Foundation Investigation and Design Report

CP Rail Overhead Replacement (Site No. 37-213)
Highway 401 Westbound Core and Collector Lanes, Neilson Road to Warden Avenue, City of Toronto, Ontario
MTO G.W.P. No. 2162-11-00

Submitted to:

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

Submitted by:

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

GEOCRES No.: 30M14-493
Lat. 43.773440, Long. -79.291684

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Table of Contents

REFERENCES

TABLES

DRAWINGS

FIGURES

APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT
CP RAIL OVERHEAD REPLACEMENT (SITE NO. 37-213)
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES, NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO, ONTARIO
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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 detail design of 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 replacement of the existing Canadian Pacific (CP) Rail overhead structure. This report was developed based on information from the current investigation, supplemented with information from a 1966 foundation investigation completed previously by others at the structure site, as follows:

- **MTO GEOCRES No. 30M14-75:** "Foundation Investigation Report for Proposed Extension of Highway 401 and C.P.R. Overhead, Metropolitan Toronto, District #6 (Toronto), W.J. 66-F-89 – W.P. 257-61", prepared by MTO Foundation Section – Materials and Testing Division, dated January 17, 1967.

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 existing Highway 401-CP Rail overhead structure is located approximately 200 m east of Birchmount Road, in the City of Toronto. The CP Rail line crosses beneath Highway 401 oriented in a northeast-southwest direction; for the purposes of this report, the CP Rail line is described as being oriented north-south.

The existing WB core structure (Site No. 37-213/2) was constructed in 1955 and is approximately 31.1 m long and 15.3 m wide. The WB collector structure (Site No. 37-213/4) was constructed in 1969 and is approximately 33. 6 m long and 26.1 m wide. Both structures are single-span, with the existing abutments supported on spread footings founded between Elevations 172.2 m and 173.3 m. The existing Highway 401 grade at the CP Rail Overhead is at approximately Elevation 184 m to 185 m, while the rail is at a grade of approximately 175 m. The Highway 401 approach embankments are up to approximately 9 m in height relative to the surrounding grade, with the side slopes oriented at approximately 3 horizontal to 1 vertical (3H:1V). At the time of the 2018 investigation, visual observations suggested no evidence of settlement on the WB lanes, or surficial/global instability on the north side slope of the existing WB collector embankment.

A residential neighbourhood is located to the north of Highway 401, and an industrial area is located to the south.

3.0 INVESTIGATION PROCEDURES

3.1 1966 Investigation

A total of five boreholes were advanced as part of the 1966 investigation (GEOCRES No. 30M14-75) for the CP Rail overhead structure. Three of these boreholes are located within or immediately adjacent to the footprint of the WB core and collector structures, while the other two are located within the eastbound (EB) structure area; the EB boreholes have been included in this report to provide additional information regarding the geotechnical subsurface conditions. The locations of the boreholes are summarized below and shown on Drawing 1; these locations have been developed based on plotting the station and offset as shown on the 1966/1967 borehole records and drawings, adjusting based on the site features shown on the drawings and converting these to geographic coordinates based on MTM NAD83 (Zone 10). The borehole records from the 1966 investigation are presented in Appendix D.

Borehole No.	Borehole Location	MTM NAD 83 (Zone 10)		Borehole Elevation (m)	Borehole Depth (m)
		Northing (m)	Easing (m)		
75-7	WB Collector West Abutment	4,848,192.2	321,528.7	175.6	9.6
75-8	WB Collector West Abutment	4,848,200.5	321,553.5	174.8	18.7
75-9	WB Collector East Abutment	4,848,215.1	321,584.8	174.2	15.7
75-10	EB Collector East Abutment	4,848,108.3	321,539.3	178.8	18.7
75-11	EB Collector West Abutment	4,848,102.0	321,503.2	177.7	15.7

The Standard Penetration Test (SPT) "N" values in the 1966 investigation were obtained using a manual hammer. The manual hammer consisted of a 63.5 kg (140 pound) hammer falling over a distance of 760 mm (30 inches).

3.2 2018 Investigation

The foundation investigation for the CP Rail overhead WB structure was carried out between February 12 and 16, 2018, during which time two boreholes (designated as Boreholes CP-01 and CP-02) were advanced at the east and west abutments in the core and collector lanes, respectively, from the Highway 401 grade at the locations shown on Drawing 1.

The borehole investigation was carried out using a CME 75 truck-mounted drill rig, supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario. Boreholes CP-01 and CP-02 were advanced through the overburden using 165 mm outside diameter hollow stem augers to depths of 20.1 m and 20.4 m below existing ground surface, respectively.

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

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. The boreholes were backfilled with bentonite to / near the surface, in accordance with Ontario Regulation 903 (Wells, as amended) and both boreholes were sealed at ground surface with cold patch asphalt.

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

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 review. Geotechnical laboratory index and classification testing; consisting of natural moisture contents, Atterberg limits and grain size distributions, was conducted on selected samples in accordance with MTO and / or ASTM Standards as applicable. One soil sample obtained during the field investigation from each of Boreholes CP-01 and CP-02, using appropriate sampling protocols, was submitted to a specialist analytical laboratory under chain of custody procedures for testing of conductivity / resistivity, pH chemical analysis of 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 marked 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 and 1 m in the horizontal and vertical directions, respectively. The locations given on the borehole records and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
CP-01	4,848,184.5 (43.773440)	321,570.3 (-79.291684)	184.0	20.1
CP-02	4,848,175.5 (43.773386)	321,524.0 (-79.292270)	184.9	20.4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

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

A surficial till sheet, which generally follows the surface topography, is generally present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial melt water ponds scattered throughout the Peel Plain and concentrated near river valleys, such as the West and East Don River valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

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

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the 2018 investigation and the results of the geotechnical laboratory tests carried out on selected soil samples are presented on the borehole records provided in Appendix A. 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, while those in the 2018 investigation are based on use of an automatic hammer; 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. The results of the geotechnical laboratory testing on soil samples are presented in Appendix B. The results of the analytical testing are provided in Appendix C.

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 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 glacial till deposit that varies in composition from silt and sand to clayey silt with sand. The till deposit contains interlayers and/or is underlain by sandy silt to silty sand, and clayey silt. Detailed descriptions of the subsurface conditions are provided in the following sections of this report.

4.2.1 Asphalt

An approximately 200 mm thick layer of asphalt pavement was encountered immediately below ground surface in Boreholes CP-01 and CP-02. An approximately 250 mm thick layer of concrete was encountered underlying the asphalt in Borehole CP-02.

4.2.2 Fill

An 8.9 m and 8.6 m thick layer of fill was encountered underlying the pavement in Boreholes CP-01 and CP-02, respectively, with its base extending to approximately 174.9 m and 175.8 m. About 1.5 m of fill material was also encountered immediately below the then-existing ground surface in Borehole 75-9, extending to approximately Elevation 172.6 m. The fill is variable in composition but is predominantly non-cohesive, comprised of gravelly sand, sand and gravel, gravelly silty sand, silty sand and silt and sand. Cobble fragments were noted within the non-cohesive fill layer in Borehole CP-01 at a depth of about 5.3 m. Approximately 0.8 m and 1.7 m thick layers of cohesive fill were noted in both boreholes; these layers consist of clayey silt, some sand to sandy clayey silt, containing trace gravel.

The Standard Penetration Test (SPT) "N"-values measured within the non-cohesive fill range from 6 blows to 67 blows per 0.3 m of penetration, indicating a loose to very dense level of compactness; one higher SPT "N" value of 50 blows for 0.06 m of penetration was measured in the sand and gravel roadbase in Borehole CP-01, and this value was likely impacted by the gravel in the sample. The SPT "N"-values measured within the cohesive fill range from 8 blows to 22 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

Grain size distribution testing was carried out on five samples of the non-cohesive fill and the results are shown on Figure B1 in Appendix B. Atterberg limits testing was carried out on two samples of the cohesive fill layer and measured liquid limits of 15 and 18 per cent, plastic limits of 11 per cent, and corresponding plasticity indices of 4 and 6 per cent. These results, which are plotted on a plasticity chart on Figure B2 in Appendix B, indicate that the cohesive fill consists of clayey silt of low plasticity. The natural water content measured on selected samples of the non-cohesive fill ranges from about 4 to 14 per cent. The natural water content measured on three selected samples of the cohesive fill ranges from about 8 to 13 per cent.

4.2.3 Silt and Sand to Clayey Silt Till

A glacial till deposit was encountered immediately below ground surface in Boreholes 75-7, 75-8, 75-10 and 75-11, and underlying the fill in Boreholes 75-9, CP-01 and CP-02. The surface of the till was encountered in the boreholes between approximately Elevation 175.8 m to 172.6 m. Boreholes 75-7, 75-8 and CP-02 along the west abutment terminated within the till deposit, penetrating it for a thickness of 9.6 m to 18.7 m. In the remaining boreholes, the boreholes extended through approximately 4.2 m to 11.6 m of till before extending into the non-till interlayers or underlying deposit.

Although the deposit was not interpreted as a till in the 1966 investigation, it has been re-interpreted as such based on the grain size distribution data from that investigation, the results of the 2018 investigation, and the physiographic mapping of the area. The till deposit is typically comprised of silt and sand containing trace to some gravel and trace to some clay; at some locations, the till deposit grades to clayey silt with sand, and trace to some gravel. A 0.7 m thick silt layer was encountered within the till in Borehole CP-02 at a depth of approximately 17.1 m, corresponding to Elevation 167.8 m. Cobble fragments and grinding were noted within the silt and sand till deposit at various depths, as identified on the 2018 borehole records provided in Appendix B.

The SPT “N”-values measured within the till deposit range from 12 blows per 0.3 m of penetration to 100 blows per 0.08 m of penetration, but were generally over 40 blows per 0.3 m of penetration, indicating a dense to very dense level of compactness or hard consistency.

Grain size distribution testing was carried out on two samples of the till from the 2018 investigation, and the results are shown on Figure B3 in Appendix B. Atterberg limits testing was carried out on selected samples of the till deposit in both the 1966 and 2018 investigations and measured liquid limits between 13 and 19 per cent, plastic limits between 11 and 14 per cent, and plasticity indices between 1 and 6 per cent. These results, two of which are plotted on a plasticity chart on Figures B4 in Appendix B, indicate that the till varies from silt of slight plasticity to clayey silt of low plasticity (i.e., plasticity indices below and above 4 per cent, respectively). The natural water content measured on selected samples of the till ranges from about 7 to 12 per cent, typically below the plastic limit for the material.

4.2.4 Sandy Silt to Silty Sand

An interlayer or deposit of sandy silt to silty sand containing trace clay and gravel was encountered underlying the till deposit in Boreholes 75-9 to 75-11 and CP-01. The surface of the deposit in Boreholes 75-9 and 75-10 is based on interpretation of the water content and grain size distribution data from the 1966 investigation, and may not be exact. In general, the surface of the deposit was encountered between Elevation 170.7 m and 163.4 m. Boreholes 75-9 to 75-11 terminated within this interlayer or deposit, penetrating it for a thickness of 4.1 m to 7.6 m. The interlayer or deposit in Borehole CP-01 is 5.0 m thick.

The SPT “N”-values measured within the sandy silt to silty sand range from 24 blows per 0.3 m of penetration to over 100 blows per 0.08 m of penetration; however in general the values are over 60 blows per 0.3 m of penetration, indicating a generally very dense level of compactness.

Grain size distribution testing was carried out on one sample of the sandy silt deposit and the result is shown on Figures B5 in Appendix B. Atterberg limits testing was carried out on one sample of the sandy silt deposit which confirmed the material to be non-plastic. The natural water content measured on selected samples of the non-cohesive deposits ranges from about 8 to 21 per cent.

4.2.5 Sandy Clayey Silt to Clayey Silt

A deposit or interlayer of sandy clayey silt to clayey silt containing some gravel was encountered underlying the sandy silt interlayer/deposit in Borehole CP-01 at a depth of 18.3 m, corresponding to Elevation 165.7 m. The borehole terminated within this layer, penetrating it for a thickness of 1.8 m.

SPT “N”-values of 62 blow per 0.3 m of penetration and 100 blows per 0.15 m of penetration were measured in this layer, suggesting a hard consistency.

The natural water content measured on one selected sample of the sandy clayey silt deposit is 10 per cent.

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations during both the 2018 and 1966 investigations, as summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)
CP-01	184.0	17.0	167.0
CP-02	184.9	Dry at 16.8 (Borehole caved)	Dry at 168.1
75-7	175.6	4.6	171.0
75-8	174.8	4.1	170.7
75-9	174.2	3.5	170.7
75-10	178.8	10.3	168.5
75-11	177.7	9.1	168.6

As these water levels were measured immediately after completion of drilling, they may not represent the stabilized groundwater level at the site, nor the current level in the case of the 1966 data. Based on the observed water conditions, together with soil colour transitions from brown to grey, it is estimated that the groundwater level is at approximately Elevation 170 m. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.4 Analytical Testing Results

Two soil samples were submitted 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 C 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)
CP-01 / 12	8.10	1500	649	340	<20
CP-02 / 11	7.94	1300	745	400	<20

5.0 CLOSURE

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

Golder Associates Ltd.

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

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

NK/LCC/rb

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PART B

FOUNDATION DESIGN REPORT
CP RAIL OVERHEAD REPLACEMENT (SITE NO. 37-213)
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES, NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO, ONTARIO
MTO G.W.P. NO. 2162-11-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation design recommendations for the proposed CP Rail overhead structure (Site No. 37-213/2 and 37-213/4) as part of the rehabilitation and 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 replacement structure foundations.

The discussions and recommendations are intended for the use of the MTO and their designers, and shall not be used or relied upon for any other purpose or by any other parties, including the 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 CP Rail overhead WB core and collector structures will require replacement. The existing WB core structure (Site No. 37-213/2) was constructed in 1955 and is approximately 31.1 m long and 15.3 m wide. The existing WB collector structure (Site No. 37-213/4) was constructed in 1969 and is approximately 33. 6 m long and 26.1 m wide. Both structures are single-span and constructed on a skew of about 45 degrees. Based on available drawings from the 1969 construction of the CP Rail Overhead WB collector structure (Drawing No. D6130-1, General Arrangement; Drawing No. D6130-5, Northwest Abutment & Footing; and Drawing No. D6130-6, Northeast Abutment & Footing, dated June 19, 1968), the abutments are supported on strip footings, with the existing foundation details summarized as follows:

Foundation Element	Footing Width (m)	Existing Footing Founding Elevation (m)
West Abutment	2.1	172.8
East Abutment	2.1	172.2 to 172.5

Details from the 1955 construction of the CP Rail overhead WB core structure (Site No. 37-213/2) were not found; however, based on the 1969 drawings for the WB collector structure, it is understood that the strip footings for the WB core structure are founded at similar elevations. Based on observations by Golder during the 2018 subsurface investigation, there is no visual evidence of settlement distress to the existing WB overpass structure, nor visual evidence of settlement or instability of the approach embankments.

