORD **105772** Page 1 of 1

Invoice Information Company Name: <u>Golden Associates Ltd.</u> Contact Name: <u>Nikol Kochmanova</u> Address: <u>10925 Century Ave. #100</u> <u>Mississauga ON</u> Phone: <u>905-567-4444</u> Fax: Email: <u>Nikol-Kochmanova@golder.com</u>		Report Information (if differs from invoice) Company Name: Contact Name: Address: Phone: Fax: Email:		Project Information (where applicable) Quotation #: P.O. #/ AFE#: <u>105772</u> Project #: <u>166995</u> Site Location: <u>Hwy 401 W Scarborough</u> Site #: Sampled By: <u>AB</u>		Turnaround Time (TAT) Required <input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS Rush TAT (Surcharges will be applied) <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days Date Required: Rush Confirmation #:	
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY							
Regulation 153 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other <input type="checkbox"/> Table <input type="checkbox"/> FOR RSC (PLEASE CIRCLE) Y / N		Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> PWQO Region <input type="checkbox"/> Other (Specify) <input type="checkbox"/> REG 558 (MIN. 2 DAY TAT REQUIRED)		Analysis Requested # OF CONTAINERS SUBMITTED FIELD FILTERED (CIRCLE) Metals / Hg / CrVI BTEX/ PHC F1 PHC F2 - F4 VOCs REG 153 METALS & INORGANICS REG 153 ICPMS METALS REG 153 METALS (Pb, Cr VI, ICPMS Metals, HWS - B) Corrosivity Package		LABORATORY USE ONLY CUSTODY SEAL Y / N Present Intact COOLER TEMPERATURES 9/17/19 COOLING MEDIA PRESENT: Y / <u>(N)</u> COMMENTS	
Include Criteria on Certificate of Analysis: Y / N SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM							
SAMPLE IDENTIFICATION		DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX			
1	BR-02 SA#11	2018/02/21	AM	Soil			
2	MA-02 SA#12	2018/02/22	AM	Soil			
3	CP-02 SA#11	2018/02/13	AM	Soil			
4	MR-03 SA#11	2018/03/04	AM	Soil			
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)
<u>Katie Nero Luthke</u>		<u>2018/03/20</u>	<u>12:05PM</u>	<u>Rougep / Rougep & Roueud</u>		<u>2018/03/20</u>	<u>12:06</u>

20-Mar-18 12:06

Emà Gitej



B862090

URE ENV-1226

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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 CaCl ₂ EXTRACT	20	2018/06/07	2018/06/07	CAM SOP-00413	EPA 9045 D m
pH CaCl ₂ 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.

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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.

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.

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

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									

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										

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	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										

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										

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

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

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

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

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

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

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

GENERAL COMMENTS

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

Package 1	20.0°C
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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.

QUALITY ASSURANCE REPORT

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

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5568601	Available (CaCl ₂) 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 (CaCl ₂) 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 (SO ₄)	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 (SO ₄)	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).

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.



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6740 Campbell 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 1 of 1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name: #1326 Golder Associates Ltd		Company Name: Nikol Kochmanova		Quotation #: B80683		Maxxam Job #:	
Attention: Accounts Payable		Attention:		P.O. #:		Bottle Order #:	
Address: 6925 Century Ave Suite 100		Address:		Project: 1669995		668025	
Mississauga ON L5N 7K2				Project Name: 401W		COC #:	
Tel: (905) 567-4444 Fax: (905) 567-6561		Tel: (905) 567-6100 Ext: 1459 Fax:		Site #:		Project Manager:	
Email: AP_CustomerService@golder.com		Email: Nikol_Kochmanova@golder.com		Sampled By:		Erna 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)		Other Regulations		Special Instructions	
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw		
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558	<input type="checkbox"/> Storm Sewer Bylaw		
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC	<input type="checkbox"/> MISA	<input type="checkbox"/> Municipality		
<input type="checkbox"/> Table		<input type="checkbox"/> PWQO			
		<input type="checkbox"/> Other			

