FINAL REPORT

Preliminary Foundation Investigation and Design Report

10th Sideroad Underpass
Highway 400 to Highway 404 Link (Bradford Bypass)
Simcoe County and York Region
MTO Assignment No. 2019-E-0048

Submitted to:

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19136074-Rev0

September 18, 2023

GEOCRES No.: 31D-814
Latitude: 44.123737°
Longitude: -79.606558°

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PART A

PRELIMINARY FOUNDATION INVESTIGATION REPORT
10TH SIDEROAD UNDERPASS
HIGHWAY 400 TO HIGHWAY 404 LINK (BRADFORD BYPASS)
SIMCOE COUNTY AND YORK REGION
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1.0 INTRODUCTION

WSP Golder (formerly Golder Associates Ltd., now a member of WSP Canada Inc. and hereafter referenced as WSP Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the proposed Bradford Bypass (BBP), a 16.3 km rural controlled access freeway connecting Highway 400 to Highway 404, in the County of Simcoe and Regional Municipality of York. This report addresses the proposed underpass structure to carry 10th Sideroad over the proposed new highway at the location shown on the Key Plan in Drawing 1.

2.0 SITE DESCRIPTION

The proposed new structure is located in the Town of Bradford West Gwillimbury in Simcoe County, Ontario. The proposed structure will be located along the existing 10th Sideroad, between 8th Line and 9th Line. The site is generally bounded by a mix of residential and agricultural areas. There is an outdoor sports complex and church in the northwest quadrant of the site (see Photograph 1) and industrial plants located at the southeast quadrant of the site (see Photograph 2). The existing 10th Sideroad is an undivided arterial road with two lanes of traffic – one lane each in the north and south directions. The existing ground surface generally slopes down from north to south and rises to the east and west of 10th Sideroad. A buried fibre-optic cable was identified at the site as part of our investigation coordination, located along the east side of the existing road embankment and running parallel and adjacent to the overhead hydro and communication lines.

Photograph 1 - Proposed underpass site along 10th Sideroad (looking north with sports complex in far background)

Photograph 2 - Proposed bridge site on east side of 10th Sideroad (looking southeast with industrial facility in background)

3.0 INVESTIGATION PROCEDURES

The field work for the current investigation was carried out between April 29 and May 21, 2021, when a total of four boreholes (10-1,10-2, 10-3 and 10-4) were advanced near the proposed structure footprint as shown in Drawing 1.

The boreholes were advanced using 210 mm outside diameter (O.D.) hollow stem augers generally set to a depth of approximately 2.5 m followed by wash-rotary techniques (advancement of rods and casing with water and drilling mud) using a Diedrich D50 track-mounted drill equipped with water tanks/totes, supplied and operated by

Walker Drilling Inc. of Utopia, Ontario. The wash-rotary technique was used to counter-balance hydrostatic forces and reduce disturbance at the sampling and testing interval. Traffic control for this field investigation was provided by PGC Traffic of Stouffville, Ontario and Direct Traffic Management Inc. of Hamilton, Ontario. Soil samples were generally obtained at 0.75 m, 1.5 m, and 3.0 m intervals of depth using a 50 mm O.D. split spoon sampler driven with an automatic hammer in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)[1]. The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions.

The water level was generally not measured in the open boreholes due to introduction of water during the drilling operations. Where encountered, the water level was measured within the hollow stem augers prior to the start of mud rotary operations. Standpipe piezometers were installed in Boreholes 10-1 and 10-4 and were screened within the clayey silt till and silty sand till deposits. All boreholes were backfilled with a bentonite mixture upon completion in general accordance with Ontario Regulation 903 Wells (as amended), and the ground surface was restored to as near original condition as practicable.

The field work was monitored on a full-time basis by a member of WSP Golder’s engineering staff who located the boreholes in the field, arranged for clearance of underground services, directed the sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers, and transported to WSP Golder’s laboratory in Mississauga for further visual review and geotechnical laboratory testing. Index and classification testing consisting of natural moisture content, Atterberg limits and grain size distribution were conducted on selected samples. All laboratory tests were carried out in general accordance with MTO and / or ASTM Standards, as applicable.

The borehole locations were surveyed in the field by WSP Golder personnel using a Trimble Geo 7X Global Positioning System (GPS) unit. The Trimble Geo 7X achieved a horizontal and vertical accuracy of 1 cm to 2 cm while in use at the site. The locations given on the borehole records (contained in Appendix A) 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 (CGVD28 datum). The borehole locations, including the geographic coordinates, the ground surface elevations, and borehole depths are summarized below.

Borehole No.	MTM NAD 83 Northing (m)	MTM NAD 83 Easting (m)	Latitude (°)	Longitude (°)	Borehole Elevation (m)	Borehole Depth (m)
10-1	4887105.4	296308.4	44.123894	-79.606104	283.0	27.8
10-2	4887137.8	296281.1	44.124185	-79.606446	285.2	27.9
10-3	4887125.1	296260.5	44.124071	-79.606703	282.5	33.6
10-4	4887087.9	296272.1	44.123737	-79.606558	282.3	30.7

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

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2], the general site lies near the border of two physiographic regions of Southern Ontario known as the Peterborough Drumlin field and the Schomberg Clay Plains.

The Peterborough Drumlin field region generally consists of calcareous till soils and is generally sandier (rather than stony) within Simcoe County. Many drumlins in this area are known to have shallow coverings of silt and fine sand which is probably wind-blown material. Deposits of clay typically lie between the drumlins in this area.

The Schomberg Clay Plain region consists of deep deposits of stratified clay and silt. In some areas, clay and silt varves (greater than 100 mm thick) are present with the clay layers typically containing up to 50% clay and 40% silt; however, the behaviour is described to be more like that of silt than clay. The Simcoe silty clay and silt loams are described to be poorly drained.

The overall topography of the area indicates the 10th Sideroad underpass site lies near the bottom of rolling hills to the east and west, suggesting the site is located on / near drumlins. The subsurface conditions encountered during the current investigation are generally consistent with the regional geology described above.

4.2 General Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes from the current investigation including piezometer installation details and water level readings, and the results of the in-situ and laboratory tests are provided on the borehole records in Appendix A. *Abbreviations and Terms Used on Records of Boreholes and Test Pits* and *List of Symbols* sheets are provided in Appendix A to assist in the interpretation of the borehole records. The results of the geotechnical laboratory testing on the soil samples are presented in more detail on the laboratory test figures in Appendix B. The analytical laboratory test results are presented in Appendix C.

The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4 were measured in the field and are considered uncorrected. The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile on Drawing 1 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. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface soils encountered at the 10th Sideroad site consist of surficial layers of topsoil and/or fill underlain by a cohesive layer of clayey silt to clayey silt-silt. These layers are underlain by a clayey silt to clayey silt-silt till deposit which is underlain by a silty sand till deposit. More detailed descriptions of the major layers encountered in the boreholes are provided in the following sections.

4.2.1 Topsoil, Organic Silt to Organic Silty Clay

A 0.2 m and 0.8 m thick layer of topsoil and organic silt to organic silty clay was encountered at ground surface in Borehole 10-1 and 10-4, and below the silty sand fill layer in Borehole 10-2; these boreholes were drilled outside

[2] Chapman, L.J. and Putnam, 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.)

of the existing 10th Sideroad pavement structure. Materials designated as topsoil were classified solely based on visual and textural evidence and field observation determined that the topsoil has cohesive properties. Testing of organic content, or for other nutrients, was not carried out and therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

The SPT 'N'-values measured within this layer ranged from 3 to 5 blows per 0.3 m of penetration suggesting a soft to firm consistency. The water content measured on a sample of the organic silty clay was about 21%.

4.2.2 Asphalt

A 0.1 m thick layer of asphalt was present at the road surface in Borehole 10-2.

4.2.3 Silty Sand Fill

A 2.1 m thick layer of silty sand fill was encountered below the asphalt in Borehole 10-2, which was drilled through the existing roadway. The silty sand contained trace clay and variable amounts of gravel.

The SPT 'N'-values measured within the silty sand fill range from 37 to 51 blows per 0.3 m of penetration, indicating a dense to very dense state of compactness. The water content measured on a sample of the silty sand fill was about 7%. The results of a grain size distribution carried out on a sample of the silty sand fill is presented on Figure B1 in Appendix B.

4.2.4 Clayey Silt Fill

A 1.4 m thick layer of clayey silt, trace sand to sandy, trace gravel, and trace organics was encountered at ground surface in Borehole 10-3.

The SPT 'N'-values measured within this fill layer ranged from 5 to 7 blows per 0.3 m of penetration suggesting a firm consistency.

4.2.5 Surficial Silty Sand

A 1.2 m thick surficial layer of silty sand containing trace organics was encountered below the surficial topsoil layer in Borehole 10-1.

The SPT 'N'-values measured within this layer were 7 and 14 blows per 0.3 m of penetration, indicating a loose to compact state. A water content measured on a sample of the silty sand was about 17%.

4.2.6 Clayey Silt to Clayey Silt-Silt

Underlying the fill and organic silty clay in Borehole 10-2, below the fill in Borehole 10-3, below the topsoil in Borehole 10-4, and below the surficial silty sand in Boreholes 10-1, a thin layer of clayey silt to clayey silt-silt was encountered with a thickness ranging from 0.8 m to 2.3 m. The clayey silt-silt layer in Borehole 10-4 contained organic silt pockets in the upper zone near the interface with the overlying topsoil.

The SPT 'N'-values measured within this layer range from 4 to 21 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The results of grain size distribution and Atterberg limits testing carried out on samples of the clayey silt are shown on Figures B2 and B3 respectively in Appendix B. Atterberg limits measured liquid limits ranging from 18% to 34%, plastic limits ranging from 11% to 18%, and plasticity indices ranging from 7% to 16% and indicate the deposit is a clayey silt to clayey silt-silt of low plasticity. The water content measured on samples of the clayey silt range between about 15% and 22%, above the plastic limit for the material.

4.2.7 Clayey Silt to Clayey Silt-Silt Till

A cohesive deposit of clayey silt to clayey silt-silt till ranging from 2.6 m to 5.7 m thick was encountered below the surficial clayey silt layer in all four boreholes advanced at the site. The cohesive till contained trace to some gravel and the sand content ranged from trace amounts to sandy. Silty sand seams were encountered within the deposit in Borehole 10-4. Although not confirmed to be encountered during the current investigation, pockets of gravel and/or cobbles are inferred to be present within the deposit due to slow advancement and grinding of the drill bit / casing during advancement, as encountered in Boreholes 10-3 and 10-4. Borehole 10-1 encountered a lower clayey silt-silt till deposit at a depth of 26 m and the borehole was terminated within that lower till at a depth of 27.8 m.

The SPT ‘N’-values measured within the clayey silt to clayey silt-silt till typically range from 14 to 33 blows per 0.3 m of penetration suggesting a stiff to hard consistency. The SPT ‘N’-value measured in the lower clayey silt till deposit in Borehole 10-1 was 100 blows for 0.25 m of penetration suggesting a hard consistency.

The results of grain size distribution and Atterberg limits testing carried out on samples of the cohesive till are presented on Figures B4 and B5 respectively in Appendix B. Atterberg limits measured liquid limits ranging from 13% to 26%, plastic limits ranging from 8% to 15%, and plasticity indices ranging from 4% to 14% and indicate the till deposit is a clayey silt to clayey silt-silt of low plasticity. The water contents measured on samples of the cohesive till range from about 8% to 18%, varying from slightly below to slightly above the plastic limit for the material.

4.2.8 Silty Sand Till

Underlying the cohesive till layer in all four boreholes, an approximately 16 m to 28 m thick layer of non-cohesive silty sand till was encountered. The non-cohesive till deposit contained trace to some clay and gravel, with gravelly zones encountered as noted in Borehole 10-3; such zones should be expected to be present throughout the deposit. Clayey silt seams / layers were encountered within the silty sand till deposit. Boreholes 10-2, 10-3 and 10-4 were terminated within the silty sand till deposit.