Based on the General Arrangement (GA) drawings provided by WSP, dated February 2018, the WB core and collector structures will be replaced by two single-span structures placed side by side with an expansion gap between the two structures. The new structures will be approximately 27.1 m long (parallel to Highway 401) and

41.5 m wide (perpendicular to Highway 401), with no proposed change in grade. The CP Rail overhead structure is planned to be replaced in four stages, with the collector structure replaced first, followed by the core structure, then followed by the median connection between the two structures. Temporary protection systems will be required along Highway 401 to facilitate the staged removal of the existing overhead structures and wing walls/retaining walls, as well as parallel to the rail tracks depending on the depth of excavation.

6.2 Foundations Options

Based on the proposed overhead structure geometry and the subsurface conditions at this site, both shallow and deep foundation options have been considered for support of the abutments for the new CP Rail overhead structure. A summary of the advantages and disadvantages associated with each option is provided below.

For all foundation options, temporary protection systems will be required along Highway 401, as well as in front of the existing/new abutments parallel to the rail tracks to facilitate the staged removal of the existing structure foundations and construction of the new foundations. It is anticipated that some groundwater seepage may 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 1 m or more below the footing founding level.

A summary of the advantages and disadvantages associated with each option is provided below, and 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 compact to very dense silt and sand till, or on top of existing footings**: Strip or spread footings are feasible for support of the new abutments and associated wing walls/retaining walls at this site. Significant excavation would be required through the existing embankment fill to remove the existing footings and reach the native soils at the existing foundation subgrade level. Temporary protection systems will be required along Highway 401 to permit the staged removal and replacement of the existing structure and foundations. This excavation would extend up to about 2 m to 3 m below the rail grade, but would be maintained above the groundwater level. Temporary protection systems are also expected to be required parallel to and between the front edge of the footings and the rail tracks; the current GA drawing shows the distance between the closest edge of rail and the front edge of the footing to be on the order of 5 m or more, and therefore the footing excavations are expected to be maintained outside of the zone of influence of the rail tracks. The structural engineers could consider leaving the existing footings in place and founding the new footings on top of the existing if the grading permits, or alternatively, reusing the existing footings, to minimize the excavation requirements adjacent to the rail. It is expected that the new footings will need to be wider than the existing, and the structural design would need to incorporate appropriate reinforcement and dowelling to either widen the existing footings, or to construct new footings on top of the existing. This option does not allow for the construction of integral abutments, but could permit semi-integral abutments.

- **Footings “perched” on a compacted granular pad in the approach embankments**: “Perched” footings are feasible for support of the new abutments for the replacement of the structure, to minimize the excavation through the existing embankment fill. However, it would be necessary to increase the span length for an open abutment configuration for this option, as perched strip footings are not permitted in a false abutment configuration. This option does not allow for the construction of integral abutments, but could permit semi-integral abutments.

- **Driven steel H-piles or pipe piles**: Driven steel piles are suitable and feasible for support of the abutments, as well as associated wing walls/retaining walls at this site. It is noted that deep foundations are not strictly required for support, as adequate settlement performance can be achieved using shallow foundations; however, a pile foundation option would permit the use of integral abutments provided they are feasible for this skew angle. It is assumed that the pile caps would be perched in the embankment fill; however, significant excavation would still be required through the existing approach embankments to remove the existing structure, unless the new pile caps are placed behind the back edge of the existing abutments, likely requiring a longer structure span. The use of a conventional abutment with the pile cap constructed at a depth of 1.2 m below the ground surface (rail grade) is not considered to be advantageous over the use of spread footings at this site, owing to the very shallow depth to very dense/hard soils; however, if this option is considered, it would likely 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 are suitable and feasible for support of the abutments, although this option would not permit integral abutment construction if feasible for the skew angle. It may be possible to core the drilled shafts through the existing footings to avoid the need to remove the footings in proximity to the rail; however, large drilled shaft equipment would be required to work within relatively limited space during construction staging. In addition, temporary liners would be required to support the sides of the drilled shaft holes through the non-cohesive overburden soils and minimize ground loss during construction, particularly once the shafts extend below the groundwater table.

Based on the above considerations, the preferred option from a geotechnical/foundations perspective is to support the abutments for the proposed new WB overhead structure on shallow strip footings founded on the very dense silt and sand till.

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 WB overhead structure 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 at this site in comparison to the degree of site understanding in Section 6.5 of CHBDC (2014), the level of confidence for design for the CP Rail Overhead has been assessed as “typical degree of site and prediction model understanding” based on having two boreholes near each foundation element.

The corresponding consequence factor, Ψ, and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the CHBDC (2014) have been used for the design.

6.3.2 Correlation of Automatic and Manual Hammer for SPT “N” Values

The results of the 2018 investigation generally demonstrate lower Standard Penetration Test (SPT) “N” values than encountered in Boreholes 75-8 to 75-11 from the 1966 investigation (GEOCRES No. 30M11-75). The differences are largely due to the use of an automated hammer with higher efficiency in the 2018 investigation as compared to a manually operated hammer (i.e., rope cathead) that was used in the 1966 investigation. The 2018 SPT “N”-values correlate reasonably well with the 1966 data when corrected to a 60% efficiency of hammer energy transfer. The foundation options and recommendations presented below are based on the correlated "N_{60}"-values, where applicable.

6.3.3 Seismic Design

6.3.3.1 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 new CP Rail overhead structure.

6.3.3.2 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.4 of the CHBDC (2014), the peak ground acceleration (PGA) values and design spectral acceleration (Sa) values for Site Class C are presented below.

Seismic Hazard Values	10% Exceedance in 50 years (475-year return period)	5% Exceedance in 50 years (975-year return period)	2% Exceedance in 50 years (2,475 return period)
PGA (g)	0.040	0.071	0.134
PGV (m/s)	0.031	0.051	0.090
Sa (0.2) (g)	0.068	0.114	0.209
Sa (0.5) (g)	0.043	0.067	0.112
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

6.3.3.3 Soil Liquefaction

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

6.4 Strip Footings

6.4.1 Founding Elevations

Strip footing (shallow) foundations are feasible for the support of the new WB CP Rail overhead structure and associated wingwalls/retaining walls. The footings should be founded below any fill or softened/loosened soils on the compact to very dense silt and sand till. 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 OPSD 3090.101 (*Foundation, Frost Penetration Depths for Southern Ontario).*

In order to extend below the fill, the footings should be founded below Elevation 173 m; however, assuming removal of the existing foundations, it is recommended that the new foundations be founded at the same elevations as the existing foundations, as summarized in the table below. The footings may also be founded on OPSS.PROV 1010 (Aggregates) Granular A or Granular B Type II fill, placed and compacted following removal of the existing footings, to raise the founding level and minimize the height of the abutment wall, while still providing adequate protection against frost penetration.

Foundation Element	Founding Stratum	Existing Footing Founding Elevation (m)
East Abutment	Very dense silt and sand till	172.2
West Abutment	Very dense silt and sand till	172.5

Consideration could be given to founding the new strip footings on top of the existing footings, which meet the founding elevation requirements as described above. Alternatively, the abutment foundations could be "perched" on a compacted granular pad within the approach embankments. In this case, where some thickness of existing or new embankment fill is present below the perched footings, the compacted granular pad should have a minimum thickness of 2 m; any existing fill, organic soils and/or loose soils within the zone of influence below the compacted granular pad should be subexcavated and replaced with engineered fill, or the pad thickened to found on the native sandy silt to silty sand / silt and sand till / clayey silt deposits at the elevations given above for footings founded on these deposits. The pad should consist of OPSS.PROV 1010 (*Aggregates*) Granular 'A' material extending at least 1 m beyond the edges of the footing(s), then outward and downward at 1H:1V. The granular fill should be placed in accordance with OPSS.PROV 501 (*Compacting*).

6.4.2 Geotechnical Resistances

Strip footings placed on the native soils at or below the design elevations given in the preceding section, or perched on compacted Granular 'A' pads within the approach embankments, 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 and sand till	3	1,250	1,000
	4	1,400	700
	5	1,600	600
Abutments or retaining wall founded at minimum 1.2 m depth on engineered fill	3	700	Does Not Govern*
	4	800	700
	5	900	600

* The factored serviceability geotechnical resistance for 25 mm of settlement is estimated to be greater than the factored ultimate geotechnical resistance, and therefore does not govern the design.

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.PROV 902 *(Excavating and Backfilling Structures)* to check that all existing fill, native soils have been removed.

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

6.4.3 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 Φ' or δ respectively, which can be taken as follows:

- Cast-in-place footing or working slab to native deposits: tan Φ' = 0.67
- Cast-in-place footing or working slab to Granular A pad: tan Φ' = 0.7
- Cast-in-place footing to concrete working slab: tan δ = 0.7

6.5 Steel H-Pile or Pipe Pile Foundations

6.5.1 Founding Elevations

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

The pile tip elevations provided below may be used for design of pile foundations driven to refusal in the “100-blow” soils.

Foundation Element	Surface Elevation of “100-blow” Material (m)	Estimated Design Pile Tip Elevation (m)
West Abutment	168.0	165.0
East Abutment	164.0	161.0

Given the variability in the SPT "N" values, it is recommended that an allowance for varying pile lengths be provided in the Contract Documents to ensure that adequate pile lengths are available on site and to reduce splicing needs.

Consideration must be given to the potential presence of cobbles and boulders within the fill and glacially-derived soils at this site. 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 till deposits. The steel H-piles should be reinforced at the tip to protect the pile; in very dense and cobbley soils such as these, driving shoes (such as Titus Standard "H" Bearing Pile Points) are preferred over flange plates. 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 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 (*Foundation Frost Depths for Southern Ontario*).

6.5.2 Geotechnical Axial Resistances

For HP 310 x 110 piles driven into the "100-blow" soil at or below the design tip elevations provided in the preceding section, 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 following note (Note 2 from the MTO *Structural Manual,* Section 3.3.3 (MTO, 2016)), or similar, 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 tip Elevation 165.0 m at the west abutment and below tip Elevation 161.0 m at the east abutment."*

Similar axial resistances and drawing note may be used in the design for 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 10% of piles or two piles (whichever is greater) at each foundation element in each stage of construction. If pile foundations are adopted for support of the replacement 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 via PDA.

6.5.3 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. For integral abutment design the steel H-piles would be installed within a 3 m long corrugated steel pipe (CSP) filled with sand fill in accordance with Table 1 in the NSSP for integral abutments.

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 cohesionless soils:

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

Where: n_h is the constant of horizontal subgrade reaction (kPa/m), as given below;

z is the depth (m); and,

B is the pile diameter/width (m).

The following values of n_h and s_u (Terzaghi, 1995) may be incorporated into the calculations of horizontal subgrade reaction (k_h) for structural analyses for a single vertical pile, based on the interpreted stratigraphic profiles shown on Drawings 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	nh (kPa/m)	su (kPa)
Loose sand within CSP	2,000	-
Existing non-cohesive fill	5,000	-
Existing cohesive fill	-	100
Compact to dense silt and sand till / sandy silt to silty sand; above the water table (assumed at Elevation 171 m)	10,000	-
Compact to dense silt and sand till / sandy silt to silty sand; below the water table (assumed at Elevation 171 m)	7,500	-
Very dense silt and sand till / silty sand to sandy silt; above the water table (assumed at Elevation 171 m)	20,000	-

Soil Unit	nh (kPa/m)	su (kPa)
Very dense silt and sand till / silty sand to sandy silt; below the water table (assumed at Elevation 171 m)	10,000	-
Hard clayey silt	-	400

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

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

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

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

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

6.6 Drilled Shafts (Caissons)

6.6.1 Founding Elevations

Drilled shaft foundations could also be considered for support of the abutments. Drilled shafts should be founded within the very dense silt and sand till deposit, socketed at least 1.5 m to 2 m into the “100-blow” soil. The estimated drilled shaft tip elevations for new abutment foundations are summarized below.

Foundation Element	Surface Elevation of "100-blow" Material (m)	Estimated Design Pile Tip Elevation (m)
West Abutment	168.0	166.0
East Abutment	164.0	162.0

6.6.2 Geotechnical Axial Resistance

For drilled shafts socketed approximately 2 m into "100-blow" soil at the elevations given in Section 6.6.1, the factored ultimate geotechnical resistance and factored serviceability geotechnical resistance may be taken as follows:

Drilled Shaft Diameter (m)	Factored Ultimate Geotechnical Resistance (kN)	Factored Serviceability Geotechnical Resistance (kN) (for 25 mm of settlement)
1.0	3,500	Does not govern*
1.2	4,500	Does not govern*
1.5	6,000	Does not govern*

* The factored serviceability geotechnical resistance for 25 mm of settlement is estimated to be greater than the factored ultimate geotechnical resistance, and therefore does not govern the design of drilled shaft foundations.

6.6.3 Resistance to Lateral Loads

The geotechnical resistance to lateral loading for the caissons should be calculated in accordance with Section 6.5.3, using the horizontal subgrade formulas and parameter values presented therein.

6.7 Retained Soil System (RSS) Walls

In addition to concrete retaining walls (the foundation recommendations for which are provided in Sections 6.4 and 6.8), retained soil system (RSS) walls are geotechnically suitable and represent the preferred option for wall construction at this site. Based on the GA drawings provided by WSP, it is understood that the first panel of the existing Retained Soil System (RSS) wall on the north side of the west and east abutments is planned to be removed and reconstructed as part of the CP Rail overhead replacement; it is anticipated that longer lengths of replacement could be required associated with the excavation for removal of the existing structure, in order to place and compact the new fill in conjunction with the geogrid reinforcing layers. Based on the drawings provided, the RSS wall sections to be replaced have a maximum height of approximately 10 m.