Include Criteria on Certificate of Analysis (Y/N)?					Field Filtered (please circle):	ANALYSIS REQUESTED (PLEASE BE SPECIFIC)										Turnaround Time (TAT) Required:	
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix		Corrosivity, pH, Reactivity/EC - no Sulphide and Redox Potential										# of Bottles	Comments
1	BL-03 SA#14	Feb 14/18	AM	SOIL	X												
2	RW-02 SA#9	Apr 9/18	AM	SOIL	X												
3	MR-01 SA#10	Feb 28/18	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	MEU-01 SA#4	Mar 19/18	AM	SOIL	X												
7	BRU-d 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	NWL-04 SA#6	Apr 5/18	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		Laboratory Use Only					
Alex Maitland de la Roche		18/06/05		16:45		Alex Maitland de la Roche		18/06/05		16:46				Time Sensitive		Temperature (°C) on Receipt	Custody Seal Present	Yes	No
														20/20/20		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



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CHAIN OF CUSTODY RECORD

2 of 4
Page 1/1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name: #1326 Golder Associates Ltd	Company Name: Nikol Kochmanova	Quotation #: B80683	Maxxam Job #:	Bottle Order #:			
Attention: Accounts Payable	Attention: Nikol Kochmanova	P.O. #:					
Address: 6925 Century Ave Suite 100	Address:	Project: 1669995					
Mississauga ON L5N 7K2		Project Name: 401W					
Tel: (905) 567-4444 Fax: (905) 567-6561	Tel: (905) 567-6100 Ext: 1459 Fax:	Site #:			COC #:		Project Manager:
Email: AP_CustomerService@golder.com	Email: Nikol_Kochmanova@golder.com	Sampled By:			C#668025-03-01		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)		Other Regulations		Special Instructions	
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw				
<input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw				
<input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC	<input type="checkbox"/> MISA Municipality				
<input type="checkbox"/> Table <input type="checkbox"/> PWQO	<input type="checkbox"/> Other				

Include Criteria on Certificate of Analysis (Y/N)?					Field Filtered (please circle): Metals / Hg / Cr / V	Corrosivity pH (CL, SO4, pH) Reactivity/EC - no Sulphide and Redox (Potential)	ANALYSIS REQUESTED (PLEASE BE SPECIFIC)										Turnaround Time (TAT) Required:	
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix													Please provide advance notice for rush projects	
1	KR-03 SA#10	Feb 25/18	AM	SOIL		X											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.	
2	NW-05 SA#7B	Apr 11/18	AM	SOIL		X											Job Specific Rush TAT (if applies to entire submission) Date Required: Time Required: Rush Confirmation Number: (call lab for #)	
3	MA-01 SA#11	Feb 26/18	AM	SOIL		X											# of Bottles	Comments
4	NW-04 SA#4	Apr 11/18	AM	SOIL		X												
5	NW-03 SA#7	Apr 6/18	AM	SOIL		X												
6	NW-02 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	Laboratory Use Only				
See page 1			See page one				Time Sensitive	Temperature, (°C) on Reel	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.

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** 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