The SPT ‘N’-values measured within this non-cohesive till deposit typically range from 47 to greater than 100 blows per 0.1 m of penetration, indicating a dense to very dense state of compactness. Although not confirmed during the drilling investigation, based on the frequent ‘N’-values measuring greater than 100 blows for less than 0.3 m of penetration and slow advancement and grinding of the drill bit / casing (as indicated on the borehole records), the presence of pockets of gravel and cobbles (and possibly boulders) is inferred within this deposit.

The water content measured on samples of the silty sand till ranged from about 6% to 8%. The results of grain size distribution and Atterberg limits testing carried out on samples of the silty sand till are presented on Figures B6 and B7 respectively. Atterberg limits testing performed on the fines content of the silty sand fill measured liquid limits ranging from 13% to 15%, plastic limits ranging from 8% to 10%, and plasticity indices ranging from 3% to 7% and indicate the silty sand till deposit is slightly plastic. The higher plasticity indices can be attributed to the clay content that typically ranged from about 8% to 14% and frequent clayey silt seams/interlayers that were encountered throughout the deposit. However, the deposit is considered to generally behave as non-cohesive.

4.2.9 Gravelly Sand

An approximately 2.8 m thick deposit of gravelly sand with some silt was encountered below the silty sand till in Borehole 10-1.

The SPT ‘N’-value measured within this deposit was 100 blows per 0.25 m of penetration, indicating a very dense state of compactness. Slow advancement of the drill bit / casing and grinding was encountered while penetrating this layer suggesting the presence of gravel pockets and/or cobbles.

4.3 Groundwater Conditions

Where water was encountered in the boreholes during drilling with the hollow stem augers and prior to switching to wash rotary methods (i.e. Borehole 10-1, 10-3 and 10-4), the water levels shown on the borehole records represent unstabilized groundwater conditions. The water level was typically not measured in the open boreholes during or upon completion of drilling after water / drilling mud was introduced as part of the wash rotary technique.

A standpipe piezometer was installed in Borehole 10-1 and 10-4 to monitor groundwater levels. The standpipe piezometers were screened within the clayey silt till and silty sand till as shown in detail on the borehole records. A summary of the groundwater levels measured in the piezometers is provided below.

Borehole No. / Standpipe Piezometer	Depth (Elevation) of Screen Interval / Sand Pack (m)	Depth (bgs) to Water Level (m)	Water Level Elevation (m)	Date of Water Level Reading
10-1	6.1 to 9.1 (Elev. 276.8 m to Elev. 273.8 m)	0.65 0.61 0.56 0.51	282.45 282.39 282.44 282.49	Feb. 4, 2022 Feb. 8, 2022 Feb. 16, 2022 May 12, 2022
10-4	3.1 to 6.1 (Elev. 279.2 m to Elev. 276.2 m)	0.92 0.91 0.88 0.89	281.38 281.39 281.42 281.41	Feb. 4, 2022 Feb. 8, 2022 Feb. 16, 2022 May 12, 2022

The groundwater level at this site is anticipated to fluctuate seasonally in response to changes in precipitation and should be expected to be higher during the spring season or during any period of heavy and/or sustained precipitation.

4.4 Analytical Testing Results

Four soil samples (one from each borehole) 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 (μmho/cm)	Soluble Chlorides (μg/g)	Soluble Sulphates (μg/g)
10-1 - 2	7.83	4100	246	100	<20
10-2 - 3	7.95	1400	700	330	<20
10-3 - 3	7.84	6900	146	25	<20
10-4 - 2	7.77	2400	416	180	<20

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Ali Yazdansepas, EIT. Mr. Kevin Bentley, P.Eng. and Ms. Lisa Coyne, both Senior Geotechnical Engineers and MTO Foundations Designated Contacts with WSP Golder, conducted technical and quality reviews of the report.

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https://golderassociates.sharepoint.com/sites/120387/project files/6 deliverables/foundations/10th sideroad/final/19136074-r-rev0-pfidr-10th sideroad_20230907.docx

PART B

PRELIMINARY FOUNDATION DESIGN REPORT
10TH SIDEROAD UNDERPASS
HIGHWAY 400 TO HIGHWAY 404 LINK (BRADFORD BYPASS)
SIMCOE COUNTY AND YORK REGION
MTO ASSIGNMENT NO. 2019-E-0048

6.0 DISCUSSION AND PRELIMINARY FOUNDATION ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides preliminary foundation recommendations for planning and preliminary design of the Bradford Bypass and 10th Sideroad underpass structure. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced as part of the current subsurface exploration.

The Preliminary Foundation Design Report (Part B of this report) including the discussion and preliminary recommendations are intended for the use of MTO and their designers for planning and preliminary design and shall not be used or relied upon for any other purpose or by any other parties, including the future construction contractor or design-build proponents. Contractors undertaking the work must make their own interpretation based on the factual data presented in the Preliminary 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 concept and preliminary design of the project and for which special provisions may be required in the future Contract Documents. Those requiring information on aspects of detail design and construction must make their own interpretation of the factual information provided and supplement as necessary, as such interpretation may affect detail design, equipment selection, proposed construction methods, scheduling and the like.

6.2 Project Understanding

Based on the latest Bradford Bypass mainline alignment and profile drawings (preliminary draft dated September 2022) and Preliminary General Arrangement drawing (draft dated January 2023) provided by AECOM, the proposed BBP / 10th Sideroad Interchange will consist of a two-span underpass to carry 10th Sideroad over the Bradford Bypass mainline. The proposed bridge has been classified as “major-route” structure (see Section 6.3.2.2) and is anticipated to be approximately 76 m long and 26.3 m wide to accommodate the interchange configuration. The proposed Bradford Bypass highway grade is shown to be slightly lower than the existing 10th Sideroad (an approximately 0.5 m cut to about Elevation 284.5 m) with the new 10th Sideroad profile grade ranging from about Elevation 291.6 m to 292.2 m on the south and north side of the bridge, respectively, immediately adjacent to the abutments. The existing ground surface adjacent to the existing 10th Sideroad is at about Elevation 282 m and 283 m on the south and north side of the bridge footprint. As a result, the proposed new south and north approach embankments are anticipated to be up to approximately 9 m high relative to the existing ground surface outside of the existing 10th Sideroad pavement surface.

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 S6-19* (CHBDC, 2019) and its *Commentary*, the underpass structure and foundation system may be classified as having medium 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.

In addition, based on the preliminary level of foundation investigation completed to date at this location (see Part A of this report) in comparison to the degree of site understanding, the level of confidence for design of the multi-span bridge foundation elements and approach embankments has been assessed as a “typical degree of site and prediction model understanding”. At the time of the borehole investigation, the locations of the abutments and pier foundations were not confirmed, and based on this together with access considerations, the boreholes are not located directly within the foundation footprint. As such, the recommendations contained in the report are generalized for planning and ongoing preliminary design and further investigation will be required when actual locations of the abutments and piers are known.

Accordingly, the ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, $\boldsymbol{\Psi}$ = 1.0 and geotechnical resistance factors, $\boldsymbol{\phi_{gu}}$ and $\boldsymbol{\phi_{gs}}$ for a typical degree of site understanding, from Tables 6.1 and 6.2 of CHBDC (2019) have been used at this stage of preliminary design. During detail design, additional investigation and testing may be performed to increase the level of confidence and potentially modify the geotechnical resistance factors as appropriate. In addition, reference is made to the MTO Material Engineering and Research Office (MERO) Memorandum #2020-01 (dated March 23, 2020) for future settlement and stability analyses during detail design, as applicable.

6.3.2 Seismic Design

6.3.2.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation. Based on the energy-corrected average standard penetration resistance, $\overline{N}_{60}$ and average undrained shear strength, s_u within the upper 30 m of the overburden below the founding level (assumed to be existing ground surface), the site may be classified as Site Class C in accordance with Table 4.1 of the CHBDC (2019), in the absence of any geophysical testing.

The CHBDC (2019) states that the seismic hazard values associated with the design earthquakes should be those established for the *National Building Code of Canada* (NBCC) by the Geological Survey of Canada (GSC). The 2015 seismic hazard maps (referred to as the 5th generation seismic hazard maps) have been used for preliminary design for this project, as selected by MTO.

6.3.2.2 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.1 of the 2019 CHBDC, the peak ground acceleration (PGA), peak ground velocity (PGV) and 5% damped spectral response acceleration ($S_a(T)$) values for Site Class C were obtained for the bridge site using the NBCC website (*earthquakescanada.nrcan.gc.ca*) and are summarized below.

Seismic Hazard Values for Site Class C	10% Exceedance in 50 years (475-year return period)	5% Exceedance in 50 years (975-year return period)	2% Exceedance in 50 years (2,475year return period)
PGA (g)	0.030	0.046	0.074
PGV (m/s)	0.027	0.042	0.067
$S_a(0.2)$ (g)	0.052	0.079	0.122
$S_a(0.5)$ (g)	0.037	0.054	0.081
$S_a(1.0)$ (g)	0.021	0.032	0.048
$S_a(2.0)$ (g)	0.010	0.016	0.025
$S_a(5.0)$ (g)	0.002	0.004	0.006
$S_a(10.0)$ (g)	0.001	0.002	0.003

The values provided above are for the reference ground condition Site Class C and must be modified (as appropriate) to the site-specific seismic site classification to be confirmed during detail design to obtain applicable design spectral values. The design spectral values will need to be assessed along with the importance category (to be defined by the owner as per Section 4.4.2 (CHBDC)) and actual structure periods to determine the Seismic Performance Category and level of seismic analysis required during detail design as per Table 4.10 of the CHBDC (2019). For preliminary design, the importance category for this bridge has been classified as “major-route”.

6.3.2.3 Soil Liquefaction

Liquefaction is a phenomenon whereby seismically-induced shaking generates shear stresses within the soil under undrained conditions. These stresses tend to densify the soil which may lead to potentially large surface deformations, and under undrained conditions generate excess pore water pressures that can lead to sudden temporary losses in strength. Where existing static shear stresses are present, the loss of strength can lead to significant lateral movements (analogous to slope failure) often referred to as “lateral spreading” or under certain conditions even catastrophic failure of slopes often referred to as “flow slides”. Lateral spreading and flow slide often accompany liquefaction along rivers and other shorelines.

In general, the soils at these bridge sites consist of interlayered stiff to very stiff clayey silt to clayey silt-silt soils and very dense silty sand till and stiff hard clayey silt till. Considering the compactness, consistency and liquidity index of the soils and the relatively low site-specific PGA, the site is considered to have a low potential for liquefaction during a seismic event based on preliminary liquefaction assessment of the soil and preliminary analyses using the simplified stress-based method as per Section 6.14.8 of CHBDC (2019).

6.4 Foundation Types

Based on the proposed 76 m long two-span structure and subsurface conditions encountered at the site, both shallow and deep foundation options have been considered for support of the new abutments and centre pier. The preliminary recommendations provided herein will be subject to change in future detailed design. Foundation construction should be in general accordance with OPSS.PROV 902 (Excavating and Backfilling – Structures).

A summary of the general advantages and disadvantages associated with each option is provided below and a comparison of the foundation alternatives based on advantages, disadvantages, relative costs and risks is provided in Table 1 following the text of this report.

For abutment foundations, shallow foundations “perched” on a compacted granular pad founded on the stiff to very stiff clayey silt / clayey silt-silt till and compact silty sand are feasible; however, some settlement of the stiff zones of cohesive soil will occur under the approximately 9 m high approach embankment loading, and hence this option is not considered the preferred alternative from a geotechnical/foundations perspective. Driven steel H- or tube piles with the pile cap perched within the approach embankments is preferred, and this option will permit integral abutments. At the pier location, caissons are considered to be the preferred alternative given that higher loads are anticipated for the structure span lengths, and subexcavation for pile caps or shallow foundations can be avoided if the caissons are designed to be continuous with the columns. Alternatively, both spread footings and driven piles are considered feasible options for the pier.

6.5 Shallow Foundations

Strip or spread footings founded below the topsoil, organic soils, and existing fills on the native stiff to very stiff clayey silt, clayey silt-silt till, or compact silty sand strata (at or below the approximate elevations identified below) are considered feasible for support of the structure abutments and piers. Temporary excavations ranging from 1 m to 3.7 m below existing ground surface to reach the competent founding strata are anticipated to be required. Consideration can be given to subexcavating the unsuitable soils and placing engineered fill such that spread footings could be “perched” within approach embankments to increase geotechnical resistance values.