6.7.1 Founding Elevations

A typical RSS wall has a front facing supported on a strip footing placed at shallow depth below the ground surface in front of the wall. The existing embankment fills generally extend to and below the CP Rail grade, to between Elevations 175.9 m and 172.7 m. Excavations to about Elevations 172.8 m and 172.2 m will be required for the removal of the existing footings for the CP Rail overhead structure, and it is assumed that the excavations for the removal of the existing retaining walls will extend to the surface of the native soils. As a result, the RSS walls will be founded on the compact to very dense silt and sand till, or on granular fill placed on the till to raise the grade to satisfy the minimum embedment depths as set out in MTO's *RSS Wall Design Guidelines* (September 2008), and as discussed further below.

The facing footing should be placed on a minimum 300 mm thick layer of compacted OPSS.PROV 1010 (*Aggregates*) Granular 'A', as shown in Figure 5.2 in the MTO *RSS Wall Design Guidelines* (September 2008). The compacted granular pad should extend at least 1.0 m beyond the outside edge of the facing footing, then downward at 1H:1V. Where sub-excavation of fill and unsuitable soils has been carried out, the Granular 'A' pad and the reinforced soil mass can be constructed immediately on top of the native subgrade, such as the compact to very dense silt and sand till. Alternatively, the thickness of the granular pad can be increased to raise the grade after sub-excavation and the facing footing and reinforced soil mass founded at a higher elevation.

The compacted Granular 'A' pad and the reinforced soil mass should be keyed into the existing embankment fills by benching into the embankment fill, similar to OPSD 208.010 (*Benching of Earth Slopes*).

6.7.2 Geotechnical Resistances

Assuming that the RSS wall acts as a unit and uses the full width of the reinforced soil mass (assumed to be about 0.67 of the retained height, therefore a total of 6.7 m wide), the proprietary RSS wall design may be based on a factored ultimate geotechnical resistance of 1,000 kPa and a factored serviceability geotechnical resistances (for 25 mm of settlement) of 500 kPa.

6.7.3 Global Stability

Slope stability analyses have been performed for the proposed retaining walls using the commercially available program SLIDE V7 produced by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum factored FoS of 1.54 is adopted for the design of retaining wall height and geometries under static conditions at the end of construction as per the CHBDC (2014). This FoS is considered adequate for the retaining walls at this site considering the design requirements and the field data available. In general, circular slip surfaces were analysed in the design.

The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations (Bowles, 1984 and Kulhawy and Mayne, 1990):

Soil Deposit	Bulk Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Cohesion (c') kPa	Effective Friction Angle (°)
Existing embankment fill	19	-	-	30
Compact to very dense silt and sand till	21	-	-	35
Compact to very dense sandy silt to silty sand	20	-	-	34
Hard clayey silt	20	400	-	33

A maximum retained wall height of 10 m was assumed for the retaining walls. The groundwater level was interpreted to be at approximately Elevation 171 m for design purposes.

The stability analysis result indicates that the proposed RSS wall with a maximum height of 10 m and a minimum reinforcing width of 0.67 times the wall height will have a FoS greater than 1.54 against global instability. An example of the static global stability results is provided on Figure 1. As can be seen on Figure 1, the FoS for 0.67H reinforcement length is above 1.54, and shorter reinforcement lengths on the order of 0.5H could be used from a geotechnical perspective if they satisfy the proprietary design requirements for internal stability.

If the wall geometry changes, for example to include a shorter wall section with a slope at the wall toe, or a slope above the top of the wall, the minimum reinforcement length may need to be increased to achieve the minimum required FoS.

6.8 Lateral Earth Pressures for Design of Abutments and Wingwalls

The lateral earth pressures acting on the abutment walls and any associated wingwalls 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. Depending on the Seismic Performance Category for the proposed overhead structure, seismic (earthquake) loading may also have to be taken into account in the design.

The following recommendations are made concerning the design of the abutment/wing 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).
- 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 1.5 horizontal to 1 vertical (1.5H: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/m3
Coefficients of static lateral earth pressure: Active, K_a At rest, K_o	 0.33 0.50

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

Material	Granular 'A'	Granular 'B' Type II
Soil Unit Weight:	22 kN/m3	21 kN/m3
Coefficients of static lateral earth pressure: Active, K_a At rest, K_o	 0.27 0.43	 0.27 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 may have to be taken into account in the design of abutment / 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	475-Yr	0.04	0.26	0.26	0.31
	975-Yr	0.071	0.27	0.27	0.32
	2,475 Yr	0.134	0.28	0.28	0.34
Non-Yielding Wall	475-Yr	0.04	0.27	0.27	0.33
	975-Yr	0.071	0.29	0.29	0.35
	2,475 Yr	0.134	0.33	0.33	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, 18, 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 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 analytical results for the samples submitted for testing are summarized in Section 4.4 and the analytical laboratory test reports are included in Appendix C.

6.9.1 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 tested samples 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.

6.9.2 Potential for Corrosion

The test results indicate a pH of 7.94 and 8.1 and a resistivity of 1,300 ohm-cm and 1,500 ohm-cm. According to the Gravity Pipe Design Guidelines (MTO, 2014), the pH is not considered detrimental to concrete durability. However, the resistivity indicates that the soil corrosiveness is "Severe" (R < 2,000 ohm-cm), as per Table 3.2 of the Gravity Pipe Design Guidelines (MTO, 2014), and some level of corrosion protection should be applied to the foundation element / materials. Further, given that the foundations are located adjacent to the roadway shoulder and will be exposed to de-icing salt, consideration should be given to selection of a “C” type exposure class as defined by CSA A23.1 Table 1.

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

6.10 Construction Considerations

6.10.1 Excavation and Control of Groundwater and Surface Water

The foundation excavations at the abutments for spread footings or pile cap construction will extend to depths of about 3 m below the present CP Rail grade, and about 13 m below the present Highway 401 road surface, through the existing fill and into the compact to very dense silt and sand till.

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

It is expected that for construction staging, temporary protection systems will be required along Highway 401 to facilitate the staged removal of the existing overhead structures and wingwalls/retaining walls, as well as parallel to the rail tracks. Recommendations for temporary protection systems are provided in Section 6.10.2 below.

Excavations for the new west and east abutment foundations will be maintained above the groundwater level, which has been interpreted to be at approximately Elevation 170 m, with the potential for seasonally higher water levels; groundwater inflow is expected to be relatively minor, especially during drier periods of the year. Some water inflow should be expected into the foundation excavations, particularly during wet months; however, it is anticipated that water inflow can be handled by pumping from filtered sump pumps placed at the base of the excavations.

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.

6.10.2 Temporary Protection Systems

To facilitate construction of the new overhead structure foundations, and removal of the existing footings foundations (if required), temporary protection systems are expected to be required between the WB and EB core lanes, and between the WB core and collector lanes. Temporary protection systems are also expected to be required in front of the existing/new abutment foundations, to protect the CP Rail tracks.

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 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. The protection systems adjacent to the rail appear to be located more than 5 m from the nearest rail; where the rail protection system is located outside the zone defined by a line extended outward and downward from the rail at 2 horizontal to 1 vertical (2H:1V), Performance Level 2 is considered appropriate; however, this requirement should be confirmed with CP Rail once the offset distances for the protection systems are confirmed.

Although the selection and design of the protection systems will be the responsibility of the contractor, it is considered that it may be difficult to install a driven, interlocking sheet pile system at this site due to the dense to very dense nature of the soils at relatively shallow depth below the fills. In this case, a soldier pile and lagging system may be required. 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 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.

6.10.3 Subgrade Protection

The till 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 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 E.

6.10.4 Obstructions

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

6.10.5 Vibration Monitoring During Construction

Vibration monitoring should be considered during driven pile or drilled shaft installation, as well as during protection system installation, to ensure that the vibration levels at nearby residential/commercial structures and on the rail lines 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 overhead structures is not expected to be required during construction at this site.

Residential homes are located about 30 m from the proposed abutment locations. A lower PPV threshold of 50 mm/s is generally considered applicable for vibration impacts on buildings. In addition, vibration monitoring on the rail tracks is expected to be required during construction. Further input from CP Rail and acceptance of the vibration monitoring approach is recommended in this regard.

Pre- and post-construction condition surveys and vibration monitoring are recommended at and near these existing structures and rail line; however, it would be prudent to carry out such monitoring during critical stages of the construction, such as during pile driving operations. An NSSP describing the requirements for vibration monitoring is presented in Appendix E.

7.0 CLOSURE

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

Golder Associates Ltd.

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

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

NK/LCC/rb

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https://golderassociates.sharepoint.com/sites/16003g/6. deliverables/5. cp overhead/3. final/1669995 fidr05 2019jan17 hwy 401wb cp overhead.docx

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

ASTM International:

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

Commercial Software:

Slide (Version 7) by Rocscience Inc.

Ontario Provisional Standard Drawing:

OPSD 208.010Benching of Earth Slopes

OPSD 3000.100Foundation, Piles, Steel H-Pile Driving Shoe

OPSD 3001.100Foundation, Piles, Tube Pile Driving Shoe

OPSD 3090.101Foundation Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specification:

OPSS.PROV 501Construction Specifications for Compacting

OPSS.PROV 539Construction Specification for Temporary Protection Systems

OPSS.PROV 902Construction Specification for Excavating and Backfilling Structures

OPSS.PROV 903 Construction Specification for Deep Foundations

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

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

RSS Design Guidelines, Ministry of Transportation Engineering Standards Branch, September 2008

TABLE 1 – COMPARISON OF FOUNDATION ALTERNATIVES – CP RAIL OVERHEAD REPLACEMENT

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.	• Suitable founding strata at shallow depths reducing depth of excavation and temporary excavation support requirements. • Existing abutments are supported on shallow foundations, and have performed well. • Excavations will be maintained above the groundwater level and only minor groundwater seepage anticipated, so pumping from filtered sumps expected to provide adequate groundwater control. • Removal of existing footings is proposed, the new footings can be founded at the same elevation	• Temporary protection systems required along edges of Highway 401 WB Core and Collector lanes, as well as along the CN Rail corridor. • Lower bearing geotechnical resistances compared to deep foundation options. • Precludes use of integral abutments; potentially greater maintenance required at abutments.	• Conventional excavation and construction techniques.	• Lower relative cost than deep foundations as removal of existing foundations will be required.
Spread/strip footings founded at minimum 1.2 m depth on engineered fill	Feasible for support of the abutments and associated wing walls/retaining walls.	• Abutment footings can be maintained higher than footings founded on native deposit	• Precludes use of integral abutments; potentially greater maintenance required at abutments • Span length would need to be increased for an open abutment configuration to adopt this type of foundation	• Conventional excavation and construction techniques.	• Lowest cost option assuming existing footings can be left in place. The cost of temporary protection system and concrete for abutment walls would be reduced, but cost for bridge increased due to longer span.
Steel H-piles founded within “100-blow” material	Feasible for support of the abutments.	• Abutment pile caps could be maintained higher than footings founded on native soils, reducing excavation depth and associated protection system requirements. • Allows for integral abutment construction.	• Temporary protection systems will be required along edges of Highway 401 WB Core and Collector lanes to facilitate excavation to pile cap level (if within approach embankments) and would also be required along the CN Rail corridor if pile caps are to be placed below the existing fill. • 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.	• Conventional construction methods for driven piles; augering into the “100-blow” material may be required to achieve minimum pile lengths.	• Estimated cost is approximately \$250/m length for pile installation and \$600/m3 for pile cap construction; the cost may be higher to account for pre-augering and for temporary liners. • Potentially less costly maintenance over life of the structure than semi-integral abutment structures.

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability	Estimated Costs
Drilled shafts founded within “100-blow” material	Feasible for support of abutments.	• Higher bearing resistances than for steel H-piles, requiring fewer elements. • It may be possible to core the drilled shafts through the existing footings to avoid the need to remove the footings in proximity to the rail.	• 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.	• Conventional construction methods for drilled shaft foundations; temporary liners required for ground and groundwater control.	• Estimated cost is approximately $1000/m length for caisson installation and $600/m3 for pile cap construction (if pile caps are adopted at the pier); this cost expected to be higher to account for temporary liners.

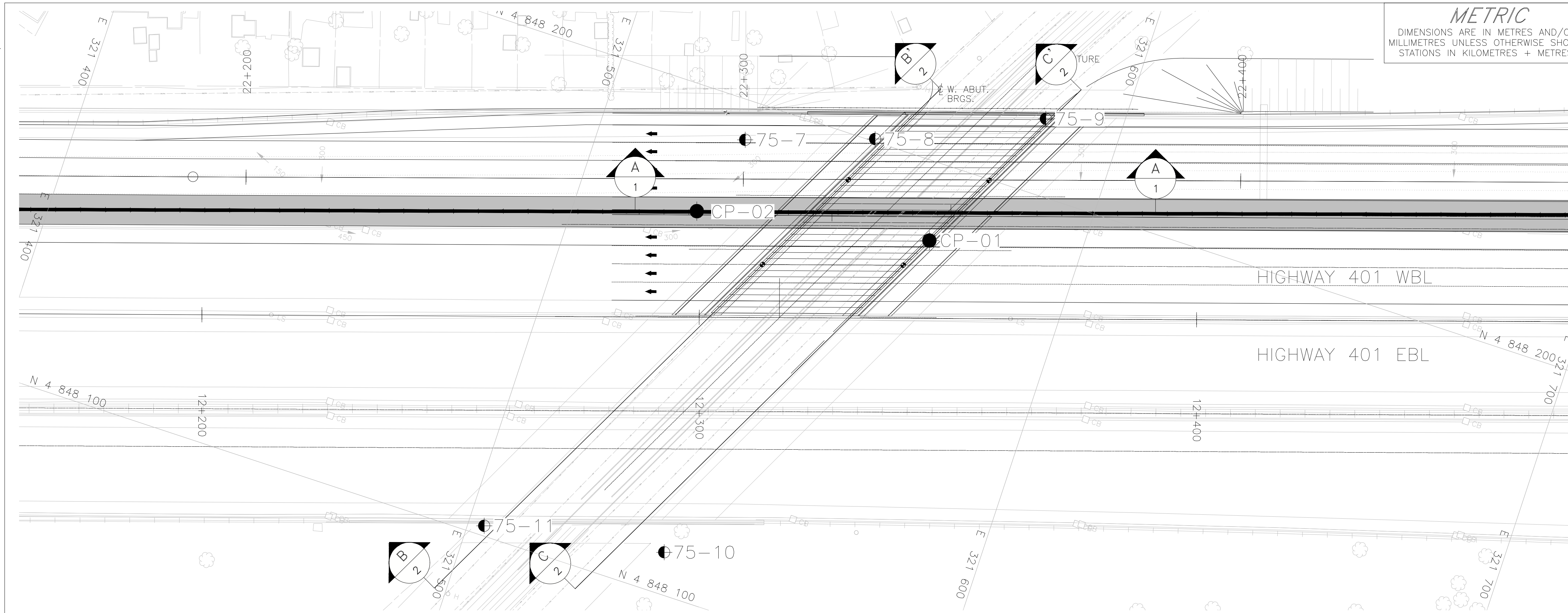
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 2162-11-00