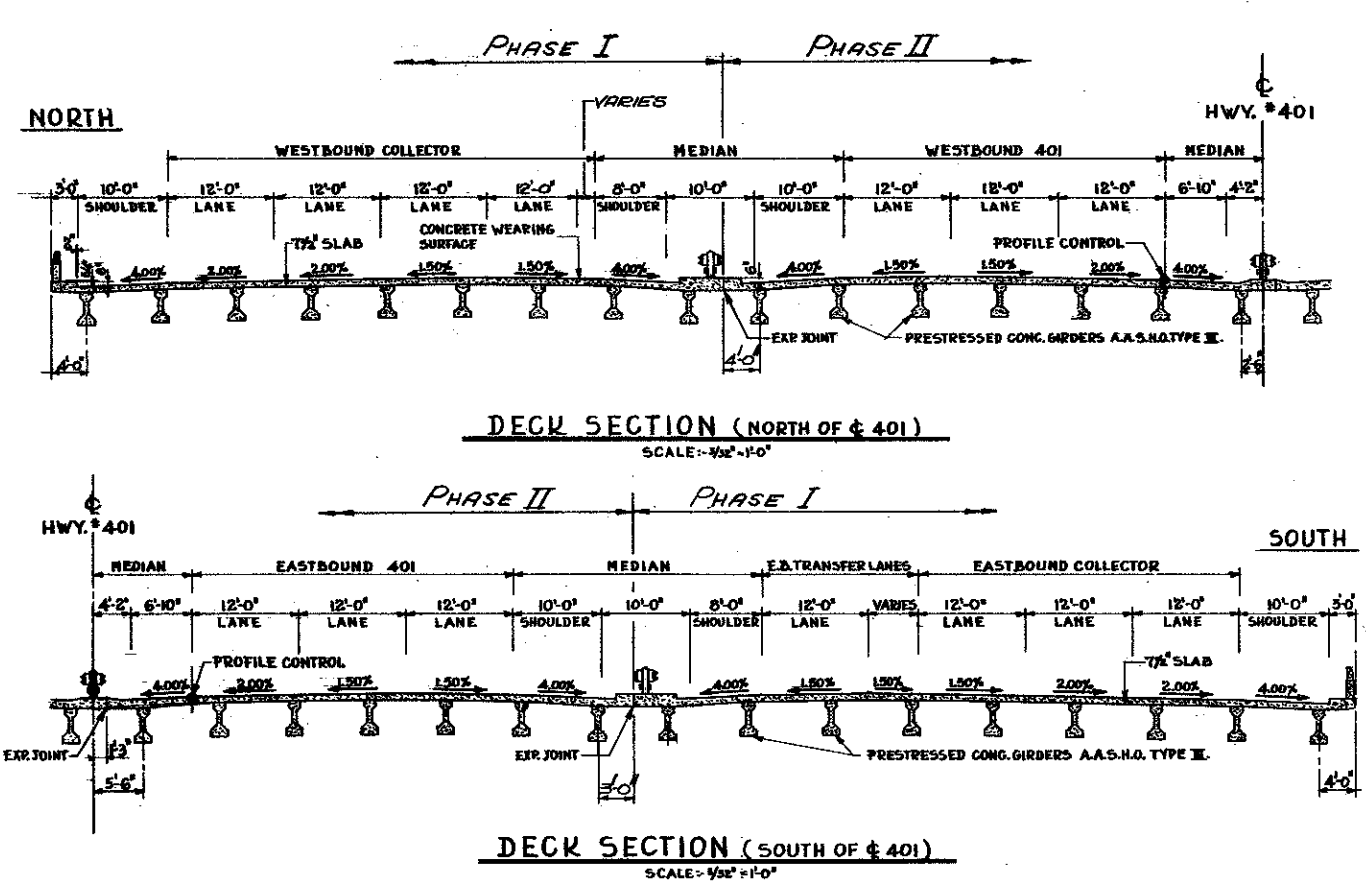
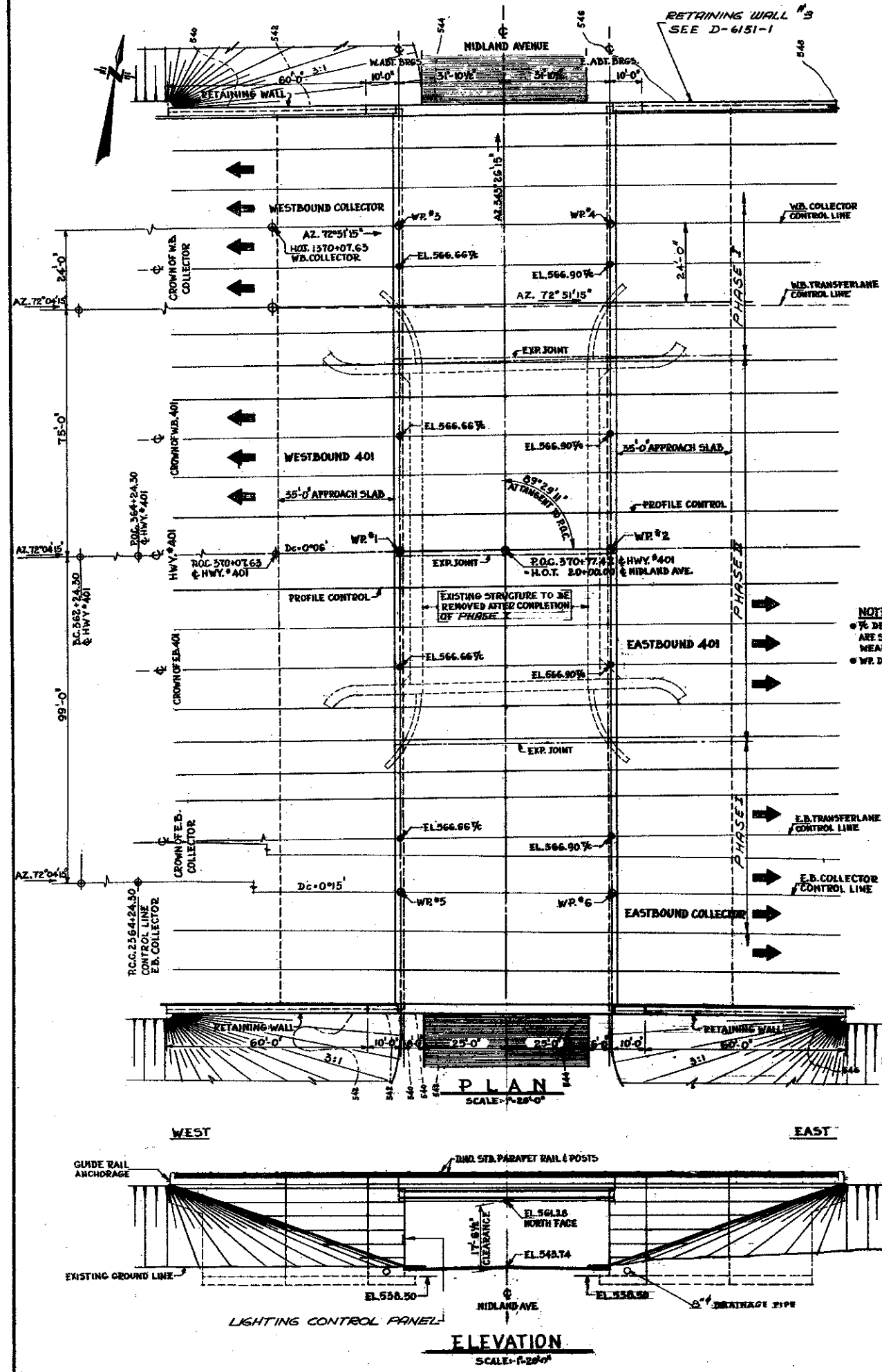
Page 4/4