The following geotechnical resistances may be used for preliminary design, assuming a 3 m and 5 m wide footing:

Foundation Element	Founding Stratum	Footing Width	Founding Elevation	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance1
North Abutment	Stiff to very stiff clayey silt-silt and/or clayey silt-silt till	3	280.5 m (west) to 281.5 m (east)	300 kPa	200 kPa
	3 m thick granular pad on stiff to very stiff clayey silt-silt and/or clayey silt-silt till	3	283.5 m (west) to 284.5 m (east)	550 kPa	325 kPa
	Stiff to very stiff clayey silt-silt and/or clayey silt-silt till	5	280.5 m (west) to 281.5 m (east)	300 kPa	160 kPa
	5 m thick granular pad on stiff to very stiff clayey silt-silt and/or clayey silt-silt till	5	285.5 m (west) to 286.5 m (east)	550 kPa	300 kPa
Centre Pier	Stiff to very stiff clayey silt-silt and/or clayey silt-silt till	3	280 m (west) to 281 m (east)	310 kPa	210 kPa
	Stiff to very stiff clayey silt-silt and/or clayey silt-silt till	5	280 m (west) to 281 m (east)	320 kPa	170 kPa
South Abutment	Stiff to very stiff clayey silt and/or clayey silt till / compact silty sand	3	280.5 m (west) to 282 m (east)	310 kPa	220 KPa
	3 m thick granular pad on stiff to very stiff clayey silt and/or clayey silt till / compact silty sand	3	285.5 m (west) to 285 m (east)	600 kPa	350 kPa
	Stiff to very stiff clayey silt and/or clayey silt till / compact silty sand	5	280.5 m (west) to 282 m (east)	325 kPa	175 kPa
	5 m thick granular pad on stiff to very stiff clayey silt and/or clayey silt till / compact silty sand	5	285.5 m (west) to 285 m (east)	600 kPa	325 kPa

Notes:

1. For 25 mm of settlement independent of any settlements induced by surrounding grade changes / embankment loading. Higher settlements may occur at abutment areas associated with the embankment loading.

The factored ultimate and serviceability geotechnical resistances are dependent on the footing width, founding elevation, and thickness of granular pad (as applicable) and as such, the geotechnical resistances must be reviewed and revised if the footing width varies from that specified above or if the founding soils differ from that given in the previous section.

Resistance to lateral loads / sliding resistance between the new concrete footing and the subgrade should be calculated in accordance with Section 6.10.4 of *CHBDC* (2019), applying the appropriate consequence and degree of site understanding factors as applicable during detailed design. For preliminary design, an effective interface angle of friction between the cast-in-place concrete footings and the native clayey silt to clayey silt-silt till may be taken as 26° (with an effective cohesion of zero), and the corresponding unfactored coefficient of friction, tan δ, of 0.49 may be used. An effective angle of friction of 33° and corresponding unfactored tan δ of 0.65 may be used for the resistance between a Granular 'A' pad and cast-in-place concrete.

6.6 Deep Foundations

6.6.1 Steel H-Pile or Tube Foundations

Steel H-piles or closed ended tube piles driven into the silty sand till deposit are considered feasible for the foundations at the bridge structure. The thick deposit of very dense silty sand till encountered at a depth of about 7 to 10 m below ground surface in the boreholes is considered suitable for design of predominantly end-bearing piles, although the thickness of consistent 100-blow soils is variable.

Although not specifically encountered in all boreholes during the current investigation, the presence of potential pockets of gravel, cobbles and/or boulders should be anticipated within the glacially derived silty sand till deposit and will need to be considered.

From a foundation capacity perspective, close-ended tube piles are preferred due to the increased steel end-bearing area and higher likelihood of achieving design geotechnical resistances during or shortly after driving to found in the variable thickness of "100-blow" soils at the proposed design tip level; it is noted that steel tubes are considered to pose a higher risk of "hanging up" during installation if cobbles or boulders are present, due to their larger steel end area. Conversely, steel H-piles have a risk of penetrating further into or through the "100-blow" soils if a sufficient "soil plug" is not formed during driving operations to provide adequate end-bearing geotechnical resistance. However, if integral abutments are being considered, driven steel H-piles may be preferred over steel tube piles given that H-piles are most commonly used for integral abutment design, although it may be possible to develop innovative pile designs to incorporate tube piles or hybrid tube/H-pile sections for integral abutments. and During detail design, it may be determined that longer driven steel H-piles (in the order of 25 m to 30 m long) may be required to achieve similar or higher geotechnical resistances due to the variable limited thickness of 100 blow soils within the upper portion of the till deposit where the current design pile tips are located.

The following geotechnical resistances are provided for a range of steel H-pile and tube pile sizes and may be used for preliminary design:

Foundation Element	Pile Type	Approx. Pile Length (m)[1]	Estimated Pile Tip Elevation (m)	Soil Strata near Pile Tip Elevation[4]	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance[2]
North Abutment	HP 310x110	8 - 12	274 (west) to 273 (east)	"100-blow" silty sand till	1,100 kN	1,100 kN
	HP 360x108	8 - 12	274 (west) to 273 (east)	"100-blow" silty sand till	1,250 kN	1,250 kN
	324 mm dia. tube pile (min. 9.5 mm thick)	8 - 12	274 (west) to 273 (east)	"100-blow" silty sand till	1,000 kN	1,000 kN
	406 mm dia. tube pile (min. 9.5 mm thick)	8 - 12	274 (west) to 273 (east)	"100-blow" silty sand till	1,500 kN	1,500 kN
Centre Pier	HP 310x110	8 - 11	274 (west) to 272 (east)	"100-blow" silty sand till	1,100 kN	1,100 kN
	HP 360x108	8 - 11	274 (west) to 272 (east)	"100-blow" silty sand till	1,250 kN	1,250 kN
	324 mm dia. tube pile (min. 9.5 mm thick)	8 - 11	274 (west) to 272 (east)	"100-blow" silty sand till	1,000 kN	1,000 kN
	406 mm dia. tube pile (min. 9.5 mm thick)	8 - 11	274 (west) to 272 (east)	"100-blow" silty sand till	1,500 kN	1,500 kN
South Abutment	HP 310x110	10 - 11	271 (west) to 272 (east)	"100-blow" silty sand till	1,100 kN	1,100 kN
	HP 360x108	10 - 11	271 (west) to 272 (east)	"100-blow" silty sand till	1,250 kN	1,250 kN
	324 mm dia. tube pile (min. 9.5 mm thick)	10 - 11	271 (west) to 272 (east)	"100-blow" silty sand till	1,000 kN	1,000 kN
	406 mm dia. tube pile (min. 9.5 mm thick)	10 - 11	271 (west) to 272 (east)	"100-blow" silty sand till	1,500 kN	1,500 kN

Notes:
1. Measured from approximate ground surface at closest borehole location.
2. For 25 mm of settlement
3. Resistance values are for single piles and do not take into account pile group efficiency.
4. Approximate 2.5 m to 7 m thick layer of "100-blow" soil underlain by soils with lower state of compactness

The estimated factored ultimate geotechnical resistances provided above are calculated on both shaft and tip resistances, but predominantly tip (end-bearing) within the “100-blow” silty sand till soil. The presence and thickness of “100-blow” material for which the end-bearing piles are designed is variable (ranging from 2.5 m to 7 m thick) and is not consistent throughout the silty sand till deposit such that there is a risk that piles may penetrate through the “100-blow” zone and much longer piles will be needed to achieve the design geotechnical resistance. The presence and thickness of “100-blow” soils should be confirmed during detail design, and longer piles (25 m to 30 m long) may be needed to achieve the recommended or higher design resistances. These design geotechnical resistances assume piles have had sufficient time to "set-up" and allow pore pressures to dissipate after initial driving, and it may be necessary to wait more than 24 hours for pile restrike to demonstrate the required ultimate geotechnical resistance has been achieved.

Considering the anticipated loads relative to the pile capacities, pile groups or closely spaced piles will likely be required at each foundation element. For preliminary design, driven steel piles spaced at, or more than three pile diameters (centre-to-centre) can be assumed to act as single piles with no group interaction effects with regards to axial resistance. For piles spaced less than three diameters, the total pile axial resistance should be reduced by a group reduction factor (R_A) (Reese, 2006) as follows:

Pile Spacing (d = Pile Diameter)	Pile Axial Resistance Group Reduction Factor (R_A)
Equal to or greater than 3.0 d	1.0
1.5 d	0.7
1.25 d	0.55

Note: Reduction factors for other pile spacings may be interpolated from the values above.

Pile installation should be carried out in accordance with Ontario Provincial Standard Specification (OPSS) PROV 903 *(Deep Foundations)* as amended by Special Provision 109F57. It is recommended that High-Strain Dynamic testing be specified on at least 10% of the piles or two piles at each foundation element (whichever is greater) in each stage of construction.

In order to optimize the design and reduce the risk of piles not achieving the design geotechnical resistance at the design tip elevation during construction, the design-builder or contractor should consider a combination of the following options:

- Advanced site-specific investigation during detail design to confirm or adjust axial geotechnical resistances for design;
- High-strain dynamic testing (PDA) on a greater proportion of piles at end-of-initial drive (EOID) and beginning-of-restrike (BOR), with a longer waiting period before restrike;
- Advanced static pile load test as per ASTM D-1143; and/or
- Evaluation of strength gain with time to ascertain that geotechnical resistance will ultimately be achieved, either via a waiting period associated with static pile load testing prior to production piling, or a long restrike period demonstrated via PDA testing in advance of or during production piling.

The selected design and testing method(s) must consider logistical challenges and potential schedule impacts as part of the detailed design and planned construction, and optimized design and testing methods must be incorporated into SP109F57 and the contract documents.

The subsequent 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, to avoid possible damage to the piles, and to calibrate with the results of the high-strain dynamic testing or advanced static pile load testing.

For conventional integral abutment design, corrugated steel pipes (CSPs) backfilled with loose sand are recommended to be installed as part of the integral abutment design consistent with the MTO Structural Office Report SO-96-01 titled “Integral Abutment Bridges”.

6.6.2 Drilled Shafts (Caissons)

Caissons founded within the silty sand till deposit are considered feasible for supporting the abutment and pier foundations.

Slow augering and grinding noticed during drilling combined with the frequent “100-blow” SPT measurements in the silty sand till deposit in various boreholes may be associated with the presence of cobbles and/or boulders. Although not specifically encountered/recovered during the current investigation, consideration must be given to the potential presence of cobbles and boulders within the glacially derived till deposits during detailed design.

The following geotechnical resistances may be used for preliminary design of the caissons:

Foundation Element	Caisson Diameter	Approximate Caisson Length (m)[1]	Estimated Caisson Base Elevation (m)	Soil Strata near Caisson Base Elevation[4]	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance[2]
North Abutment	0.9 m	8 -12	274 (west) to 273 (east)	“100-blow” silty sand till	2,100 kN	>2,100 kN
	1.2 m	8 -12	274 (west) to 273 (east)	“100-blow” silty sand till	3,500 kN	>3,500 kN
	1.5 m	8 -12	274 (west) to 273 (east)	“100-blow” silty sand till	5,500 kN	>5,500 kN
Centre Pier	0.9 m	8 - 11	274 (west) to 272 (east)	“100-blow” silty sand till	2,100 kN	>2,100 kN
	1.2 m	8 - 11	274 (west) to 272 (east)	“100-blow” silty sand till	3,500 kN	>3,500 kN
	1.5 m	8 - 11	274 (west) to 272 (east)	“100-blow” silty sand till	5,500 kN	>5,500 kN
South Abutment	0.9 m	10 - 11	271 (west) to 272 (east)	“100-blow” silty sand till	2,100 kN	>2,100 kN
	1.2 m	10 - 11	271 (west) to 272 (east)	“100-blow” silty sand till	3,500 kN	>3,500 kN
	1.5 m	10 - 11	271 (west) to 272 (east)	“100-blow” silty sand till	5,500 kN	>5,500 kN

Notes:

1. Measured from approximate ground surface at closest borehole location
2. For 25 mm of settlement
3. Resistance values assume single caisson and do not take into account caisson group efficiency.
4. Approximate 3 m to 6 m thick layer of “100-blow” soil.