SHEET

CP RAIL OVERHEAD REPLACEMENT
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS
BOREHOLE LOCATIONS PLAN AND SOIL STRATA

GOLDER



PLAN
SCALE
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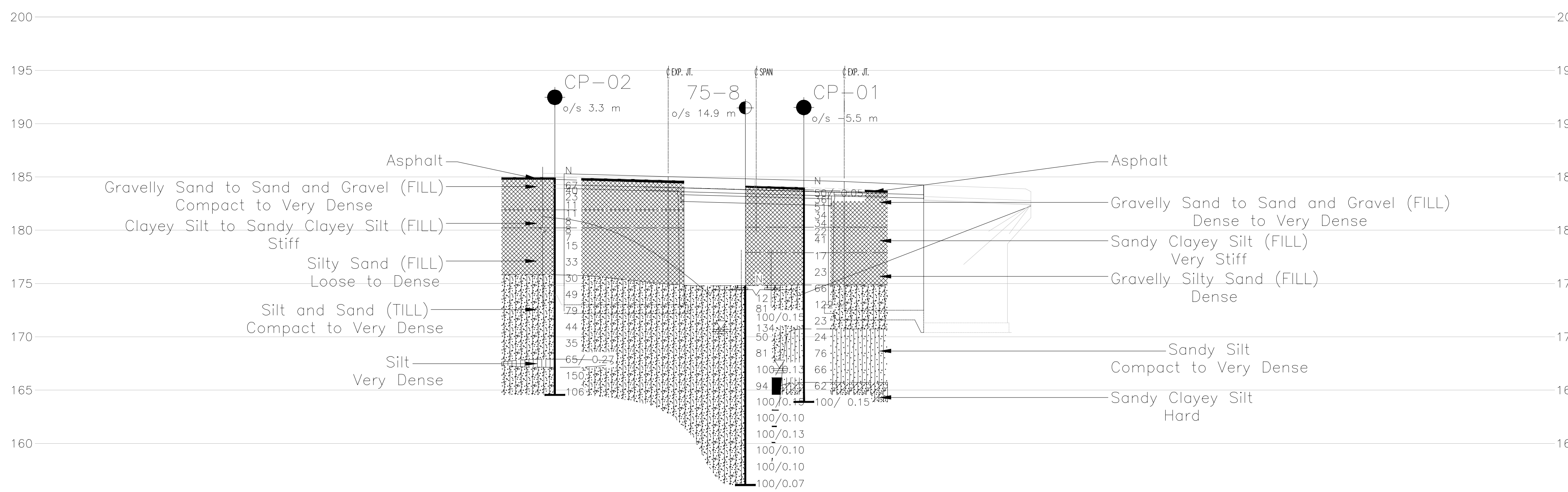
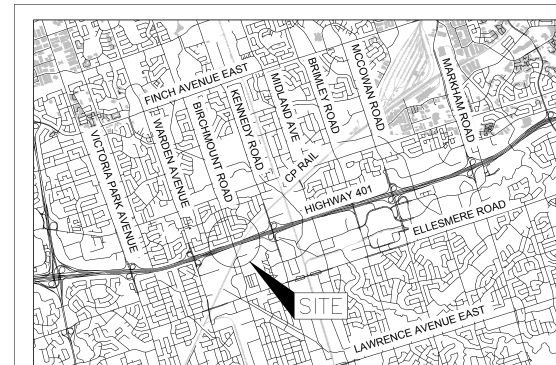


PROFILE A - A'
HORIZONTAL SCALE
10 0 10 20 m
VERTICAL SCALE
5 0 5 10 m



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- Borehole - 1966 Investigation (GEOCRES No. 30M14-75)
- 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
75-7	175.6	4848192.2	321528.7
75-8	174.8	4848200.5	321553.5
75-9	174.2	4848215.1	321584.8
75-10	178.8	4848108.3	321539.3
75-11	177.7	4848102.0	321503.2
CP-01	184.0	4848184.5	321570.3
CP-02	184.9	4848175.5	321524.0

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, drawings files no. S17M-01449-00-301-001GA.dwg, received June 5, 2018.

LICENSED PROFESSIONAL ENGINEER — L.C. COYNE — Jan. 16, 2019 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — N. KOCHMAN 100117863 — Jan. 16, 2019 — PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M14-493

HWY. 401	PROJECT NO. 1669995		DIST.
SUBM'D. NK	CHKD. NK	DATE: 01/16/2019	SITE:
DRAWN: DD	CHKD. NK	APPD. LCC	DWG. 1

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

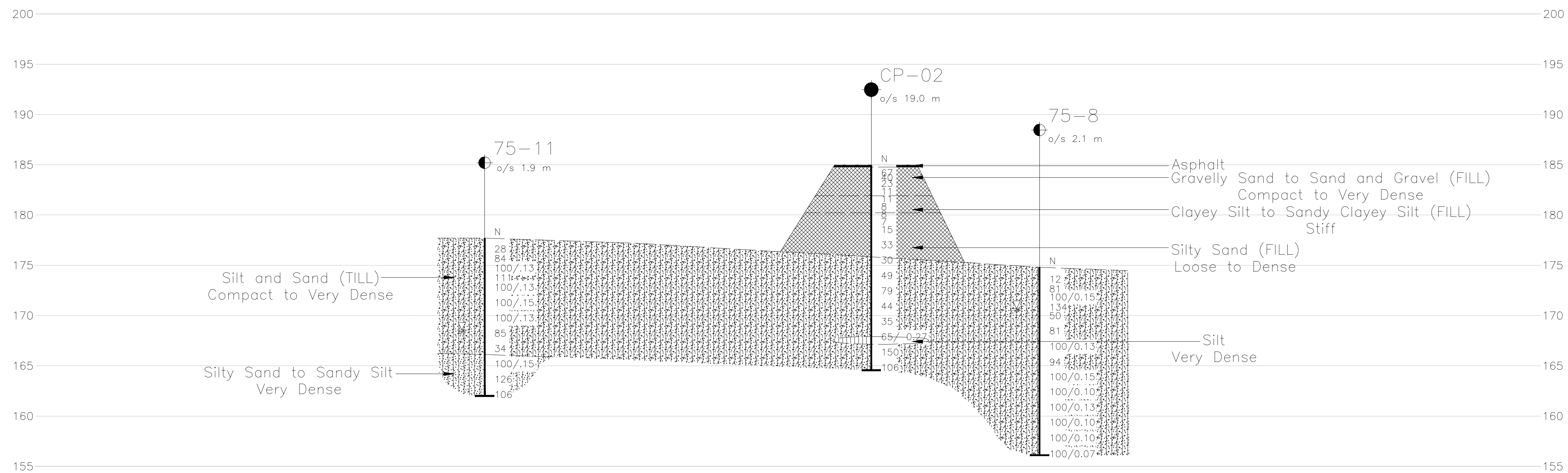
CONT No.
WP No. 2162-11-00

CP RAIL OVERHEAD REPLACEMENT
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS

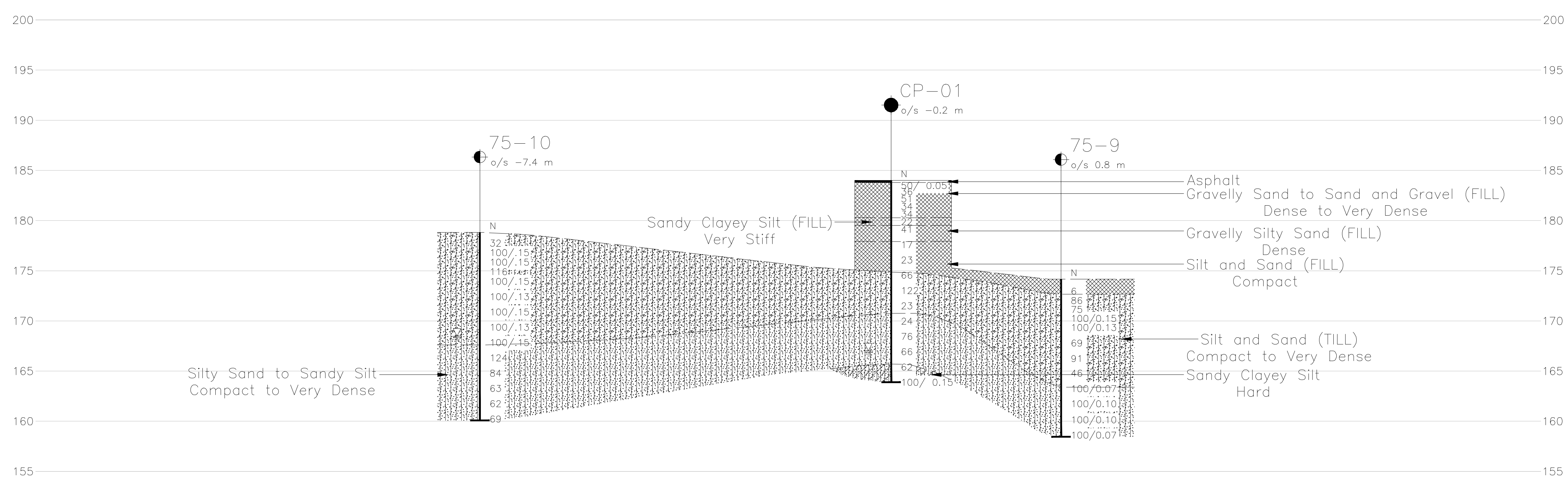
SOIL STRATA

SHEET

GOLDER



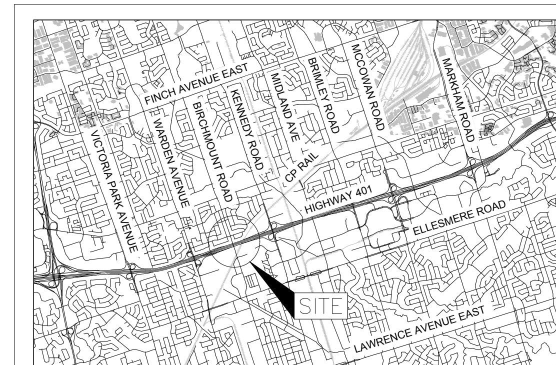
CROSS SECTION B – B'



CROSS SECTION C – C'

HORIZONTAL SCALE 10 0 10 20 m

VERTICAL SCALE 5 0 5 10 m



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

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NO.	DATE	BY	REVISION

Geocres No. 30M14-493

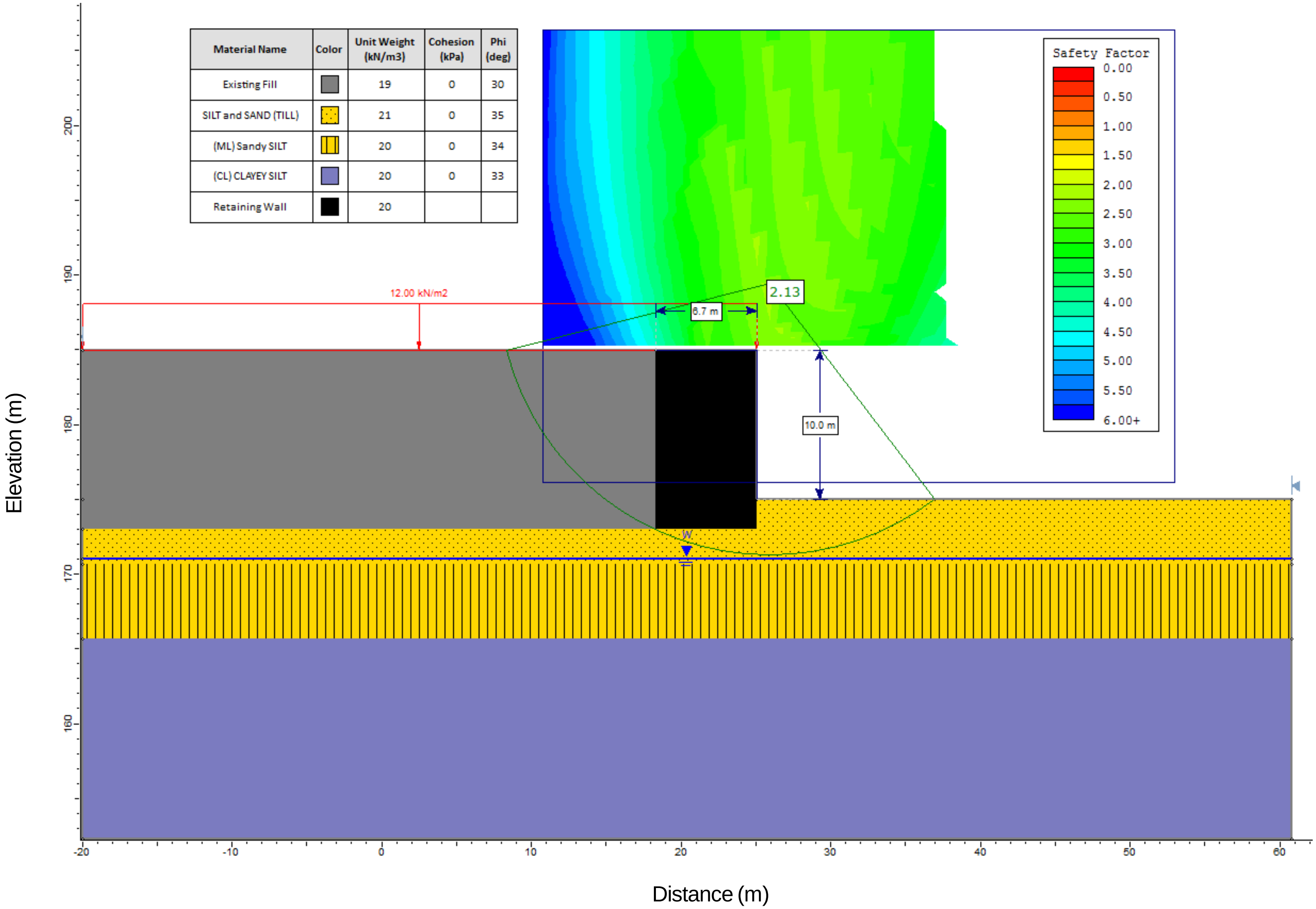
HWY. 401	PROJECT NO. 1669995	DIST.
SUBM'D. NK	CHKD. NK	DATE: 01/16/2019	SITE:
DRAWN: DD	CHKD. NK	APPD. LCC	DWG. 2

MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: January 17, 2019

1669995_1007_CPRailOverhead_SlopeStability

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Fill		19	0	30
SILT and SAND (TILL)		21	0	35
(ML) Sandy SILT		20	0	34
(CL) CLAYEY SILT		20	0	33
Retaining Wall		20		



CLIENT
Ministry of Transportation Ontario (MTO)

CONSULTANT

GOLDER

YYYY-MM-DD	2018-07-19
PREPARED	DH
DESIGN	XX
REVIEW	XX
APPROVED	XX

PROJECT
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES
NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO
W.P. NO. 2162-11-00

TITLE
CP RAIL OVERHEAD
STATIC GLOBAL STABILITY ANALYSIS
RETAINED SOIL SYSTEM (RSS) WALL

PROJECT No.
1669995

1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

APPENDIX A

Borehole Records from Current 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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_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 $= \sigma'_p / \sigma'_{vo}$

(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 δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

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

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CP-01

SHEET 1 OF 2

METRIC

PROJECT 1669995

G.W.P. 2219-14-00

LOCATION N 4848184.5; E 321570.3 MTM NAD 83 ZONE 10 (LAT. 43.773440; LONG. -79.291684)

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 14 and 16, 2018

CHECKED BY NK/LCC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	PLASTIC/LIQUID LIMIT	GR	SA	SI	CL
184.0	GROUND SURFACE										
0.0	ASPHALT (203 mm)										
0.2	Sand and gravel, some silt (FILL) Very dense Brown Wet	1	SS	50/ 0.05							
183.2 / 0.8	Gravelly sand, some silt, trace clay (FILL) Dense to very dense Brown-grey Moist	2	SS	36	183	○					
		3	SS	51	182	○		28	56	13	3
		4	SS	34							
		5	SS	34	181						
180.3 / 3.7	Sandy clayey silt, trace gravel (FILL) Very stiff Brown Moist	6	SS	22	180	○	├─┤				
179.5 / 4.5	Gravelly silty sand, trace to some clay (FILL) Dense Brown Moist - Grinding on inferred cobble at a depth of approximately 5.3 m	7	SS	41	179	○		21	52	21	6
177.9 / 6.1	Silt and sand, trace gravel, trace clay (FILL) Compact Grey-brown Moist	8	SS	17	178	○					
	- Trace organics at a depth of approximately 7.6 m - Grinding on inferred cobble at a depth of approximately 7.6 m	9	SS	23	177 / 176						
174.9 / 9.1	SILT and SAND, trace to some clay, trace to some gravel (TILL) Compact to very dense Grey-brown Moist	10A / 10B	SS	66	175	○	├─┤	7	39	44	10
		11	SS	122	174 / 173	○					
	- Grinding on inferred cobble between depths of approximately 13.0 m and 13.3 m	12	SS	23	172 / 171						
170.7 / 13.3	Sandy SILT, trace clay Compact to very dense Brown Moist to wet	13	SS	24	170						

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

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No CP-01

SHEET 2 OF 2

METRIC

PROJECT 1669995
G.W.P. 2219-14-00
DIST Central HWY 401
DATUM Geodetic

LOCATION N 4848184.5; E 321570.3 MTM NAD 83 ZONE 10 (LAT. 43.773440; LONG. -79.291684)
BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 165 mm O.D. Hollow Stem Augers
DATE February 14 and 16, 2018

ORIGINATED BY AB
COMPILED BY KAW
CHECKED BY NK/LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Sandy SILT, trace clay Compact to very dense Brown Moist to wet	14	SS	76				NP	0	23	74	3
						168						
		15	SS	66	∇	167						
165.7 / 18.3	Sandy CLAYEY SILT, some sand, some gravel Hard Grey Moist	16	SS	62		166						
						165						
163.9 / 20.1	END OF BOREHOLE	17	SS	100/0.15		164						

NOTES:

1. Water level measured in open borehole at a depth of about 17.0 m below ground surface upon completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

RECORD OF BOREHOLE No CP-02

SHEET 1 OF 2 **METRIC**

PROJECT 1669995

G.W.P. 2219-14-00

LOCATION N 4848175.5; E 321524.0 MTM NAD 83 ZONE 10 (LAT. 43.773386; LONG. -79.292270)

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 12 to 14, 2018

CHECKED BY NK/LCC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT w (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.9	GROUND SURFACE					
0.0	ASPHALT (203 mm)					
	CONCRETE (254 mm)					
0.5	Gravelly sand to sand and gravel, trace to some silt, trace clay (FILL) Compact to very dense Brown Moist	1	SS	67		
		2	SS	40		
		3	SS	23		
		4	SS	11	o	55 37 6 2
181.9 / 3.1	Clayey silt to sandy clayey silt, trace gravel (FILL) Stiff Brown to grey Moist to wet	5	SS	11	o	
		6	SS	8	wP–w–wL plotted	
180.2 / 4.8	Silty sand to silt and sand, trace to some clay (FILL) Loose to dense Brown, containing oxidation stains in Sample 9 Moist, becoming wet in Sample 9	7A / 7B	SS	8		
		8	SS	7	o	0 72 27 1
		9A / 9B	SS	15		
		10	SS	33	o	0 52 42 6
175.8 / 9.1	SILT and SAND, trace to some clay, trace to some gravel (TILL) Dense to very dense Brown to grey Moist to wet	11	SS	30		
		12	SS	49	o	
		13	SS	79		
		14	SS	44	o H	

Elevation scale: 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170

Dynamic cone penetration resistance plot: 20 40 60 80 100. Shear strength kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100. Water content (%): 10 20 30. Unit weight γ kN/m³.

Continued Next Page

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

RECORD OF BOREHOLE No CP-02

SHEET 2 OF 2 **METRIC**

PROJECT 1669995
G.W.P. 2219-14-00
LOCATION N 4848175.5; E 321524.0 MTM NAD 83 ZONE 10 (LAT. 43.773386; LONG. -79.292270)
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 12 to 14, 2018
CHECKED BY NK/LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILT and SAND, trace to some clay, trace to some gravel (TILL) Dense to very dense Brown to grey Moist to wet - Grinding on inferred cobble at depth of approximately 14.8 m and 15.1 m	15	SS	35	169					
167.8		16A 16B	SS	65/ 0.27	168					
167.8 17.1	SILT, some sand, some clay, trace gravel Very dense Grey Moist									
167.1 17.8	SILT and SAND, trace to some clay, trace gravel (TILL) Very dense Grey Moist	17	SS	150	167	~9	4	48	40	8
		18	SS	106	166, 165	~10				
164.5 20.4	END OF BOREHOLE NOTES: 1. Borehole caved to a depth of approximately 16.8 m upon removal of augers. 2. Open borehole dry upon completion of drilling.									

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

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

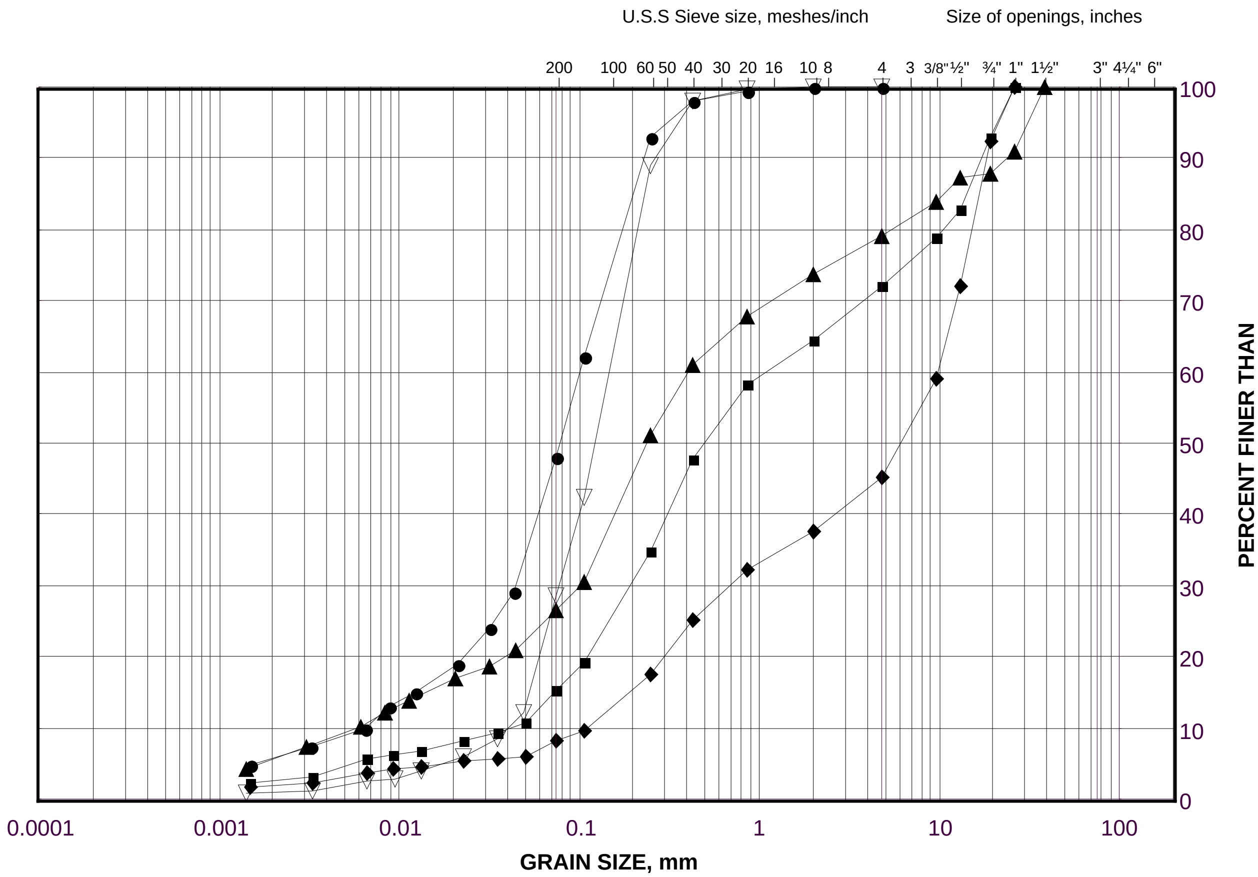
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand and Gravel (Fill)

FIGURE B1



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CP-02	10	177.0
■	CP-01	3	182.2
◆	CP-02	4	182.3
▲	CP-01	7	179.1
▽	CP-02	8	179.2

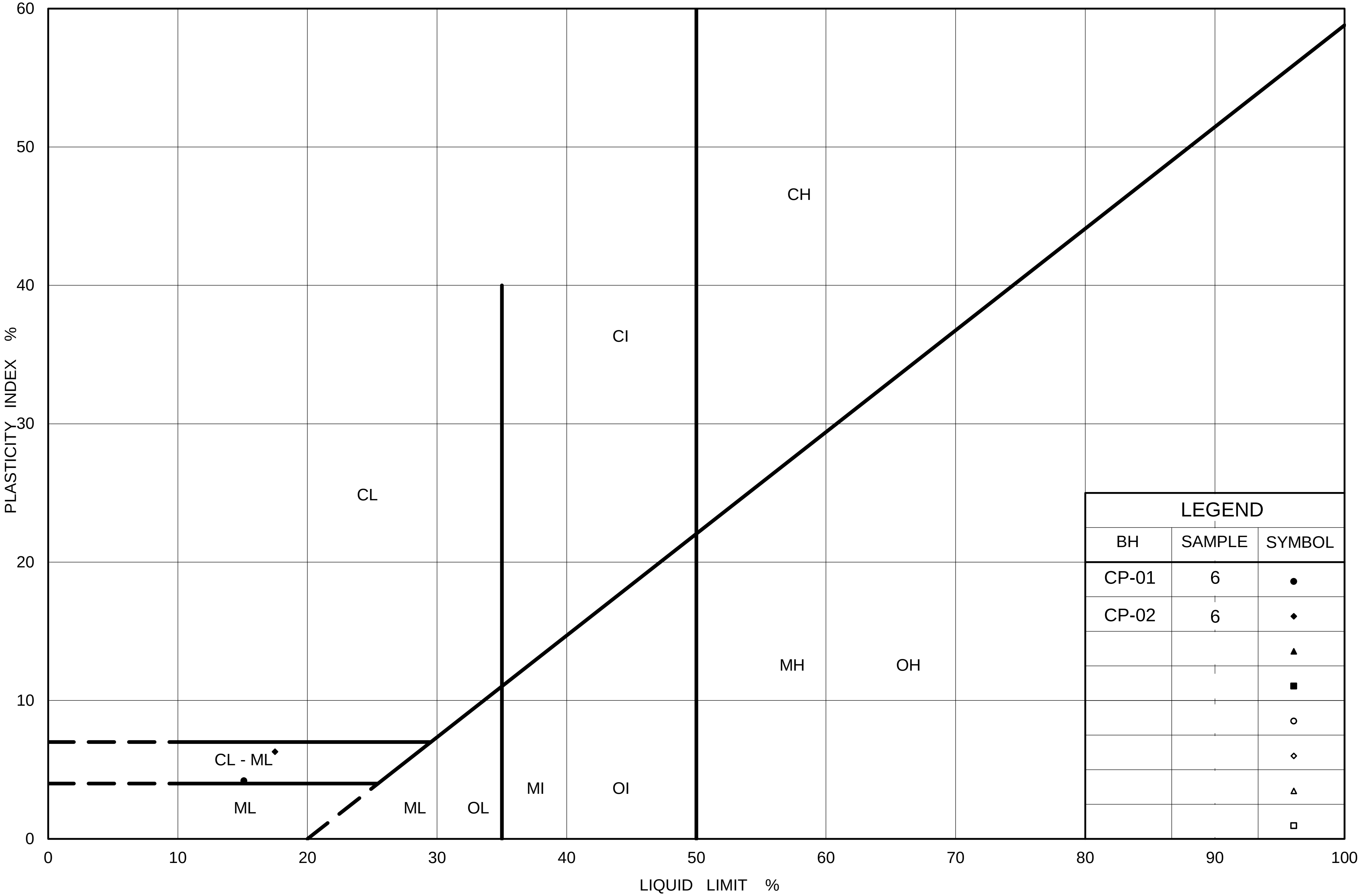
Project Number: 1669995

Checked By: NK

Golder Associates

Date: 19-Jul-18

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt to Sandy Clayey Silt (Fill)