INVOICE TO:			REPORT TO:			PROJECT INFORMATION:			Laboratory Use Only:								
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			Company Name: Attention: Nikol Kochmanova Address: Tel: (905) 567-6100 Ext: 1459 Fax: Email: Nikol_Kochmanova@golder.com			Quotation #: B80683 P.O.#: Project: 1669995 Project Name: 401W Site #: Sampled By:			Maxxam Job #: Bottle Order #: COC #: 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						ANALYSIS REQUESTED (PLEASE BE SPECIFIC)						Turnaround Time (TAT) Required: Please provide advance notice for rush projects					
Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____			Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA Municipality _____ <input type="checkbox"/> PWQO <input type="checkbox"/> Other _____			Special Instructions											
* Include Criteria on Certificate of Analysis (Y/N)?						Field Filtered (please circle): Metals / Hg / Cr V Corrosivity pH (CL SO4 pH) Resistivity/EC - no Sulphide and Redox (Potential)						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.					
Sample Barcode Label						Sample (Location) Identification						Date Sampled					
Time Sampled						Matrix						# of Bottles					
Comments																	
NW1-01 SA#4 Mar 26/18 AM SOIL						X											
NBPI-1 SA#9 Apr 9/18 AM SOIL						X											
CN-01 SA#20A Mar 6/18 AM SOIL						X											
CP-01 SA#12 Feb 25/18 AM SOIL						X											
OH-5 SA#7 Apr 12/18 AM SOIL						X											
OH-9 SA#5 Apr 13/18 AM SOIL						X											
NB-02 SA#4 May 19/18 AM SOIL						X											
OH-1 SA#7 Apr 12/18 AM SOIL						X											
KR-02 SA#3 May 9/18 AM SOIL						X											
MR-02 SA#7 May 7/18 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						Laboratory Use Only						Custody Seal					
Time Sensitive						Temperature (°C) on Reel						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.												White: Maxxa Yellow: Client					
* 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.												SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM					
** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC-PDF.																	