For preliminary design, bored caisson piles spaced at eight diameters (centre-to-centre) can be assumed for design purposes to act as single caisson piles, with no group interaction effects with regards to axial resistance. For caissons spaced less than eight diameters, the total caisson axial resistance should be reduced by a group reduction factor (R_A) (Reese, 2006) as follows:

Caisson Spacing (d = Pile Diameter)	Caisson Axial Resistance Group Reduction Factor (R_A)
Equal to or greater than 8 d	1.0
6 d	0.9
4 d	0.75
3 d	0.7

Note: Reduction factors for other caisson pile spacings may be interpolated from the values above.

If caisson foundations are adopted for support of any of the foundation elements, a temporary or permanent liner or casing (at least within the upper zone) is expected to be required to support the soils during construction, to reduce disturbance and loss of ground in the water-bearing cohesionless soils and cohesive soils containing silt and sand interlayers. If a permanent liner is used, the design geotechnical resistance provided above may need to be revised to account for the reduced adhesion between the liner material and surrounding soil along the length of the liner compared to the adhesion between concrete and surrounding soil if temporary liners area used. Specialized construction techniques are expected to be required during advancement of the caisson to maintain a sufficient head of water within the liner or polymer slurry within an open hole to prevent basal heave and disturbance of water-bearing cohesionless layers/interlayers along the shaft and at the base. Given that the above drilled shaft capacities have both a shaft friction and end-bearing component, the performance of the drilled shafts in compression will depend to a large degree upon the final cleaning and verification of the condition of the base of the drilled shaft. Following cleaning to remove all loose cuttings, the base should be inspected by a qualified geotechnical engineer using a shaft inspection device (SID) or a shaft quantitative inspection device (SQUID); because of the likelihood of water with entrained sediment or the presence of polymer slurry, it is recommended that SQUID testing be specified on some or all caissons to demonstrate and verify base cleaning. Should the inspection indicate that loosened material is present at the base of the drilled shaft, the base would need to be re-cleaned and re-inspected.

Alternatively, a design based solely on shaft friction may be considered provided the design geotechnical resistances are reduced accordingly and appropriate quality assurance procedures are adopted by the design-builder / contractor.

In order to optimize the design, the design-builder or contractor can consider a combination of the following options:

- Advanced site-specific investigation during detail design to confirm or adjust axial geotechnical resistances for design based on the degree of understanding; and/or
- Advanced static pile load test as per ASTM D-1143, bi-directional static load (“Osterberg Cell”) test (CFEM, 2006), or Statnamic Load Test (CFEM, 2006).

Caisson installation must be in accordance with OPSS.PROV 903 (Deep Foundations) and MTO's recent special provision should be included in the Design-Build output specifications to address the requirements for supply and installation of drilled shafts (caissons) including the use of temporary or permanent liners/casings and slurry, the placement of concrete by tremie methods, cleaning and inspection of the shafts and base of the drilled shafts as applicable, and quality control testing. Non-destructive post-construction testing in selected drilled shafts should also be included in the output specification and is recommended to verify the integrity of the concrete given the groundwater conditions, presence of saturated cohesionless soils, and specialized installation methods to counterbalance the hydrostatic pressures.

6.6.3 Resistance to Lateral Loads

The design of piles or caissons subjected to lateral loads should take into account such factors as the relative rigidity of the pile / caisson to the surrounding soil, the fixity condition at the head of the pile / caisson (i.e., at the pile / caisson cap level), the structural capacity of the pile / caisson to withstand bending moments and shear, the soil resistance that can be mobilized, the tolerable lateral deflections at the head of the pile / caisson and group effects. Lateral loading could be resisted fully or partially by the use of battered piles. For vertical piles, the resistance to lateral loading will have to be derived from the soil in front of the piles. For integral abutment design, there will also be a requirement for the piles to move sufficiently to accommodate the bridge deck deflections.

For design purposes, both the structural and geotechnical resistances should be evaluated to establish the governing case. Lateral pile / caisson analysis for detail design should be carried out using non-linear methods (such as p-y curves) when the pile / caisson group configuration is established as per the CHBDC (2019).

For preliminary design, the resistance to static lateral loading in front of the piles / caissons may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, k_h (kPa/m), is based on the following equations (CFEM, 2002 as referenced in CHBDC, 2006):

For non-cohesive soils:

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

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

For cohesive soils:

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

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

It is understood that an integral abutment design may be considered. Where the integral abutment design includes the installation of 3 m long Corrugated Steel Pipe (CSP) liners (with the annular space between the pile and the liner filled with uniform grained, uncompacted sand), the upper portion of the H-pile will be generally free to flex and move laterally within the limits of the CSP.

The following values of n_h and S_u may be assumed in the structural analyses for a single vertical pile or caisson, using the interpreted stratigraphic conditions from the boreholes and as shown on Drawing 1. The range in the values reflect the variability of the subsurface conditions, the soil properties and groundwater level, and the approximate nature of the linear-elastic subgrade reaction analysis.

Soil Unit	n_h (kPa/m)	S_u (kPa)
New granular fill (Granular 'A' or 'B' Type II)	50,000 – 60,000	-
Loose sand within CSP (if applicable)	1,500 - 2,500	-
Dense to very dense silty sand (Existing fill)	30,000 – 50,000	-
Firm clayey silt (Existing fill)	5,000 – 10,000	25 - 50
Firm to very stiff clayey silt	-	50 - 100
Very stiff to hard clayey silt till	10,000 – 12,500	100 - 150
Dense to very dense silty sand till	25,000 – 40,000	-

Group action for lateral loading should also be evaluated by reducing the coefficient of horizontal subgrade reaction either in the direction of loading or perpendicular to the direction of loading by relevant group pile / caisson efficiency factors as outlined in Section C6.11.3.4 of the *Commentary to the CHBDC* (2019).

6.6.4 Downdrag Loads on Piles or Caissons

Based on the preliminary profile drawings, the approach embankments at the 10th Sideroad structure are about 9 m high with total settlements in the foundation soils estimated to range from less than 30 mm to 40 mm (see Section 6.8.2), assuming some subexcavation of soft zones of cohesive or organic soil. As a result, downdrag loads are not anticipated to be a major concern although this must be assessed further during detailed design as part of the future design-build based on planned construction staging including any selected settlement mitigation measures. Downdrag loads can likely be mitigated by designing piles / caissons to resist the additional load in the structural design and/or reducing downdrag forces by preloading the foundation soil to induce settlements prior to driving piles or installing caissons.

6.7 Frost Protection

Spread / strip footings and pile / caisson caps should be founded at a minimum depth of 1.5 m below the lowest surrounding final grade, including any distance measured perpendicular to sloping ground surfaces, to provide adequate protection against frost penetration (as interpreted from OPSD 3090.101 – *Foundation Frost Penetration Depths for Southern Ontario)*.

6.8 Approach Embankments

Based on the preliminary profile alignments and borehole information, the details of the approach embankments and anticipated foundation soils at the proposed bridge structure are summarized below.

Foundation Element	Height of Approach Embankment	Anticipated Foundation Soils
North Abutment	9 m	Firm to very stiff clayey silt to clayey silt-silt
South Abutment	9 m	Firm to stiff clayey silt / Loose to compact silty sand

For preliminary design, it is assumed that prior to construction of the new approach embankments, all topsoil, peat/organic soil, existing unsuitable fill materials and any soft/loose surficial alluvial deposits will be stripped from the footprint of the new embankments and replaced with suitable granular fill. Based on the borehole information, stripping of unsuitable soil is assumed to range from 0.2 m to 1.4 m below existing ground surface at the approach embankments. The organic silty clay (0.8 m thick) encountered below the existing 10th Sideroad granular embankment fill to a depth of about 3 m below road surface on the north side should be assessed further during detail design so that consideration can be given to leaving the existing embankment fill in place (i.e., reduce subexcavation requirements) and construct the new embankments on top of the existing fill. Additional details regarding embankment construction are provided in Section 6.8.1.

Conventional embankment construction is considered feasible at the site and any earth embankments greater than 8 m in height must include a mid-height berm as per OPSD 202.010 (*Slope Flattening*). Where space limitations exist, consideration can be given to designing reinforced earth slopes or retaining walls at this site.

Global stability and settlement analyses were carried out for the maximum embankment heights anticipated on the north and south side of the bridge using the closest borehole information to develop idealized stratigraphy and the foundation engineering parameters summarized below.

Idealized Stratigraphic Unit	γ (kN/m^3)	ϕ' (°)	S_u (kPa)	E' (MPa)
New Granular Fill (Granular 'A' or 'B' Type II)	21	36	--	--
Dense to very dense Silty Sand (Existing Fill)	20	34	--	--
Firm Clayey Silt (Existing Fill)	19	30	25 - 50	--
Firm to very stiff Clayey Silt	20	28 - 30	50 – 100	20 - 50
Very stiff to hard Clayey Silt to Clayey Silt-Silt (Till)	20	34	100 - 150	50 - 80
Dense to very dense Silty Sand (Till)	21	36	--	120 - 150

The groundwater elevation is assumed to be the highest measured water level in the boreholes which was about 0.5 m below the native ground surface (Elevation 281.5 m to 282.5 m). The groundwater level should be assessed further during detail design (see Section 6.12) and the analyses checked and refined as applicable.

6.8.1 Stability

The Factor of Safety for global stability is equal to the inverse of the product of the consequence factor, Ψ, and the geotechnical resistance factor, ϕ_{gu} (i.e. $FoS = 1/(\Psi \cdot \phi_{gu})$. Accordingly, given the level of investigation and typical degree of site understanding, minimum target Factors of Safety of 1.3 and 1.5 have been used for the preliminary design of the approach embankment slopes for the temporary (short-term) and permanent (long-term) conditions, respectively, as per Table 6.2 of CHBDC (2019) and MERO (2020). Both total stress and effective stress analyses were carried out as part of the global stability assessment.

The idealized geometry and results of the stability analysis (modelled using Slide 2 (Version 9.017)) for the highest embankment on the south side of the bridge are shown in Figures 1 and 2 for the undrained and drained conditions respectively. Based on the results, the new approach embankments constructed with suitable granular fill and side slopes no steeper than 2H:1V (with a mid-height 2 m wide bench for embankments higher than 8 m) will have an adequate factor of safety (i.e., greater than 1.3 for short-term “undrained” conditions and greater than 1.5 for long-term “drained” conditions) for global stability.

When more detailed foundation investigation is completed at the site (increased level of understanding), the resistance factor can be increased and the target Factor of Safety for the temporary and permanent conditions can be decreased accordingly.

6.8.2 Settlement

Settlement analyses were carried out for the proposed maximum embankment height on the north and south side of the bridge and represent the maximum anticipated values. The settlement analyses assume that the topsoil, existing fills and underlying organic soils, and any softened/loosened deposits have been removed and replaced with suitable granular fill.

The target settlement performance criteria for design of approach embankments are outlined in MTO’s “Embankment Settlement Criteria for Design”, dated July 2, 2010. In general, new embankments approaching structural elements such as bridge abutments are to be designed such that total settlement and rate of differential settlement do not exceed 25 mm, over a 20-year period following completion of construction.

The estimated magnitude of settlement for the north and south approach embankments are presented below, assuming the use of conventional granular fill for construction. The estimated settlements do not account for immediate settlement of the embankment fill itself which is expected to occur during or shortly after construction (within a few months) and would need to be assessed during detail design.

Location	Relevant Boreholes	Proposed Maximum Embankment Height	Estimated Total Settlement (mm)	Estimated Post-Construction Settlement over a 20-Year Period (mm)
North Approach Embankment	10-2, 10-3	9 m	δ_{Total} = 30 - 40 mm	δ_{20yr} < 25 mm
South Approach Embankment	10-1, 10-4	9 m	δ_{Total} = 30 – 40 mm	δ_{20yr} < 25 mm

Given that the existing clayey silt, clayey silt-silt till and silty sand till soils are considered to be over consolidated and contain significant sand content, the majority of the settlement is anticipated to occur rapidly during or shortly after construction. Based on the preliminary investigation and calculated results above, post-construction settlements are estimated to be within tolerable values and are not anticipated to be a concern at the approach embankments.