Figure No. B2

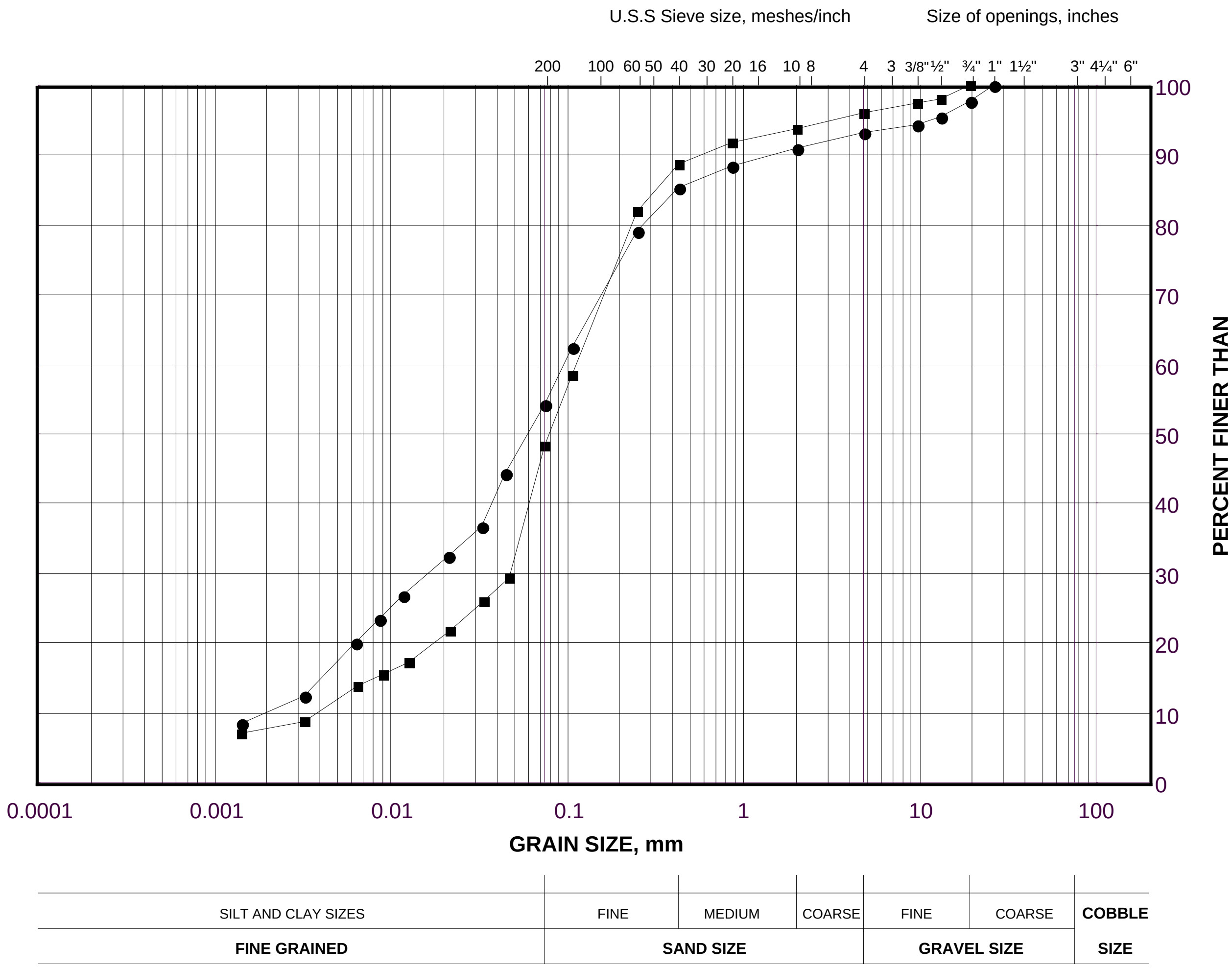
Project No. 1669995

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand Till

FIGURE B3



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CP-01	10B	174.4
■	CP-02	17	166.4

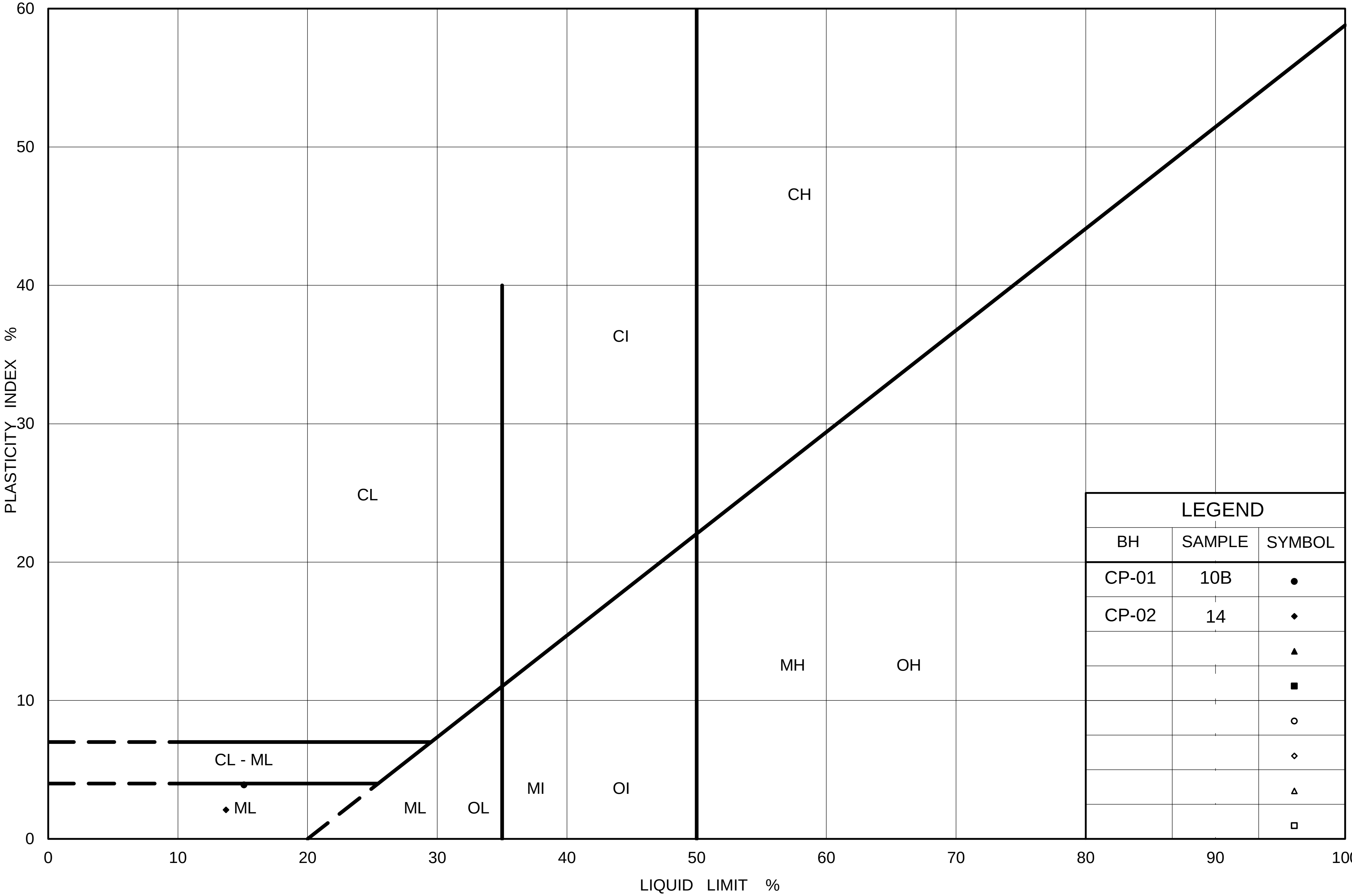
Project Number: 1669995

Checked By: NK

Golder Associates

Date: 19-Jul-18

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand Till

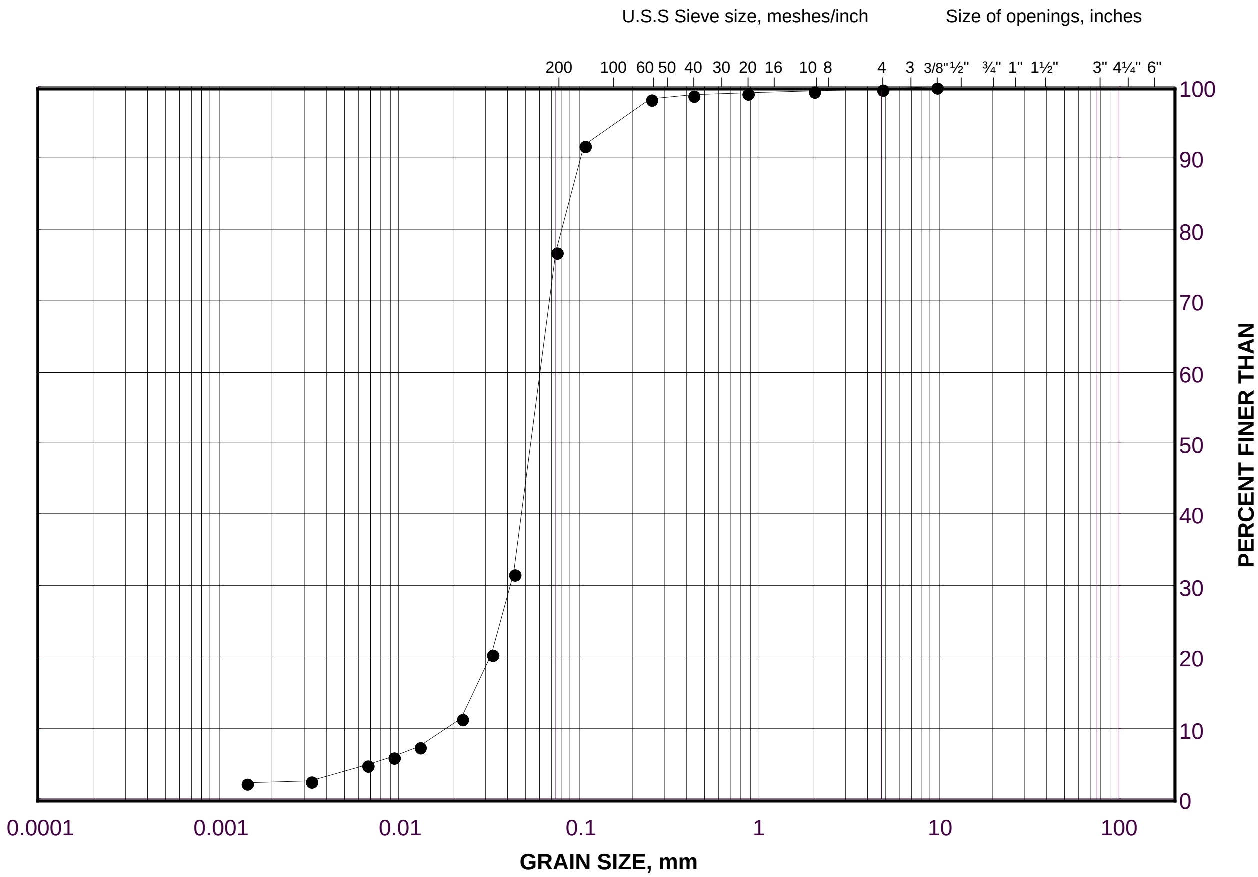
Figure No. B4

Project No. 1669995

Checked By: NK

GRAIN SIZE DISTRIBUTION
Sandy Silt to Silty Sand

FIGURE B5



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CP-01	14	168.5

Project Number: 1669995

Checked By: NK

Golder Associates

Date: 19-Jul-18

APPENDIX C

Analytical Chemical Test Results

Maxxam
A Bureau Veritas Group Company

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

Attention: Nikol Kochmanova

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

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

CERTIFICATE OF ANALYSIS

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

Sample Matrix: Soil
Samples Received: 4

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

Remarks:

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

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

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

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

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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.

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Maxxam
A Bureau Veritas Group Company

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

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

SOIL CORROSIVITY PACKAGE (SOIL)

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

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

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Maxxam
A Bureau Veritas Group Company

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

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

TEST SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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.