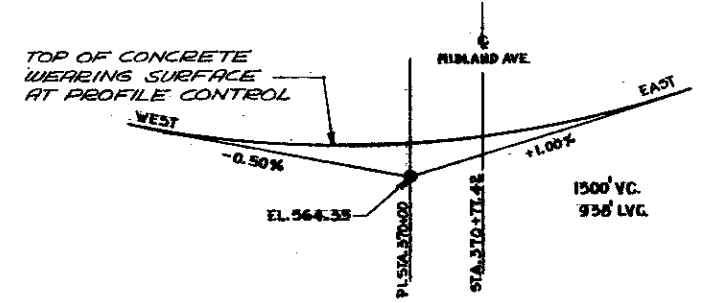
INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name: #1326 Golder Associates Ltd		Company Name:		Quotation #: B80683		Maxxam Job #:	
Attention: Accounts Payable		Attention: Nikol Kochmanova		P.O. #:		Bottle Order #:	
Address: 6925 Century Ave Suite 100		Address:		Project: 1669995		668025	
Mississauga ON L5N 7K2				Project Name:		COC #:	
Tel: (905) 567-4444 Fax: (905) 567-6561		Tel: (905) 567-6100 Ext: 1459 Fax:		Site #:		Project Manager:	
Email: AP_CustomerService@golder.com		Email: Nikol_Kochmanova@golder.com		Sampled By:		C#668025-05-01	
Ema Gitej							
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY				ANALYSIS REQUESTED (PLEASE BE SPECIFIC)			
Regulation 153 (2011)		Other Regulations		Special Instructions		Turnaround Time (TAT) Required:	
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine		<input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw				Please provide advance notice for rush projects	
<input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse		<input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw				Regular (Standard) TAT:	
<input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC		<input type="checkbox"/> MISA Municipality				(will be applied if Rush TAT is not specified):	
<input type="checkbox"/> Table		<input type="checkbox"/> PWQO				Standard TAT = 5-7 Working days for most tests.	
		<input type="checkbox"/> Other				Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.	
Include Criteria on Certificate of Analysis (Y/N)?				Job Specific Rush TAT (if applies to entire submission)			
				Date Required: Time Required:			
				Rush Confirmation Number: (call lab for #)			
				# of Bottles Comments			
Sample Barcode Label				Sample (Location) Identification			
Date Sampled				Time Sampled			
Matrix							
Field Filtered (please circle):				Metals / Hg / Cr VI			
Conductivity pHg (Cl, SO4, pH, Resistivity/EC, no Suphate and Resonance Potential)							
1				BR-d SA#4 May 30/18 AM SOIL			
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		Date: (YY/MM/DD)		Time	
# jars used and not submitted		Laboratory Use Only		Time Sensitive		Temperature (°C) on Receipt	
Custody Seal		Yes		No		Intact	
White: Maxxa		Yellow: Client		SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM			
* 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.			

APPENDIX E

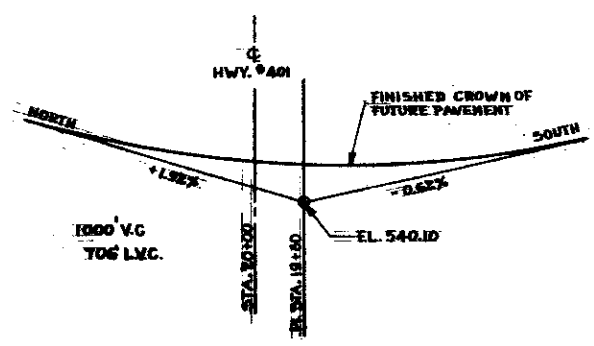
**Drawing Nos. D-6132-1 and
D-6132-3**



NOTE
• % DENOTES ELEVATIONS
ARE SHOWN TO TOP OF CONC.
WEARING SURFACE.
• WP DENOTES WORKING POINT



PROFILE OF HWY. #401
N.T.S.