6.9 Lateral Earth Pressures for Design

The lateral earth pressures acting on the abutment walls and any associated wingwalls should be designed in accordance with Section 6 of the CHBDC (2019) and 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. The following recommendations are made concerning the design of the abutment walls and wingwalls:

- 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. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*). Other aspects of the granular backfill requirements with respect to subdrains and frost taper should be in general accordance with OPSD 3101.150 (*Walls, Abutment, Backfill, Minimum Granular Requirement*), OPSD 3121.150 (*Walls, Retaining, Backfill, Minimum Granular Requirement*), and 3190.100 (*Walls, Retaining and Abutment, Wall Drain*).

- 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* (2019) Section 6.12.3 and Figure 6.8. Care must be taken during the compaction operation not to overstress the wall, with limitations required on heavy construction equipment and requirements for the use of hand-operated compaction equipment per OPSS.PROV 501 *(Compacting).* 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 1.5 m behind the back of the wall in accordance with Figure C6.31(a) of the *Commentary to the CHBDC* (2019). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at flatter than 1 horizontal to 1 vertical (1H:1V) extending up and back from the rear face of the footing or pile cap in accordance with Figure C6.31(b) of the *Commentary to the CHBDC* (2019).

6.10 Corrosion Assessment and Protection

Soil corrosivity may affect the concrete and/or steel elements (e.g., reinforcing steel) of foundations or related structures 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 can be assessed based on the soil resistivity / electrical conductivity, hydrogen ion concentration (pH), and salts (chloride and sulphate) concentrations. The analytical results for the soil samples submitted for testing at this site are summarized in Section 4.4 and the analytical laboratory test reports are included in Appendix C.

6.10.1 Potential for Sulphate Attack

The analytical test results were compared to CSA Standard, CAN/CSA-A23.1-14 Table 3 *("Additional requirements for concrete subjected to sulphate attack")* for potential sulphate attack on concrete. The sulphate concentrations measured in the tested samples are below the exposure class of S3 (Moderate). Therefore, based on the soil samples tested, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

6.10.2 Potential for Corrosion

The test results indicate a pH of 7.8 to 7.9 and a resistivity of 1400 to 6900 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 generally Low to Moderate (10,000 ohm-cm > R > 2000 ohm-cm), with the exception of one sample that was Severe (2000 ohm-cm > R) in the existing fill soils in borehole 10-2, as per Table 3.2 of the Gravity Pipe Design Guidelines (MTO, 2014). Appropriate corrosion protection should be applied to the foundation element / materials and given that the foundations are located adjacent to the highway shoulder / ditches and will be exposed to de-icing salt, consideration should be given to selection of a “C” type exposure class for any concrete as defined by CSA A23.1 Table 1.

These recommendations are provided as guidance only; the design-builder should take the results of the laboratory testing into consideration for selecting appropriate materials and corrosion susceptibility for design service of the structure foundations and determine the appropriate exposure class and ensure that all aspects of CSA A23.1 Section 4.1.1 “Durability Requirements” are satisfied.

6.11 Construction Considerations

6.11.1 Subgrade Preparation and Approach Embankment Construction

Prior to construction of the new approach embankments, it is recommended that all unsuitable soils such as topsoil or organics, and existing surficial fill materials or loosened/softened soils from farming activities be stripped from the embankment footprint and replaced with OPSS Select Subgrade Material (SSM), Granular A or Granular B soils. Based on the boreholes, stripping of about 0.2 m to 1.4 m below native ground surface may be required to remove the unsuitable soils at the approach embankments. The existing 10th Sideroad embankment fill and underlying organic silty clay (extending to about 3 m below road surface) should be assessed further during detail design if new embankment construction on top of the existing 10th Sideroad embankment fill is to be considered.

Engineered fill for construction of the new embankments should consist of OPSS.PROV 1010 (*Aggregates*) granular materials (i.e., SSM, Granular A or Granular B). Earth fill consisting of suitable borrow material from elsewhere on the project site may also be considered where sufficient volumes are available. The embankment fill should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*) and OPSS.PROV 206 (*Grading*). Permanent embankment side slopes should be constructed no steeper than 2 horizontal to 1 vertical (2H:1V) in granular fill. Where earth fill is used, slightly flatter side slopes on the order of 2.25H:1V may be necessary depending on the composition of the material to reduce the potential for shallow surficial failures.

In accordance with MTO’s standard practice, a minimum 2 m wide bench should be provided where embankment slopes are greater than 8 m in height, such that the uninterrupted slope height does not exceed 8 m, consistent with OPSD 202.010 (*Slope Flattening*).

To reduce surface water erosion on the granular embankment side slopes, topsoil and seeding as per OPSS.PROV 804 (*Seed and Cover*) or pegged sod should be carried out as soon as possible after construction of the embankments.

6.11.2 Temporary Excavations

In general, temporary excavations up to about 1.7 m and 2 m below the ground surface (up to 3.7 m below existing 10th Sideroad embankment pavement surface) are required for shallow foundations and/or subexcavation and replacement with a granular pad. Temporary excavations can be reduced to about 1.5 m below ground surface (i.e. frost depth) and/or eliminated for pile and caisson caps “perched” within the approach embankments, as applicable.

All temporary excavations must be carried out in accordance with OPSS.PROV 902 (Excavating and Backfilling) and Ontario Regulation 213 of the Ontario Occupational Health and Safety Act for Construction Projects (OHSA), as amended. The existing fill, firm to stiff clayey silt / organic silty clay, and loose to compact silty sand soils are classified as Type 3 soils and the very stiff to hard clayey silt till and dense to very dense silty sand till and are classified as Type 2 soils. Temporary excavations (i.e., those open for a relatively short time period) should be made with side slopes of no steeper than 1H:1V. For Type 2 soils, the excavation may be sloped to within 1.2 m of the bottom of the excavation.

Where required, temporary protection systems must be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection System*) and Special Provision 105S09. The lateral movement of the temporary protection systems must meet Performance Level 2 as specified in OPSS.PROV 539, provided that any existing adjacent utilities can tolerate this magnitude of deformation.

6.11.3 Groundwater / Surface Water Control

The highest groundwater level measured in the standpipe piezometers was at about Elevation 282.5 m (about 0.5 m below ground surface) and Elevation 281.4 m (about 0.9 m below ground surface) on the east and west sides of bridge respectively. The groundwater level is anticipated to be slightly higher on the north and east side compared to the south and west side, consistent with the slope of the natural ground surface.

The excavations for shallow foundations are anticipated to extend about 1.7 m to 2 m below ground surface (3.7 m below 10th Sideroad pavement surface) and will be about 0.5 m to 1 m below the measured groundwater levels. As such, it is expected that groundwater seepage into the foundation excavations can likely be adequately controlled by ditching and pumping from filtered sumps within or adjacent to the excavations. If the excavation operations are carried out in the wet season, the groundwater level could be higher and more extensive groundwater control measures may be required depending on the excavation requirements. Dewatering operations should be in accordance with OPSS.PROV 517 (*Dewatering*) as referenced in OPSS.PROV 902 (*Excavation and Backfilling – Structures*). Inclusion of a special provision for foundation dewatering will need to be considered in the future contract documents or output specifications to address potential instability / base heave of the foundation subgrade, temporary flow diversion and pre-construction survey requirements, as applicable.

Construction water takings in excess of 50,000 L/day are regulated by the Ministry of the Environment, Conservation and Parks (MECP). Certain takings of groundwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self registration on the MECP's Environmental Activity and Sector Registry (EASR), requiring a "Water Taking Plan" and a "Discharge Plan" (to be developed by the Design-Builder). A Category 3 PTTW would be required for water takings in excess of 400,000 L/day. The contractor will be responsible for obtaining any required discharge approvals.

Surface water must be directed away from the excavations at all times. In particular, surface water drainage on the north and east (i.e. high) side of the site must be properly diverted / controlled such that the integrity of any foundation subgrade is maintained.

To reduce erosion of the permanent embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection must be in accordance with OPSS.PROV 804 (*Seed and Cover*).

6.11.4 Obstructions during Pile Driving / Caisson Installation

During pile installation through the glacially derived soils, especially the silty sand till layer at this site, there is a risk of encountering pockets of gravel or cobbles and boulders. It is recommended that steel H-piles or tube piles be reinforced and protected from damage with appropriate driving shoes as per OPSD 3000.100 (Steel H-Pile Driving Shoe) or 3001.100 (Steel Tube Driving Shoe) or equivalent. Pre-augering may be considered to reduce the risk of piles "hanging up" or deflecting on potential "100-blow" stratum and if considered, the design geotechnical resistances provided must be reviewed and revised as necessary during detail design. Caisson installation equipment must be capable of penetrating and/or removing obstructions as required.

6.12 Recommendations for Additional Work

The preliminary foundation recommendations provided in this report are based on the limited available subsurface information in the four boreholes advanced near the proposed structure. Additional subsurface investigation is recommended to be carried out during detail design to confirm the subsurface soil and groundwater conditions at the location of the bridge foundation elements (abutments and pier locations), approach embankments, and any associated retaining walls. The competency and performance of the existing 10th Sideroad fill embankment and the underlying organic layer must be further investigated and appropriate mitigation options provided if consideration is being given to supporting foundations or the high fill embankments on the existing soils.

When more details are known on actual loading conditions, the foundation types, sizes and geotechnical resistances will need to checked and revised as necessary. The global stability of the approach embankments and retaining walls will need to be checked for the finalized geometry and the magnitude of foundation settlements and any mitigation measures will need to be reassessed.

The use of GSC 5th Generation or 6th Generation seismic hazard maps to define the Site Class should be confirmed for detail design.

Additional foundation investigation and design should meet the general requirements outlined in the latest version of the *Guideline for MTO Foundation Engineering Services*. The existing standpipe piezometers (installed in Boreholes 10-1 and 10-4) should be maintained operational to allow for continued monitoring of the groundwater level during detail design and up to construction, at which time the piezometers will need to be decommissioned in accordance with Ontario Regulation 903 (as amended). Additional piezometers (particularly on the north side of the bridge) should be installed near the proposed foundation elements to provide the necessary information to assess dewatering requirements.

7.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Ali Yazdansepas, EIT. Mr. Kevin Bentley, P.Eng., and Ms. Lisa Coyne, P.Eng., both Senior Geotechnical Engineers and MTO Foundations Designated Contacts with WSP Golder, conducted technical and quality reviews of this report.

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https://golderassociates.sharepoint.com/sites/120387/project files/6 deliverables/foundations/10th sideroad/final/19136074-r-rev0-pfidr-10th sideroad_20230907.docx

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

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Terzaghi, K.V., 1955. Evaluation of Coefficient of Subgrade Reaction. Getechnique, 5(4): 297-326.

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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 Tests and Split Barrel Sampling of Soils.

Canadian Standards Association (CSA):

CAN/CSA A23.114 Concrete Materials and Methods of Concrete Construction

Commercial Software:

Settle3 (Version 5.015) by Rocscience Inc.

Slide2 (Version 9.017) by Rocscience Inc.

Ontario Provisional Standard Drawing:

OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario

OPSD 3101.150 Walls, Abutments, Backfill, Minimum Granular Requirements

OPSD 3121.150 Walls, Retaining, Backfill, Minimum Granular Requirements

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS.PROV 804 Construction Specification for Seed and Cover

OPSS.PROV 902 Construction 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

Special Provision 109F57 Amendment to OPSS.PROV 903

Ontario Regulations

Ontario Regulation 903 Wells (as amended)

Ontario Regulation 213 Construction Projects (as amended)

Ministry of Transportation, Ontario

Gravity Pipe Design Guidelines, Circular Culverts and Storm Sewers, April 2014.

MTO Foundations Guideline, Embankment Settlement Criteria for Design, July 2010.