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

QUALITY ASSURANCE REPORT

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

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

N/A = Not Applicable

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

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

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

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

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

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VALIDATION SIGNATURE PAGE

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

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

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

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

CHAIN OF CUSTODY RECORD 105772 Page 1 of 1

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

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

Rush Confirmation #:

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

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

Include Criteria on Certificate of Analysis: Y / N

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

LABORATORY USE ONLY

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

COOLING MEDIA PRESENT: Y / (N)

Analysis Requested

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

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Katie Nero [signature]	2018/03/20	12:05PM	[signature] / Parseep Parsend	2018/03/20	12:06

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

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

COC-1004 (03/17)

White: Maxxam ~ Yellow: Client

Maxxam
A Bureau Veritas Group Company

Your Project #: 1669995
Site Location: 401W

Attention: Nikol Kochmanova

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

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

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

CERTIFICATE OF ANALYSIS

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

Sample Matrix: Soil
Samples Received: 31

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

Remarks:

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

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

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

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

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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

Encryption Key

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

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

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

RESULTS OF ANALYSES OF SOIL

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

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

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

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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

RESULTS OF ANALYSES OF SOIL

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

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

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

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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

RESULTS OF ANALYSES OF SOIL

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

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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

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

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

RESULTS OF ANALYSES OF SOIL

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

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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

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

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

RESULTS OF ANALYSES OF SOIL

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

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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

TEST SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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TEST SUMMARY

Maxxam ID: GWL602 **Collected:** 2018/04/11
Sample ID: OH-7 SA#5 **Shipped:**
Matrix: Soil **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 **Collected:** 2018/04/12
Sample ID: OH-4 SA#4 **Shipped:**
Matrix: Soil **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 **Collected:** 2018/03/19
Sample ID: MRU-01 SA#4 **Shipped:**
Matrix: Soil **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 **Collected:** 2018/03/21
Sample ID: BRU-01 SA#6 **Shipped:**
Matrix: Soil **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 **Collected:** 2018/03/14
Sample ID: CN-02 SA#23B **Shipped:**
Matrix: Soil **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

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

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

TEST SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Golder Associates Ltd
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Sampler Initials: AM

TEST SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Report Date: 2018/06/08

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Sampler Initials: AM

TEST SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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

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Report Date: 2018/06/08

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Site Location: 401W
Sampler Initials: AM

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

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Sampler Initials: AM

TEST SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

GENERAL COMMENTS

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

Package 1	20.0°C

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

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

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

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

N/A = Not Applicable

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

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

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

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

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

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

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

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

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

VALIDATION SIGNATURE PAGE

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

Cristina Carriere, 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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1 of 4

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CHAIN OF CUSTODY RECORD

Page [illegible]

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

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

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

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

Special Instructions:

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

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

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

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

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

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered	Metals / Hg / Cr VI	Corrosivity pkg	# of Bottles	Comments
1		BR-03 SA#14	Feb 14/18	AM	Soil			X		
2		RW-02 SA#9	April 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		MRU-01 SA#4	Mar 19/18	AM	Soil			X		
7		BRU-01 SA#6	Mar 21/18	AM	Soil			X		
8		CN-02 SA#23b	Mar 14/18	AM	Soil			X		
9		KR-01 SA#9	Mar 22/18	AM	Soil			X		
10		NWI-04 SA#6	Apr 5/18	AM	Soil			X		

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

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Alex MacMillan [signature]	18/06/05	16:45	[signature] JUNAID [illegible]	18/06/05	16:46	

Laboratory Use Only: Time Sensitive; Temperature (°C) on Recei: 20/20/20; Custody Seal Present: No ✓; 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

NO ICE

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CHAIN OF CUSTODY RECORD

Page 2 of 4

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683
Attention:	Accounts Payable	Attention:	Nikol Kochmanova	P.O. #:	
Address:	6925 Century Ave Suite 100, Mississauga ON L5N 7K2	Address:		Project:	1669995
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	(905) 567-6100 Ext: 1459 Fax:	Project Name:	401 W
Email:	AP_CustomerService@golder.com	Email:	Nikol_Kochmanova@golder.com	Site #:	
				Sampled By:	

Laboratory Use Only:

Maxxam Job #:	Bottle Order #:
	668025
COC #:	Project Manager:
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): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine; ☐ Table 2 ☐ Ind/Comm ☐ Coarse; ☐ Table 3 ☐ Agri/Other ☐ For RSC; ☐ Table ___

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

Special Instructions

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

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

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

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

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

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

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

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

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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

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CHAIN OF CUSTODY RECORD

Page ___ of ___

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

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

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

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

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

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

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

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

#	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered / Metals / Hg / Cr VI	Corrosivity pkg	# of Bottles	Comments
1		NW1-01 SA#4	Mar 26/18	AM	SOIL		X		
2		NBP1-1 SA#9	Apr 9/18	AM	SOIL		X		
3		CN-01 SA#20A	Mar 6/18	AM	SOIL		X		
4		CP-01 SA#12	Feb 25/18	AM	SOIL		X		
5		OH-5 SA#7	Apr 12/18	AM	SOIL		X		
6		OH-9 SA#5	Apr 13/18	AM	SOIL		X		
7		NB-02 SA#4	May 29/18	AM	SOIL		X		
8		OH-1 SA#7	Apr 12/18	AM	SOIL		X		
9		KR-02 SA#3	May 9/18	AM	SOIL		X		
10		MR-02 SA#7	May 7/18	AM	SOIL		X		

* 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 Receipt; Custody Seal Present / Intact: Yes / No

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

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CHAIN OF CUSTODY RECORD

Page

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

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

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

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

Special Instructions

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

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Corrosivity pkg (Cl, SO4, pH, Resistivity/EC - no Sulphide and Redox Potential)	# of Bottles	Comments
1		BR-01 SA#4	May 30/18	AM	SOIL		X		
2									
3									
4									
5									
6									
7									
8									
9									
10									

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

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

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

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

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

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APPENDIX D

Borehole Records from Previous Investigation (GEOCRES No. 30M14-75)

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 75-7

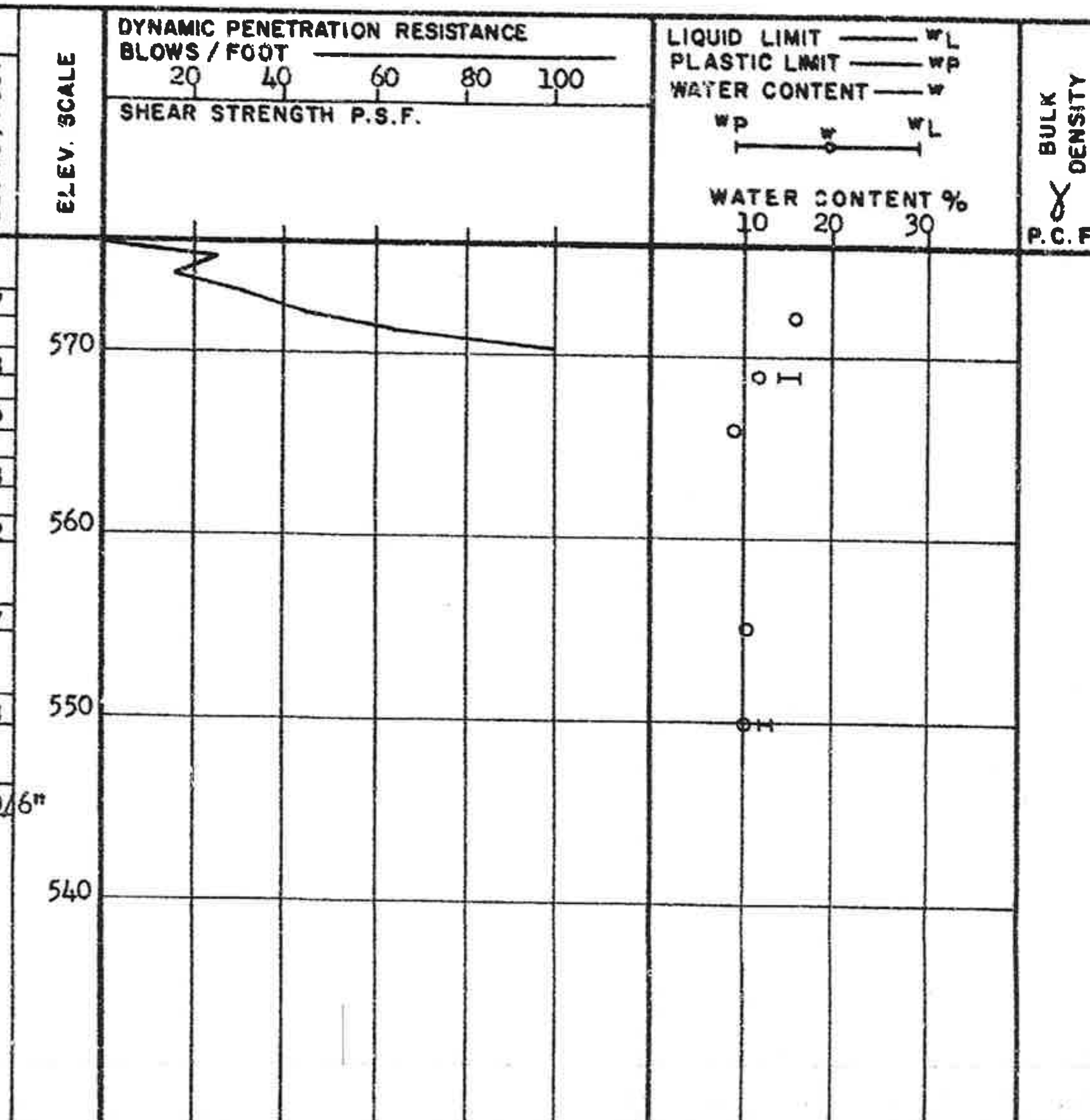
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 66-F-89
W. P. 257-61
DATUM Geodetic
LOCATION Hwy.401 & C.P.R.(Ret.Wall No.2) Sta. 322 ≠ 70 118' Lt.
BORING DATE November 29, 1966
BOREHOLE TYPE Pen Drill Auger
ORIGINATED BY V.K.
COMPILED BY V.K.
CHECKED BY [initials]

(m)	ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	REMARKS
175.6	576.0	GROUND LEVEL				
	0.0	(Brown) (trace of organics in sample No. 1)	1	SS	27	2.7% Org.
		Clayey silt to silt with sand and trace of gravel. (Grey)	2	SS	33	Gr.5, Sa.44 Si.46 Cl.5
			3	SS	86	
			4	SS	93	El. 561. ▼
			5	SS	42	
		Very stiff to Hard.	6	SS	37	Gr. 7 Sa.47 Si.40 Cl. 6
			7	SS	23	
166.0	544.5		8	SS	100/6"	
9.6	31.5	End of Borehole				



FORM OB-MT-126
66-4846

OFFICE REPORT ON SOIL EXPLORATION

BH 75-8

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB 66-F-89
W.P. 257-61
DATUM Geodetic

LOCATION Hwy. 401 & C.P.R., Sta. 323 ∠ 59 119' Lt.
BORING DATE November 30, 1966
BOREHOLE TYPE Pen Drill Auger

ORIGINATED BY V.K.
COMPILED BY V.K.
CHECKED BY [signature]

SOIL PROFILE

(m)	ELEV. DEPTH	DESCRIPTION
174.8	573.6	GROUND LEVEL
	0.0	Clayey silt to (Grey) silt with pockets of silty sand and occ. gravel. Hard
156.1	512.1	
18.7	61.5	End of Borehole

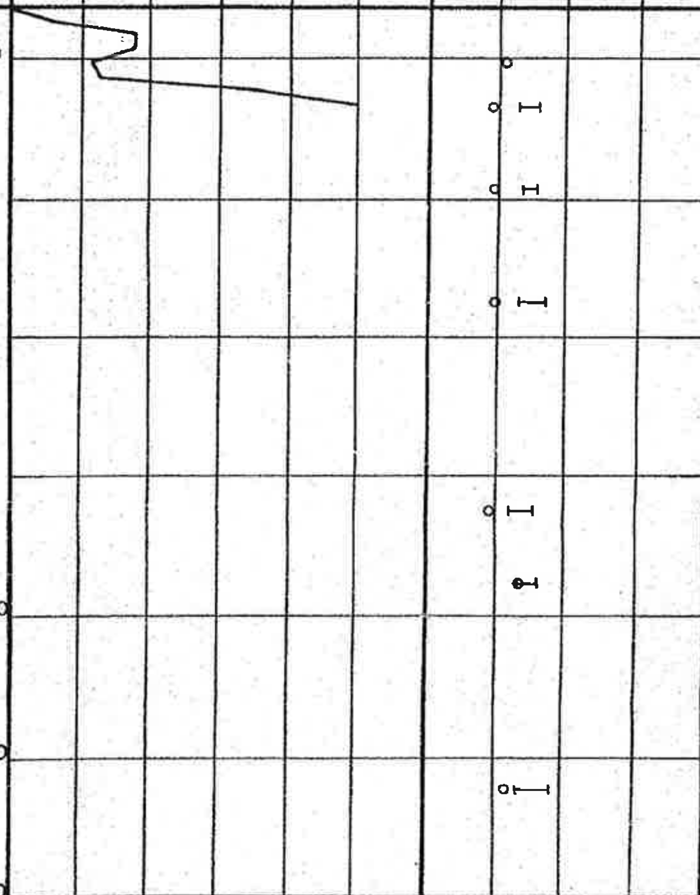
SAMPLES

NUMBER	TYPE	BLOWS / FOOT
1	SS	12
2	SS	81
3	SS	100/5"
4	SS	134
5	SS	50
6	SS	81
7	SS	100/5"
8	SS	94
9	SS	100/5"
10	SS	100/4"
11	SS	100/5"
12	SS	100/4"
13	SS	100/4"
14	SS	100/3"

ELEV. SCALE: 570, 560, 550, 540, 530, 520, 510

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (20, 40, 60, 80, 100) — SHEAR STRENGTH P.S.F.

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
WATER CONTENT % (10, 20, 30)



BULK DENSITY γ P.C.F.

REMARKS

Gr.1, Sa.43, Si.47, Cl. 9

El. 560.1 ▽

Gr.1, Sa.44, Si.45, Cl.10

FORM OB-MT-126
66-4346

OFFICE REPORT ON SOIL EXPLORATION

BH 75-9

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 66-F-89
W.P. 257-61
DATUM Geodetic

LOCATION Hwy.401 & C.P.R., Sta. 324 + 74 133' Lt.
BORING DATE November 25, 1966
BOREHOLE TYPE Drive BX Casing & Wash

ORIGINATED BY V.K.
COMPILED BY V.K.
CHECKED BY [illegible]

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	REMARKS
571.4	GROUND LEVEL					
0.0	(Brown) Fill material					
566.4			1	SS	6	
5.0	Clayey silt to silt with pockets (Grey) of silty sand and trace of gravel Hard		2	SS	86	Gr.2, Sa.45 Si.43 Cl.10
			3	SS	75	El.559.9 (water level)
			4	SS	100/6"	Gr.7 Sa.43 Si.41 Cl. 9
			5	SS	100/5"	
			6	SS	69	
			7	SS	91	
			8	SS	46	Gr.4, Sa.40 Si.53 Cl. 3
			9	SS	100/3"	
			10	SS	100/4"	
			11	SS	100/4"	Gr. 1 Sa.13 Si.78 Cl. 8
519.9			12	SS	100/3"	
51.5	End of Borehole					

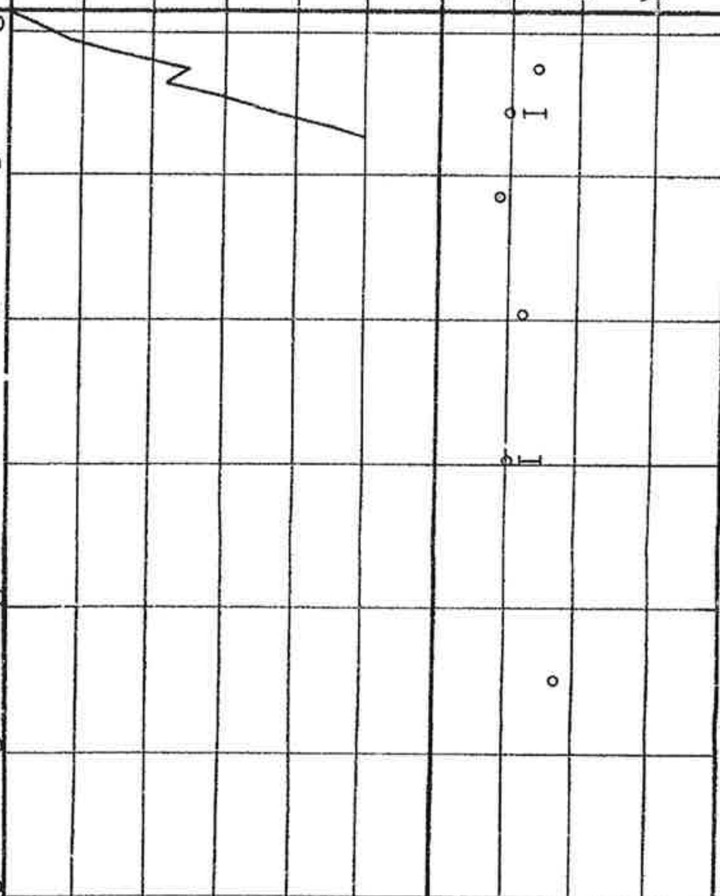
ELEV. SCALE: 570, 560, 550, 540, 530, 520, 510

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100
SHEAR STRENGTH P.S.F.