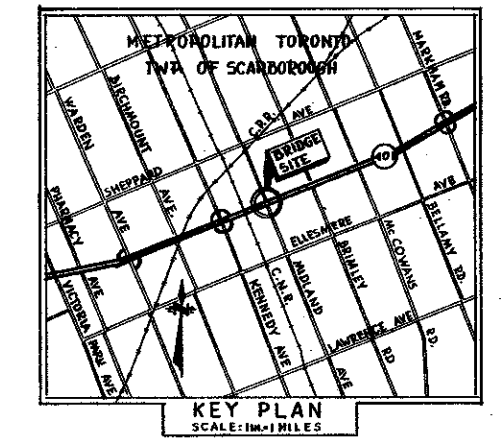


PROFILE OF MIDLAND AVENUE
N.T.S.

- LIST OF DRAWINGS**
- D-6132-1 GENERAL LAYOUT
 - 2. BORE HOLE LOCATION AND SOIL TESTS
 - 3. FOOTING & SITE LAYOUT PLANS
 - 4. ABUTMENTS - PHASE I
 - 5. ABUTMENTS - PHASE II
 - 6. RETAINING WALLS
 - 7. PRESTRESSED GIRDERS & BEARINGS
 - 8. DECK DETAILS - PHASE I
 - 9. DECK DETAILS - PHASE II
 - 10. SCREED ELEVATIONS
 - 11. 35 FOOT APPROACH SLAB TYPE B
 - 12. PARAPET WALL DETAILS
 - 13. STANDARD STEEL PARAPET RAIL
 - 14. STANDARD DETAILS

PROPOSED SEQUENCE OF CONSTRUCTION

1. REMOVE EXISTING NORTH AND PART OF SOUTH RETAINING WALLS
2. BUILD ABUTMENTS, RETAINING WALLS FOR PHASE I
3. PROVIDE TEMPORARY PROTECTION DURING PLACING OF DECK SLAB AND COMPLETE SUPERSTRUCTURE FOR PHASE I
4. DIVERT TRAFFIC FROM EXISTING HWY. #401 TO NEW COLLECTOR LANES.
5. CLOSE TRAFFIC ON MIDLAND AVE.
6. DRIVE TEMPORARY SHEETING IF NECESSARY AND REMOVE EXISTING STRUCTURE
7. PROCEED WITH PHASE II CONSTRUCTION



KEY PLAN
SCALE: 1/4" = 1 MILE

NOTES

CLASS OF CONCRETE
DECK, CURBS AND PARAPET WALL 4,000 P.S.I.
REMAINDER 3,000 P.S.I. (OR AS NOTED)

CLEAR COVER ON REINFORCING STEEL
FOOTINGS 3"
ABUTMENTS 3"
CURBS 2"
PARAPET WALLS 1 1/2"
DIAPHRAGMS 1 1/2"

DECK 1 1/2" TOP
1" BOT.