Provincial Engineering Memorandum #20201, Material Engineering and Research Office (MERO), March 23, 2020

Guideline for MTO Foundation Engineering Services, Version 3, dated April 2022

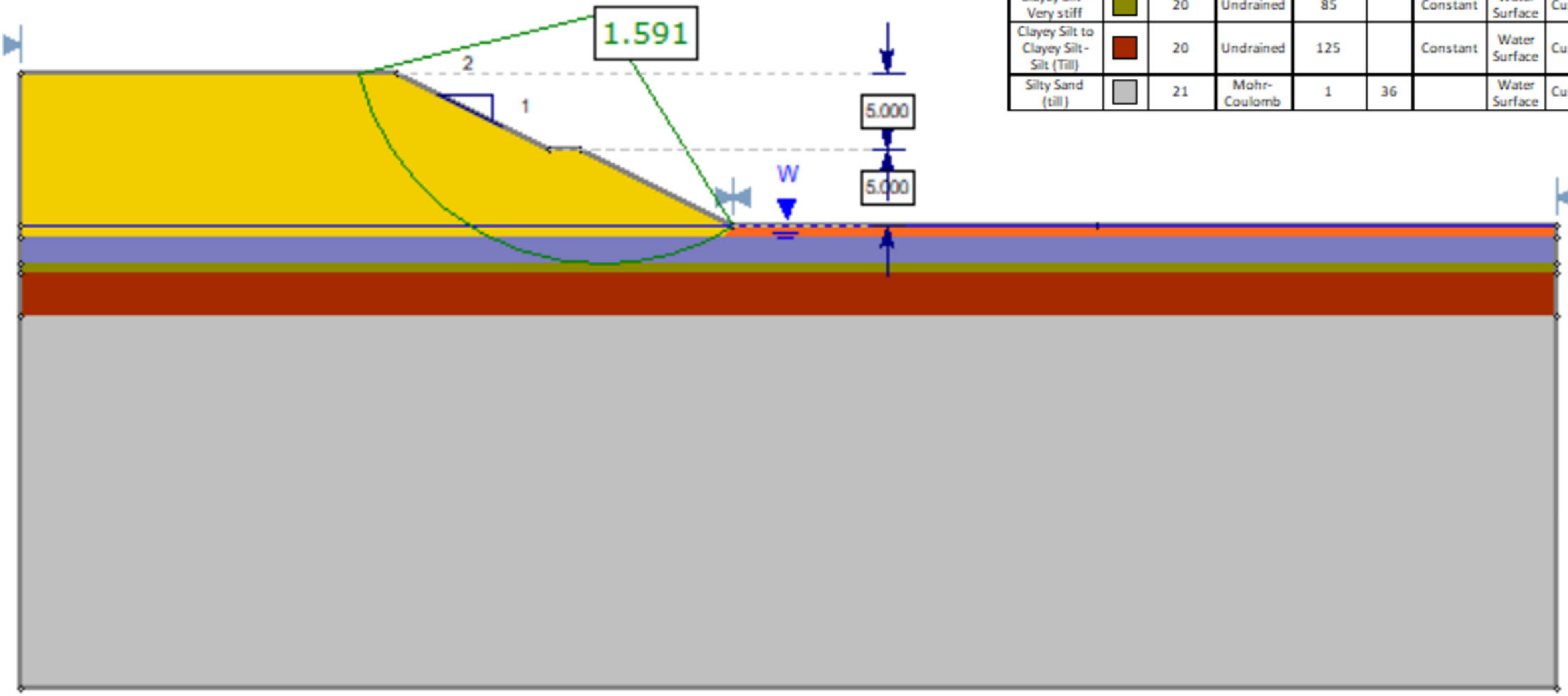
Table 1: Comparison of Foundation Alternatives – 10th Sideroad Underpass Bridge

Foundation Option	Feasibility	Advantages	Disadvantages	Relative Costs	Risk / Consequences
Strip / Spread footings founded on native stiff to very stiff clayey silt-silt / clayey silt-silt till, or compact silty sand	■ Feasible at the abutments and centre pier	■ Conventional construction ■ Relatively competent soils at shallow depth (below surficial firm to stiff clayey silt layer) will provide adequate geotechnical resistance	■ Lower geotechnical resistance compared to deep foundations ■ Excavation of unsuitable soils to about 2 m depth is required (with up to 3.7 m depth required below existing 10th Sideroad pavement surface) to reach competent founding stratum. ■ Dewatering of near-surface silty sand may be required to allow for excavation and construction of footings in dry conditions and maintain stable foundation subgrade. ■ Temporary protection systems may be needed if 10th Sideroad is to remain open during construction; alternatively, closure or temporary realignment of 10th Sideroad will be required during construction. ■ Does not allow for conventional integral abutment design.	■ Lower cost than deep foundations although additional costs for dewatering and temporary protection systems will need to be considered	■ Less competent soils may be encountered at preliminary founding level during detail design investigation at actual abutment and pier locations. ■ Risk of deeper excavation and increased dewatering and/or temporary shoring efforts.
"Perched" abutment spread footings founded on a compacted granular pad within approach embankments	■ Feasible at abutments; not applicable at pier	■ Conventional construction ■ Granular pad can be constructed within approach embankment for abutment locations. ■ Founding level can easily be adjusted within approach embankment. ■ Depth of excavation, dewatering effort, and height of abutment wall stems can be reduced. ■ Increased geotechnical resistance compared to shallow foundation on native deposits.	■ Lower geotechnical resistance compared to deep foundations ■ Subexcavation and replacement of unsuitable soils to about 2 m depth (with up to 3.7 m depth required below existing 10th Sideroad pavement surface) is required within foundation zone of influence to mitigate settlement under embankment loading, or other settlement mitigation (such as preloading and/or surcharging or ground improvement) required to be developed during detail design. ■ Dewatering of surficial silty sand may be required to allow for subexcavation and placement and compaction of granular pad in dry conditions and maintain stable subgrade. ■ Temporary protection systems may be needed for subexcavation and replacement if 10th Sideroad is to remain open during construction; alternatively, closure or temporary realignment of 10th Sideroad will be required during construction. ■ Does not allow for conventional integral abutment design.	■ Lower cost than deep foundations ■ Similar costs for spread footings founded on native soil due to subexcavation and dewatering to construct granular pad.	■ Less competent soils may be encountered at preliminary founding level during detail design investigation at actual abutment locations. ■ Risk of deeper excavation and increased dewatering and/or temporary shoring efforts. ■ Lower risk to foundation performance if subgrade soils are wet / disturbed during construction as compacted granular pad will distribute and decrease loads on native soils.
Driven Steel H-piles or tube piles driven into "100-blow" silty sand till, or terminating above or beyond such soils	■ Feasible for all foundation elements; piles can also be designed to terminate above or beyond 100-blow soils	■ Conventional construction methods for driven steel pile foundations. ■ Higher axial resistances available compared to shallow footings. ■ Pile caps perched within approach embankments can be considered to reduce or eliminate dewatering / subexcavation requirements. ■ Allows for integral abutment design.	■ Noise and vibrations to adjacent properties, although limited residential and industry near site. ■ Dewatering measures may be required at abutments and piers for the construction of pile caps, unless perched in embankment fill at abutments. ■ Driving shoes and/or thicker pile section may be required to drive into the "100-blow" glacial till soils that may contain cobbles / boulders.	■ Lower relative cost than drilled shafts (caissons) ■ Comparable cost to spread footings if dewatering and subexcavation of unsuitable soils can be reduced by designed perched pile caps.	■ Reduced impact on design if variable near surface soils are encountered during detailed investigation. ■ Risk of piles "hanging up" or being deflected from alignment when driving through glacial till deposits that may contain pockets of gravel or cobbles and boulders. ■ Limited thickness (3 m to 6 m) of "100-blow" soil results in high risk of piles penetrating through and not achieving design resistance at design founding tip level resulting in longer piles.
Drilled Shafts (Caissons) founded within "100-blow" silty sand till, or terminating above or beyond such soils	■ Feasible for all foundation elements	■ Offers higher geotechnical resistance compared to driven steel piles, requiring fewer foundation elements. ■ May be designed to eliminate pile cap and associated temporary excavations / dewatering at the centre pier as the caissons could be cast continuously with structural columns to the underside of the superstructure.	■ Temporary or permanent liner or special measures such as polymer slurry will be required to reduce risk of loosening / softening of the sides of the drilled shaft and heave / blow-out at base of shaft during drilling and concrete placement (by tremie methods). ■ Generation and disposal of soils cuttings / slurry during drilled shaft advancement ■ Does not allow for conventional integral abutment design.	■ Higher relative cost than shallow foundations. ■ Higher cost than piles but reduced dewatering / subexcavation costs if pier caissons are cast continuously with structural columns to eliminate pile cap.	■ Reduced impact on design if variable near surface soils are encountered during detailed investigation. ■ Risk of difficulties penetrating through glacial till deposits that may contain pockets of gravel or cobbles and boulders. ■ Challenging to inspect the shaft and base of the drilled shafts due to the need for liners, slurry, and tremie concrete methods.

Stability Analysis Results (Undrained Condition)
South Abutment - Bradford Bypass / 10th Sideroad Underpass

Figure 1

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
New Embankment Fill		21	Mohr-Coulomb	0	36		Water Surface	Custom	1
Organica Clayey Silt - soft		20	Undrained	35		Constant	Water Surface	Custom	1
Clayey Silt - firm		20	Undrained	50		Constant	Water Surface	Custom	1
Clayey Silt - Very stiff		20	Undrained	85		Constant	Water Surface	Custom	1
Clayey Silt to Clayey Silt-Silt (Till)		20	Undrained	125		Constant	Water Surface	Custom	1
Silty Sand (till)		21	Mohr-Coulomb	1	36		Water Surface	Custom	1



Date: December 2022
Project No: 19136074

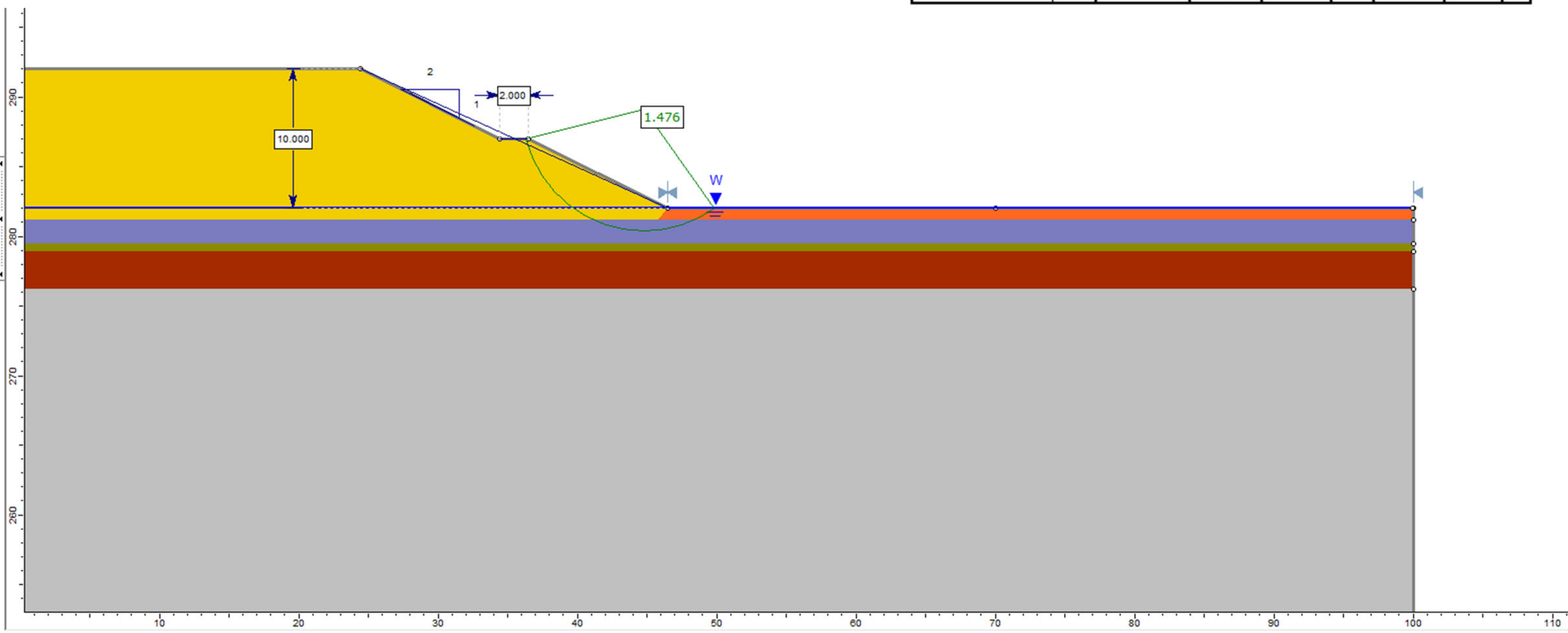
Analysis By: AY **Reviewed By:** KJB wsp GOLDER