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

WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.



FORM 08-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

BH 75-10

DEPARTMENT OF HIGHWAYS – ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 10

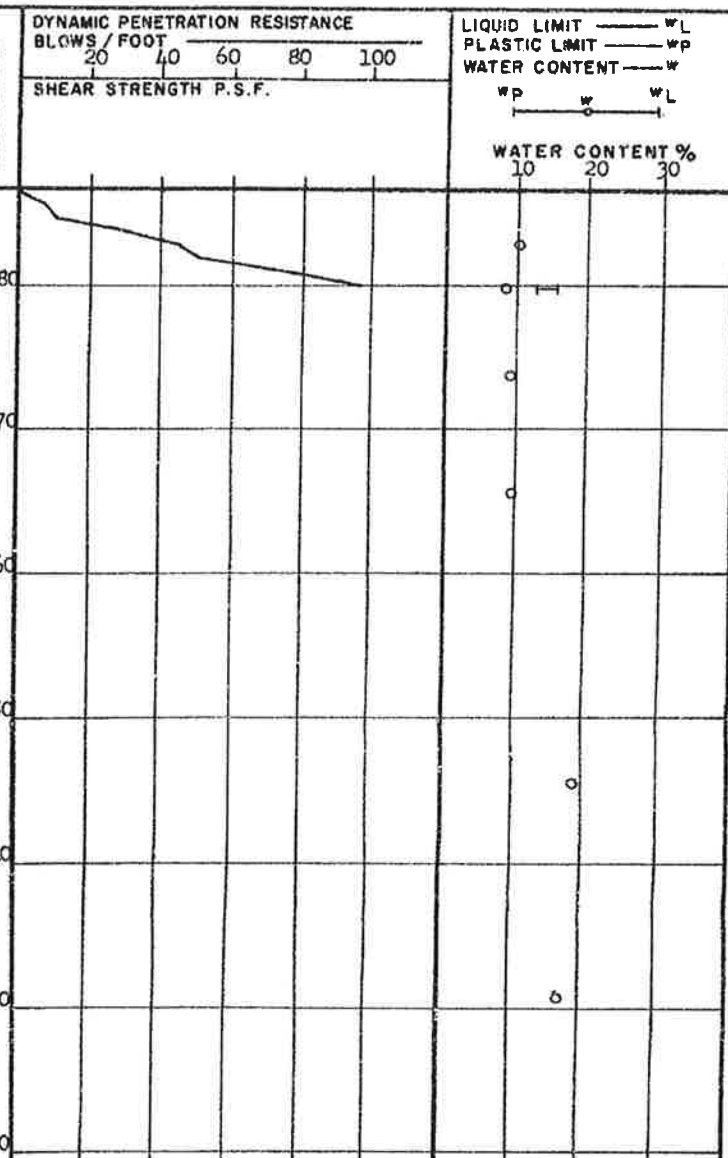
FOUNDATION SECTION

JOB 66-F-89
W.P. 257-61
DATUM Geodetic

LOCATION Hwy. 401 & C.P.R. (Sta. 322 + 22 155' Rt.
BORING DATE December 2, 1966
BOREHOLE TYPE Pen-Drill Auger

ORIGINATED BY V.K.
COMPILED BY V.k.
CHECKED BY

SOIL PROFILE ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BULK DENSITY γ P.C.F.	REMARKS
(m) 178.8 586.7	GROUND LEVEL							
0.0	(Brown)							
			1	SS	32			
			2	SS	100/6"	580		Gr.2,Sa.48 Si.38 Cl.12
	Silty sand to sandy silt with trace of clay and occasional gravel.		3	SS	100/6"			
			4	SS	116			Gr.1,Sa.46 Si.44 Cl. 9
			5	SS	100/6"	570		
			6	SS	100/5"			
	Dense to very dense.		7	SS	100/6"	560		
			8	SS	100/5"			El. 552.7
			9	SS	100/6"	550		
			10	SS	124			Gr.0,Sa.81 Si.&Cl. 19
			11	SS	84	540		
			12	SS	63			
			13	SS	62	530		
160.1 525.2			14	SS	69			
18.7 61.5	End of Borehole					520		



BH 75-11

DEPARTMENT OF HIGHWAYS – ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 66-F-89

W.P. 257-61

DATUM Geodetic

LOCATION Hwy. 401 & C.P.R., Sta. 321 ∤ 02, 131' Rt.

BORING DATE December 2, 1966

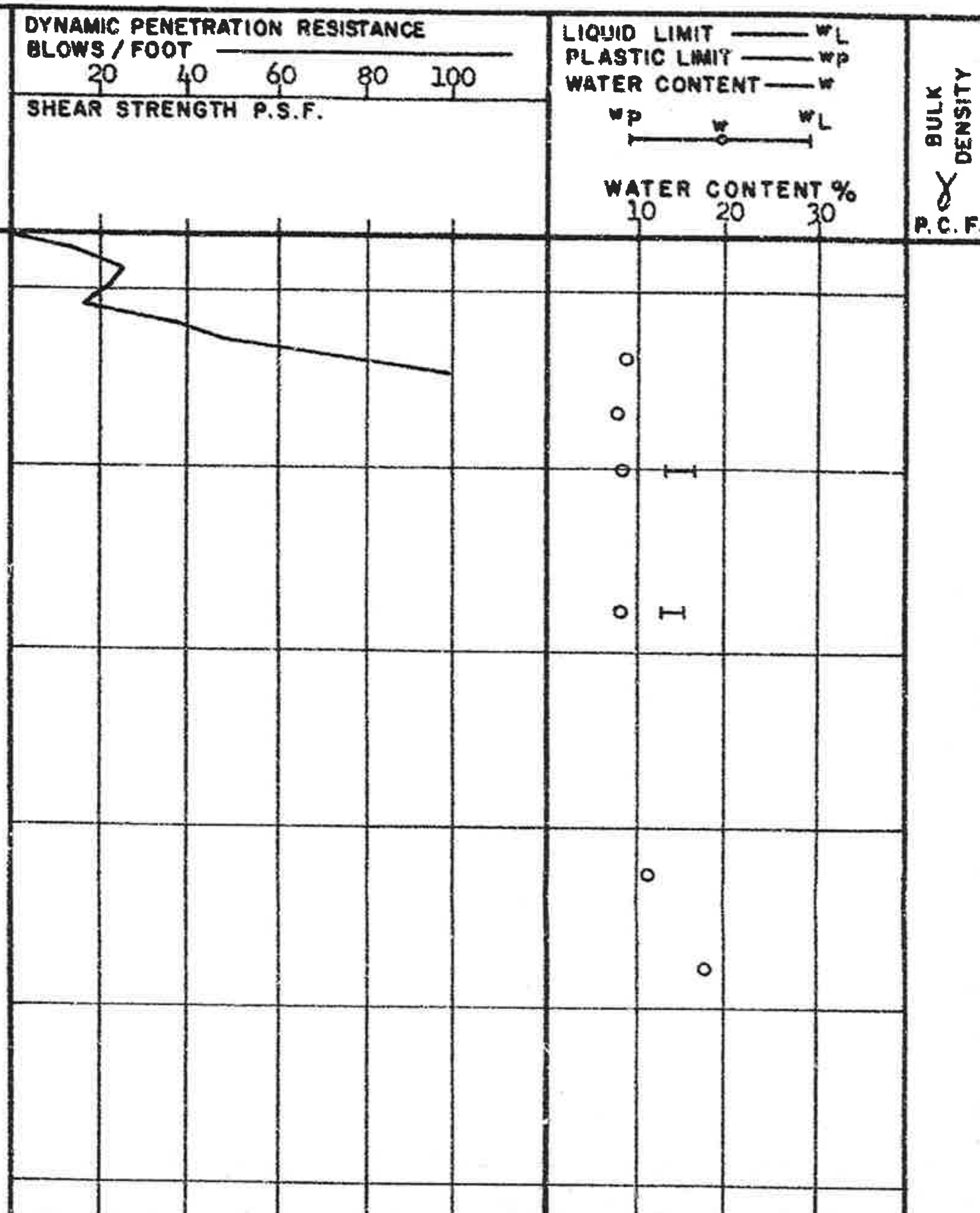
BOREHOLE TYPE Drive BX Casing & Wash

ORIGINATED BY V.K.

COMPILED BY V.K.

CHECKED BY [signature]

(m)	ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	REMARKS
177.7	583.0	GROUND LEVEL						
	0.0	(Brown) Clayey silt with pockets of silty sand and trace of gravel. Very Stiff to Hard						
				1	SS	28	580	
				2	SS	84		Gr.2, Sa.47 Si.38 Cl.13
				3	SS	100/6"		
				4	SS	111	570	
				5	SS	100/5"		
				6	SS	100/6"	560	Gr.6, Sa.45 Si.38 Cl.11
				7	SS	100/5"		El.553. ▼
				8	SS	85	550	
166.1	545.0			9	SS	34		
11.6	38.0	Silty sand to sandy silt, occasional gravel. Very Dense.		10	SS	100/6"	540	Gr.0, Sa.91 Si.&Cl. 9
				11	SS	126		
162.0	531.5			12	SS	106	530	
15.7	51.5	End of Borehole						



APPENDIX E

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 CP Rail Overhead replacement.

2.0 References

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

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

3.0 Definitions - Not Used

4.0 Design and Submission Requirements - Not Used

5.0 Materials

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

6.0 EQUIPMENT - Not Used

7.0 CONSTRUCTION

7.01 Excavation

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

7.03 Protection of Subgrade

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

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

7.04 Dewatering

Dewatering shall be carried out according to OPSS 902.

8.0 Quality Assurance - Not Used

9.0 Measurement for Payment - Not Used

10.0 Basis of Payment

10.01 Working Slab - Item

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

END OF SECTION

CSP FOR INTEGRAL ABUTMENTS – Item No

Non-Standard Special Provision

Scope

This specification covers the requirements for the installation of the corrugated steel pipes (CSPs) at the integral abutments.

Submission and Design Requirements

All submissions shall bear the seal and signature of an Engineer.

At least two weeks prior to commencement of installation of the abutment piles, the Contractor shall submit to the Contract Administrator, for information purposes only, three (3) sets of the working drawings.

The Contractor shall have a copy of the submitted working drawings on site at all times. Working drawings shall include at least the following:

1. Layout and elevations of the CSPs;
2. Location of reference points, and location of the centroid of each pile with respect to the reference points;
3. Construction sequence and details;
4. Source of the sand fill, and description of placing methods and equipment;
5. Location and details of all temporary bracing and spacers for the piles and CSPs;
6. Method for preventing water and debris from entering the CSP prior to placing sand; and
7. Method for preventing concrete from abutment pours from entering the CSPs during placement.

The Contractor shall be responsible for the complete detailed design of all temporary bracing, including spacers required to maintain the piles, CSP spacing and abutment stems in their specified positions through all stages of construction until the CSPs have been backfilled. All temporary bracing shall be removed.

Material

Corrugated steel pipe

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

CSPs shall be supplied in the lengths and with the end treatments, either square or skew, as specified on the Contract drawings; field cutting and splicing of CSPs will not be permitted. Cut ends shall be neat and free of burrs. The planes defined by the end treatments of each CSP shall be parallel to each other.

Handling and storage of CSPs shall be in accordance with the manufacturer’s recommendations. Damaged CSPs shall be rejected. Localized areas of damaged galvanizing on otherwise acceptable CSPs shall be repaired with two coats of zinc-rich paint.

Sand Fill

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

Table 1 – Sand Fill Gradation Requirements

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

Construction

The sequence of construction shall be in accordance with the working drawings and as follows, unless otherwise approved:

1. Construct levelling pad and place CSPs and spacers.
2. Install piles by driving to design criteria.
3. Place loose sand into 600 diameter CSP.
4. Remove temporary spacers.

The CSP shall be positioned such that the piles are centrally positioned within the CSP. Temporary blocking and bracing shall be used to hold the CSP in position.

The Contractor shall ensure the full perimeters of the tops of all CSPs at each abutment are at the elevation and orientation shown on the working drawings.
The CSP at each pile shall be constructed to the following tolerances:

Criteria	**Tolerance**
Maximum deviation of CSP from pile centroid	+/- 50 mm
Maximum deviation of any point on the top perimeter of the CSP from the specified elevation	+/- 10 mm

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

The placing of the sand fill shall be carried out in a manner such as to not damage and displace the CSP.

Basis of Payment

Payment at the contract price for the above tender item shall include all labour, equipment and material required to do the work.

END OF SECTION

EARTH EXCAVATION FOR STRUCTURE – Item No.

Special Provision

Amendment to OPSS 902, November 2010

Excavating and Backfilling – Structures

902.07 CONSTRUCTION

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

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

VIBRATION MONITORING - Item No.

Non-Standard Special Provision

Scope

This special provision describes requirements for vibration monitoring during piling / caisson installation works for the construction of the Highway 401 – CP Rail overhead bridge structure.

References

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

CP Rail Overhead Replacement
Highway 401 Westbound Core and Collector Lanes
Neilson Road to Warden Avenue
City of Toronto, Ontario
W.P. No. 2162-11-00

Definitions

Contractor's Engineer (CE): An Engineer with a minimum of five (5) years' experience in the field of installation of piling and vibration monitoring or, alternatively, with expertise demonstrated by providing satisfactory quality verification services for 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 certificates 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 residential structures located within 100 m of the works during driving of each pile, 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 has been driven, prior to continuing with the subsequent piles. As a minimum, the pile number, location, set criteria and driving 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.

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

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