AND/OR AS NOTED ON DRAWINGS

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

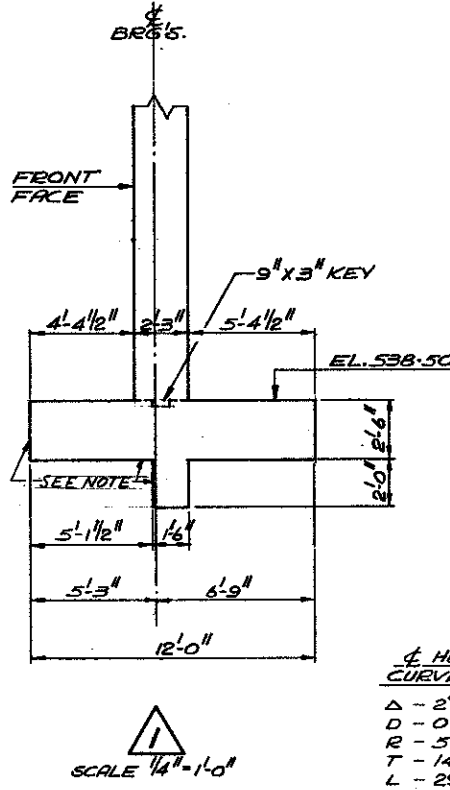
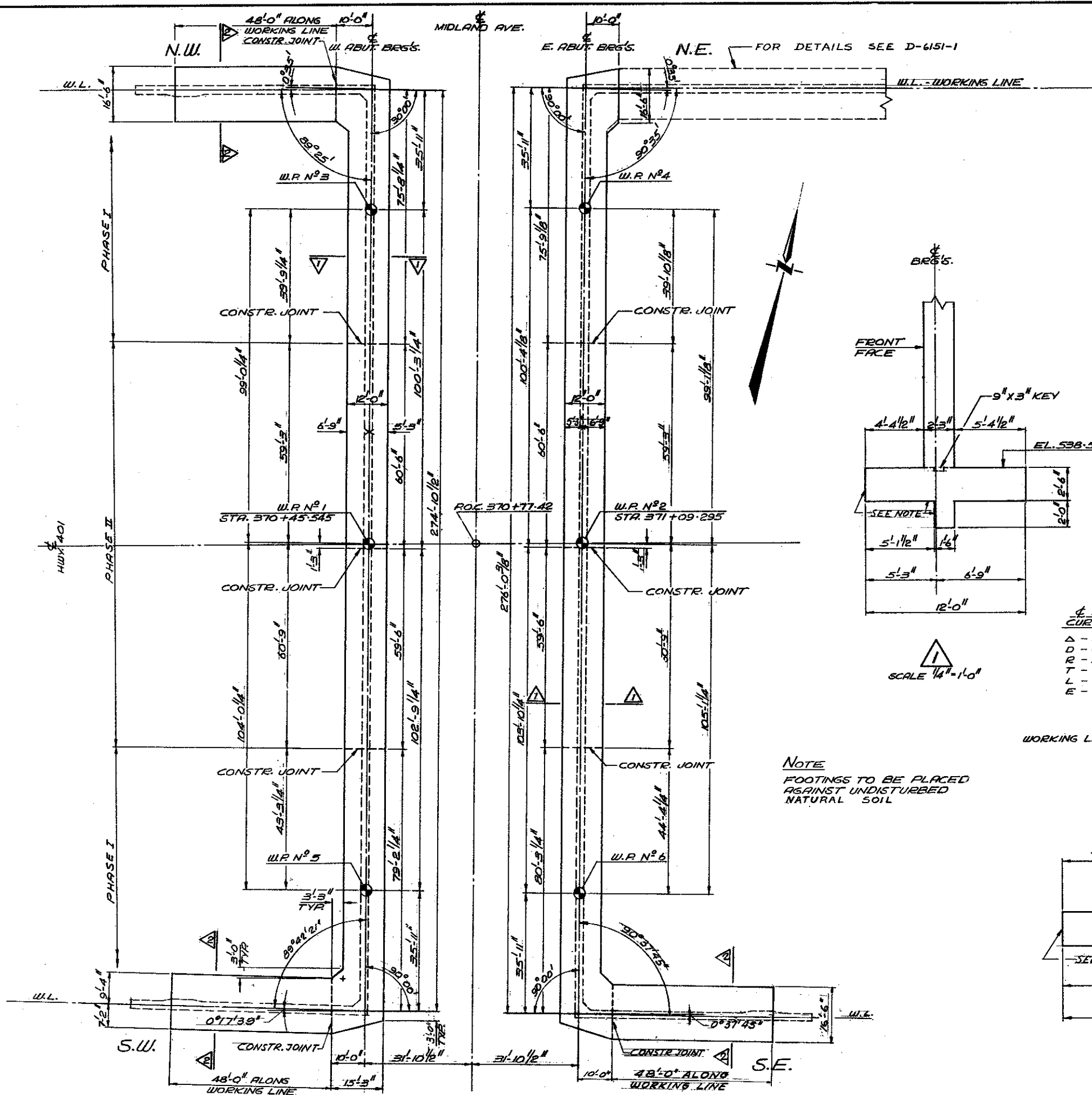
BACKFILL BEHIND ABUTMENTS SHALL NOT BE PLACED UNTIL CONCRETE IN DECK FOR EACH PHASE HAS REACHED A STRENGTH OF 4,000 P.S.I.