Stability Analysis Results (Drained Condition)

South Abutment - Bradford Bypass / 10th Sideroad Underpass

Figure 2

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
New Embankment Fill		21	Mohr-Coulomb	0	36	Water Surface	Custom	1
Organica Clayey Silt - soft		20	Mohr-Coulomb	0	28	Water Surface	Custom	1
Clayey Silt - firm		20	Mohr-Coulomb	0	28	Water Surface	Custom	1
Clayey Silt - Very stiff		20	Mohr-Coulomb	0	30	Water Surface	Custom	1
Clayey Silt to Clayey Silt-Silt (Till)		20	Mohr-Coulomb	0	34	Water Surface	Custom	1
Silty Sand (till)		21	Mohr-Coulomb	1	36	Water Surface	Custom	1



Date: December 2022

Project No: 19136074

Analysis By: AY **Reviewed By:** KJB

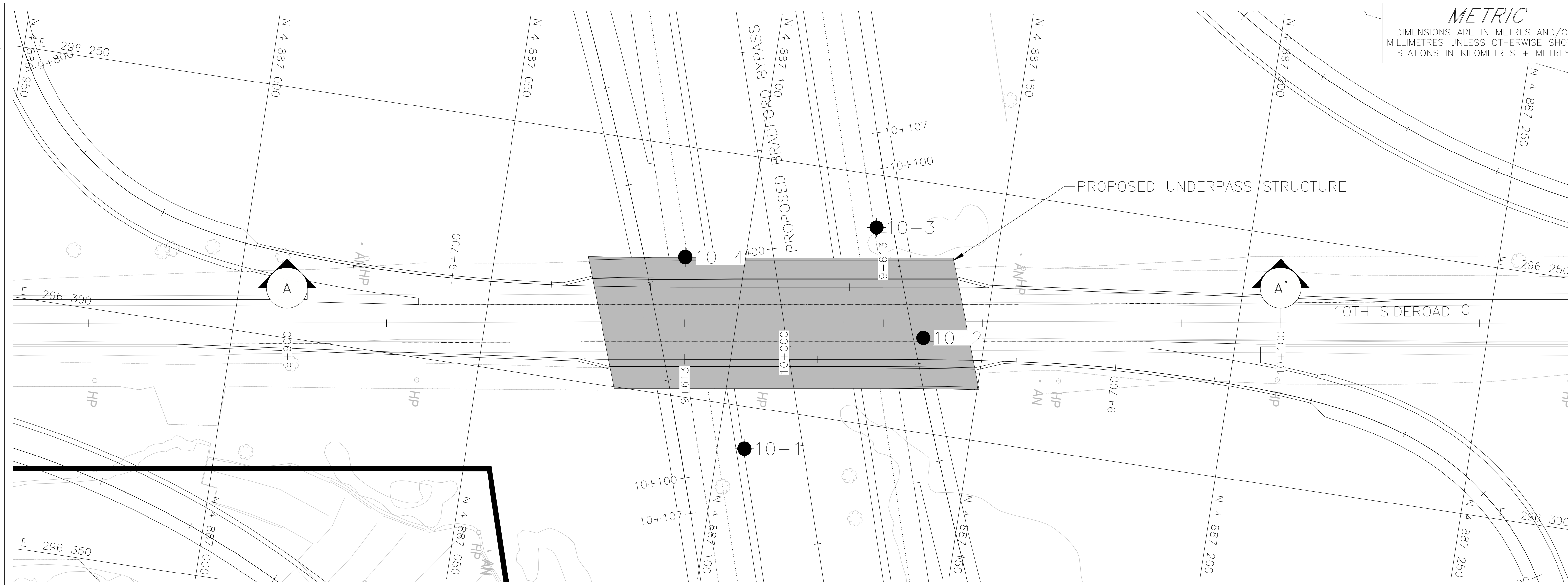
Drawings

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

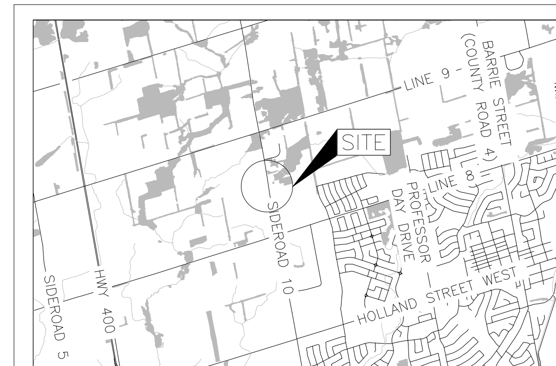
CONT No.
WP No.

BRADFORD BYPASS
10TH SIDEROAD UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



PLAN
SCALE
10 0 10 20 m



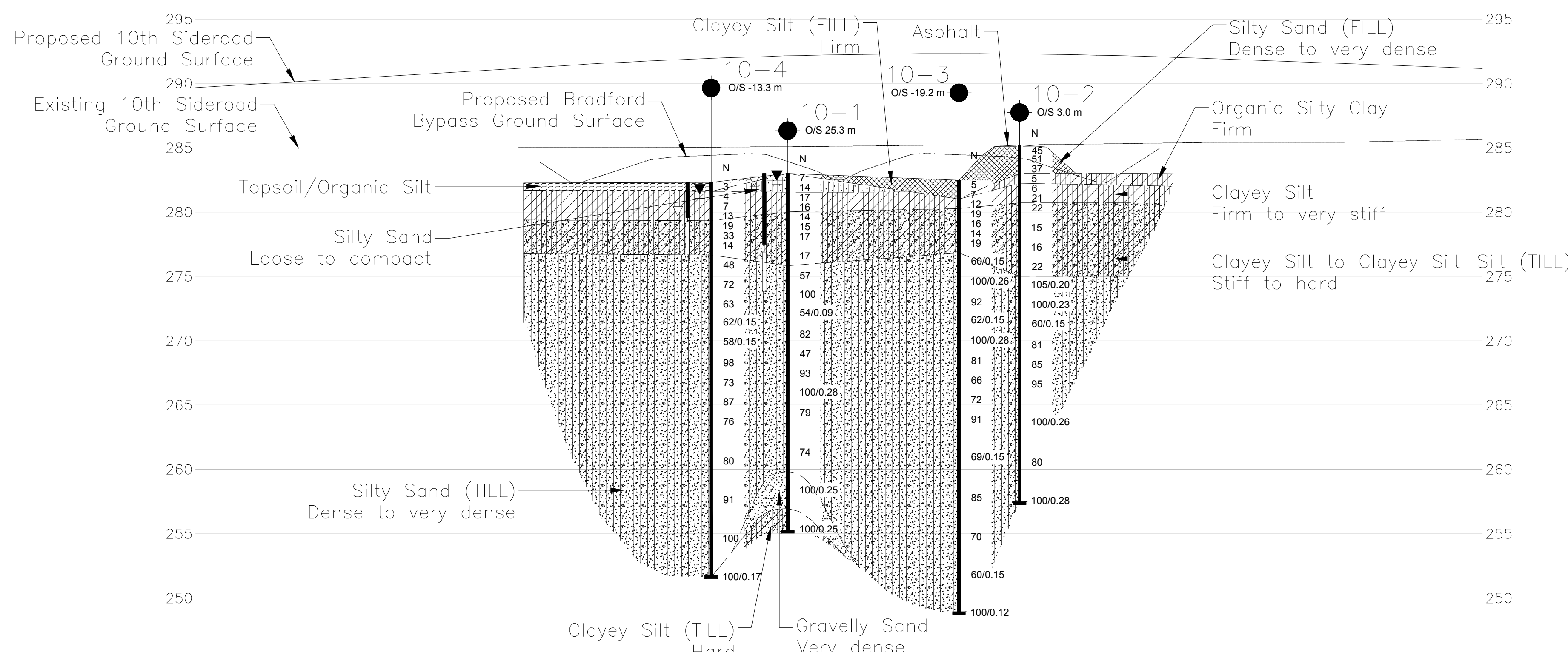
KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on May 12, 2022
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
10-1	283.0	4887105.4	296308.4
10-2	285.2	4887137.8	296281.1
10-3	282.5	4887125.1	296260.5
10-4	282.3	4887087.9	296272.1



A–A' PROFILE 10TH SIDEROAD ℄

HORIZONTAL SCALE
10 0 10 20 m

VERTICAL SCALE
5 0 5 10 m

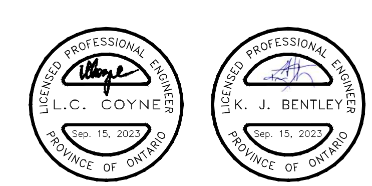
NOTES

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 plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. 221011_X-60636190-C-DES-10th Sideroad IC Plan and Profile.dwg, received October 11, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. X-60636190-C-DES-BBP Overall Plan.dwg, received September 14, 2022.



NO.	DATE	BY	REVISION

Geocres No. 31D-814

HWY. BRADFORD BYPASS	PROJECT NO. 19136074		DIST.
SUBM'D. KJB	CHKD. AY	DATE: 09/15/2023	SITE:
DRAWN: DD	CHKD. KJB	APPD. LCC/KJB	DWG. 1

APPENDIX A

Borehole Records

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An 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 (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

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

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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , 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, Gs)
DS	direct shear test
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

1. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
2. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	< 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

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
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

* Density symbol is ρ. Unit weight symbol is γ. where $\gamma = \rho \cdot g$ (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 $= (w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_{\alpha(e)}$	secondary compression index
C_α	rate of secondary compression
$C_{\alpha(\varepsilon)}$	modified 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
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
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 or 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

Ontario

WSP GOLDER

RECORD OF BOREHOLE No. 10-1

METRIC

PROJECT	19136074		
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4887105.4; E 296308.4 NAD83 / MTM Zone 10 (LAT. 44.123894; LONG. -79.606104)
ORIGINATED BY	SS		
DIST	Central	HWY	BBP- 10th SR Line
BOREHOLE TYPE	Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY	AY
DATUM	CGVD28 Surface Elevation:283.0 m	DATE	Apr 29, 2021 - Apr 30, 2021
CHECKED BY	KJB		

SOIL PROFILE | SAMPLES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH (kPa): ○ Unconfined, ⊕ Field Vane, ● Quick Triaxial, ✕ Remoulded, ■ Pocket Pen | WATER CONTENT (%) PL W_p, NMC W, LL W_l (20 40 60); NP Nonplastic | UNIT WEIGHT γ kN/m³ | GR SA SI CL | REMARKS

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
0.0	TOPSOIL (200mm)								
282.8 / 0.2	SILTY SAND (SM), trace organics Loose to compact Brown Moist to wet	1	SS	7					
		2	SS	14	282				
281.5 / 1.4	CLAYEY SILT (CL), trace sand, trace gravel Very stiff Brown to grey, iron oxide staining Moist	3	SS	17	281	0	3	48	49
		4	SS	16					
280.0 / 3.0	CLAYEY SILT (CL), some sand to sandy, trace to some gravel (TILL) Stiff to very stiff Grey Moist	5	SS	14	280				
		6	SS	15	279				
		7	SS	17	278	2	19	54	25
					277				
		8	SS	17	276				
275.8 / 7.2	SILTY SAND (SM), trace gravel, some clay, contains clayey silt layers, (TILL) Dense to very dense Grey Moist	9	SS	57	275				
					274				
		10	SS	100		9	50	28	13

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

wsp GOLDER

PROJECT 19136074	**RECORD OF BOREHOLE No. 10-1**	Sheet 2 of 3	**METRIC**
G.W.P. Assignment No 2019-E-0048	LOCATION N 4887105.4; E 296308.4 NAD83 / MTM Zone 10 (LAT. 44.123894; LONG. -79.606104)		ORIGINATED BY SS
DIST Central HWY BBP- 10th SR Line	BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing		COMPILED BY AY
DATUM CGVD28 Surface Elevation:283.0 m	DATE Apr 29, 2021 - Apr 30, 2021		CHECKED BY KJB