BACKFILL BEHIND BOTH ABUTMENTS TO BE PLACED SIMULTANEOUSLY AND REASONABLY UNIFORM IN A NORTH AND SOUTH DIRECTION.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO BRIDGE DIVISION			
MIDLAND AVENUE OVERPASS			
KING'S HIGHWAY No. 401		DIST. No. 6	
CO. YORK			
TWP. SCARBOROUGH		LOT CON.	
GENERAL LAYOUT			
APPROVED	DESIGN	CHECK	LOADING
	A. K.	V. F. B.	
DRAWING	DATE	CHECK	LOADING
	JULY 65	A. K.	HS20-44
SITE No. 37-216		W.P. No. 260-61	
CONTRACT No.		69-09	
DRAWING No.		D-6132-1	



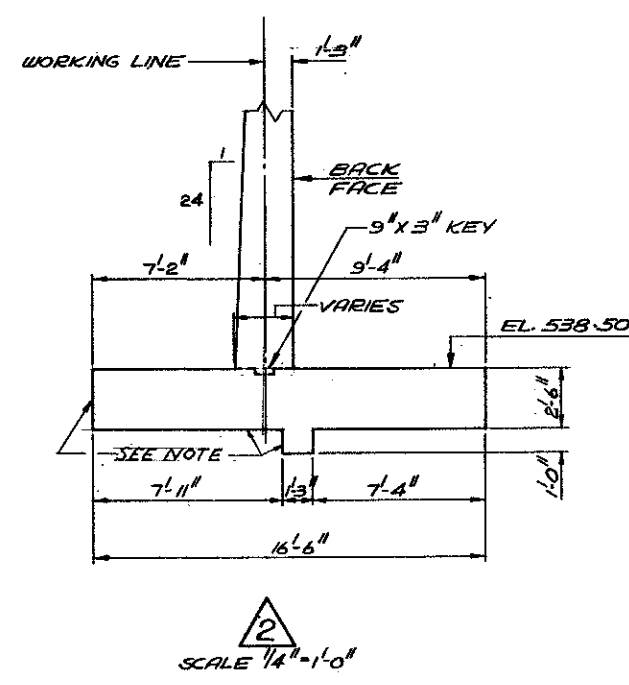


HWY. 401 CURVE DATA

Δ	2° 58' 00"
D	0° 06'
R	57295.78
T	1466.99
L	2933.33
E	18.78

E.B. COLLECTOR LINE CURVE DATA

Δ	3° 40'
D	0° 15'
R	22918.31
T	733.58
L	1466.67
E	11.74



SITE LAYOUT PLAN
N.T.S.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO BRIDGE DIVISION	
MIDLAND AVENUE OVERPASS	
KING'S HIGHWAY No. 401	DIST. No. 6
CO. YORK	
TWP. SCARBOROUGH	LOT CON.
FOOTING & SITE LAYOUT PLANS	
APPROVED <i>[Signature]</i>	SITE No. 37-216 W.P. No. 260-61
DESIGNER A.K. CHECK V.E.B.	CONTRACT No. 69-09
DRAWING E.O.N. CHECK A.K.	DRAWING No. D-6132-3
DATE JULY 68	LOADING W.S. 20.44



NOTE
FOOTINGS TO BE PLACED AGAINST UNDISTURBED NATURAL SOIL

FOOTING PLAN
SCALE 1/16" = 1'-0"

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/Midland Avenue 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 be of the same composition and compressive strength as the concrete used for the footing construction.

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/Midland Avenue 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.

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/Midland Avenue 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:

Midland Avenue Overpass (Site No. 37-216)
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 100 m of the works during installation of any deep foundation elements (including 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.

Notice To Contractor

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.

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

593.07.02 Removal 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.



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