Column headings: SOIL PROFILE (ELEV. / DEPTH; DESCRIPTION; STRATA PLOT) · SAMPLES (NUMBER; TYPE; "N" VALUES) · GROUNDWATER CONDITIONS · ELEVATION SCALE · DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, X Field Vane · WATER CONTENT (%): PL W_p, NMC W, LL W_l; NP Nonplastic (20 40 60) · UNIT WEIGHT γ kN/m³ · GR SA SI CL · REMARKS

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
	SILTY SAND (SM), trace gravel, some clay, contains clayey silt layers, (TILL) Dense to very dense Grey Moist				273					
	- 10.7 m: Slow augering and grinding	11	SS	54/0.09						
					272					
					271					
		12	SS	82		○–┤	6	51	30	13
					270					
	- 13.7 m: Slow augering	13	SS	47	269					
					268					
	- 15.2 m: Slow augering to 15.24 m - 15.3 m: Contains clayey silt layers	14	SS	93						
					267					
		15	SS	100/0.28	266	○–┤	7	50	30	13
265.3 17.7	SILTY SAND (SM), trace to some gravel (TILL) Very dense Grey Moist				265					
	- 18.3 m: Slow augering to 18.29 m	16	SS	79		○				
					264					

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT 19136074	**RECORD OF BOREHOLE No. 10-1**	Sheet 3 of 3	**METRIC**
G.W.P. Assignment No 2019-E-0048	LOCATION N 4887105.4; E 296308.4 NAD83 / MTM Zone 10 (LAT. 44.123894; LONG. -79.606104)		ORIGINATED BY SS
DIST Central HWY BBP- 10th SR Line	BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing		COMPILED BY AY
DATUM CGVD28 Surface Elevation:283.0 m	DATE Apr 29, 2021 - Apr 30, 2021		CHECKED BY KJB

ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	SILTY SAND (SM), trace to some gravel (TILL) Very dense Grey Moist					263					
						262					
		17	SS	74		261					
259.8 23.2	Gravelly SAND (SP), some silt Very Dense Grey Wet - 23.2 to 24.4 m: Slow augering and grinding					260					
						259					
		18	SS	100/0.25		258					
257.0 26.0	- 26.0 to 27.4 m: Slow augering and grinding CLAYEY SILT-SILT (CL-ML) trace sand, trace gravel, (TILL) Hard Grey Moist					257					
						256					
		19	SS	100/0.25				o			
255.2 27.8	End of Borehole Notes: 1. Water level measured at a depth of 0.6 m (Elev. 282.4 m) prior to introducing water for mud rotary . 2. Water Level measured at a depth of 0.9 m (El. 282.1 m) after the installation of monitoring well.					255					
						254					

Legend: X Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; O Unconfined. DCPT scale: 20 40 60 80 100. Water content: PL W_p, NMC W, LL W_l; NP Nonplastic; 20 40 60.

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario

WSP GOLDER

PROJECT	19136074	RECORD OF BOREHOLE No. 10-2	Sheet 1 of 3	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4887137.8; E 296281.1 NAD83 / MTM Zone 10 (LAT. 44.124185; LONG. -79.606446)	ORIGINATED BY SS
DIST	Central HWY BBP- 10th SR Line	BOREHOLE TYPE	Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY AY
DATUM	CGVD28 Surface Elevation:285.2 m	DATE	May 21, 2021	CHECKED BY KJB

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT	GR	SA	SI	CL	REMARKS
0.0	ASPHALT.									
285.1 / 0.1	SILTY SAND (SM), trace clay, trace gravel to gravelly, (FILL) Dense to very dense Brown Moist	1	SS	45						
		2	SS	51	o	5	50	36	9	
		3	SS	37						
283.0 / 2.2	ORGANIC SILTY CLAY (CI), trace sand, trace gravel Firm Black to greenish grey Wet	4	SS	5	o					
282.2 / 3.0	CLAYEY SILT (CL), sandy to some sand, trace gravel. Firm to very stiff Brown Wet	5A / 5B	SS	6						
		6	SS	21	⊢o⊣	2	27	41	30	
280.7 / 4.5	Sandy CLAYEY SILT (CL), trace gravel. (TILL) Stiff to very stiff Brown Wet	7	SS	22						
		8	SS	15	⊢o⊣					
		9	SS	16						
276.5 / 8.7	CLAYEY SILT-SILT (CL-ML), trace sand, trace gravel, (TILL) Very Stiff Grey Wet	10	SS	22	o⊣					

Column headings: SOIL PROFILE; STRATA PLOT; SAMPLES; GROUNDWATER CONDITIONS; ELEVATION SCALE (285, 284, 283, 282, 281, 280, 279, 278, 277, 276); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, × Field Vane; WATER CONTENT (%) PL W_p, NMC W, LL W_l (20 40 60), NP Nonplastic; UNIT WEIGHT γ kN/m³.

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT 19136074 — **RECORD OF BOREHOLE No. 10-2** — — **METRIC**

G.W.P. Assignment No 2019-E-0048 | LOCATION N 4887137.8; E 296281.1 NAD83 / MTM Zone 10 (LAT. 44.124185; LONG. -79.606446) | ORIGINATED BY SS

DIST Central HWY BBP- 10th SR Line | BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing | COMPILED BY AY

DATUM CGVD28 Surface Elevation:285.2 m | DATE May 21, 2021 | CHECKED BY KJB

Dynamic cone penetration resistance plot: 20 40 60 80 100. Shear strength (kPa): X Field Vane, ⊕ Remoulded, ■ Pocket Pen, ● Quick Triaxial, O Unconfined. Water content (%): PL (W_p), NMC (W), LL (W_l); NP Nonplastic; 20 40 60. Unit weight γ kN/m³.

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL	REMARKS
	CLAYEY SILT-SILT (CL-ML), trace sand, trace gravel, (TILL) Very Stiff Grey Wet										
275.0 / 10.2	SILTY SAND (SM), some clay, trace gravel, (TILL) Very dense Grey Moist				275						
		11	SS	105/0.20		O					
					274						
		12	SS	100/0.23	273	O–|	5	48	31	16	
	- Contains clayey silt seams / layers				272						
		13	SS	60/0.15	271						
		14	SS	81	270	O					
		15	SS	85	269, 268						
		16	SS	95	267	O	2	49	36	13	
					266						

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+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

RECORD OF BOREHOLE No. 10-2

METRIC

PROJECT	19136074	ORIGINATED BY	SS
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4887137.8; E 296281.1 NAD83 / MTM Zone 10 (LAT. 44.124185; LONG. -79.606446)
DIST	Central	HWY	BBP- 10th SR Line
BOREHOLE TYPE	Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY	AY
DATUM	CGVD28 Surface Elevation:285.2 m	DATE	May 21, 2021
CHECKED BY	KJB		

Column headings: SOIL PROFILE (ELEV. / DEPTH; DESCRIPTION; STRATA PLOT) — SAMPLES (NUMBER; TYPE; "N" VALUES) — GROUNDWATER CONDITIONS — ELEVATION SCALE — DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, X Field Vane — WATER CONTENT (%): PL (W_p), NMC (W), LL (W_l); NP Nonplastic (20 40 60) — UNIT WEIGHT γ kN/m³ — GR SA SI CL — REMARKS

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
	SILTY SAND (SM), some clay, trace gravel, (TILL) Very dense Grey Moist				265					
					264					
	- Contains clayey silt seams / layers	17	SS	100/0.26						
					263					
					262					
					261					
		18	SS	80						
					260					
					259					
					258					
257.4		19	SS	100/0.28		O–I	4	58	27	11
27.9	End of Borehole Notes: 1. Groundwater level not measured due to introduction of water during mud rotary operations.				257					
					256					

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT	19136074	RECORD OF BOREHOLE No. 10-3	Sheet 1 of 4	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION N 4887125.1; E 296260.5 NAD83 / MTM Zone 10 (LAT. 44.124071; LONG. -79.606703)	ORIGINATED BY	SS
DIST	Central HWY BBP- 10th SR Line	BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY	AY
DATUM	CGVD28 Surface Elevation:282.5 m	DATE May 05, 2021 - May 06, 2021	CHECKED BY	KJB

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL	REMARKS
0.0	CLAYEY SILT (CL), trace sand to sandy, trace gravel, trace organics, (FILL) Firm Brown, iron oxide staining; Moist to wet	1	SS	5		282						
		2	SS	7								
281.0 1.4	Sandy CLAYEY SILT-SILT (CL-ML) trace gravel, Stiff Brown Moist	3	SS	12		281		3	28	51	18	
280.3 2.2	CLAYEY SILT-SILT (CL-ML) trace sand, trace gravel, (TILL) Stiff to very stiff Grey Moist	4	SS	19	▽	280						
		5	SS	16		279						
		6	SS	14		278						
		7	SS	19		277						
276.8 5.6	- 5.6 to 6.1 m: Slow augering and grinding. SILTY SAND (SM), some clay, trace gravel to gravelly, (TILL) Very dense Grey Moist to wet	8	SS	60/0.15		276						
	- 7.6 m: Grinding of casing	9	SS	100/0.26		275		19	42	27	12	
	- 8.5 to 9.1 m: Slow advancement and grinding.	10	SS	92		274 273						

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): × Field Vane, ⊕ Remoulded, ■ Pocket Pen, ● Quick Triaxial, ○ Unconfined; WATER CONTENT (%): PL W_p, NMC W, LL W_l (20 40 60), NP Nonplastic; UNIT WEIGHT γ kN/m³; STRATA PLOT.

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

PROJECT	19136074	**RECORD OF BOREHOLE No. 10-3**	Sheet 2 of 4	**METRIC**	
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4887125.1; E 296260.5 NAD83 / MTM Zone 10 (LAT. 44.124071; LONG. -79.606703)	ORIGINATED BY	SS
DIST	Central HWY BBP- 10th SR Line	BOREHOLE TYPE	Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY	AY
DATUM	CGVD28 Surface Elevation:282.5 m	DATE	May 05, 2021 - May 06, 2021	CHECKED BY	KJB

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	SILTY SAND (SM), some clay, trace gravel to gravelly, (TILL) Very dense Grey Moist to wet						272					
			11	SS	62/0.15							
							271					
			12	SS	100/0.28		270		○		2 48 35 15	
							269					
			13	SS	81							
							268					
	- 15.2 m: Grinding of casing during advancement											
			14	SS	66		267					
							266					
			15	SS	72				○		3 48 34 15	
							265					
	- 18.3 m: Grinding of casing during advancement											
			16	SS	91		264					
							263					

Legend: Shear strength: X Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined. Dynamic cone scale: 20 40 60 80 100. Water content: PL W_p, NMC W, LL W_l; NP Nonplastic; scale 20 40 60.

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+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT	19136074	RECORD OF BOREHOLE No. 10-3	Sheet 3 of 4	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4887125.1; E 296260.5 NAD83 / MTM Zone 10 (LAT. 44.124071; LONG. -79.606703)	ORIGINATED BY SS
DIST	Central HWY BBP- 10th SR Line	BOREHOLE TYPE	Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY AY
DATUM	CGVD28 Surface Elevation:282.5 m	DATE	May 05, 2021 - May 06, 2021	CHECKED BY KJB

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILTY SAND (SM), some clay, trace gravel to gravelly, (TILL) Very dense Grey Moist to wet				262					
		17	SS	69/0.15	261					
					260					
					259					
		18	SS	85	258					
					257					
					256					
	- 27.1 to 30.5 m: Grinding of casing during advancement.				255					
		19	SS	70		○	2	54	30	14
					254					

Column headings: STRATA PLOT; GROUNDWATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH (kPa) ○ Unconfined ● Quick Triaxial ■ Pocket Pen ⊕ Remoulded × Field Vane; WATER CONTENT (%) PL NMC LL W_p W W_l 20 40 60, NP Nonplastic; UNIT WEIGHT γ kN/m³; REMARKS

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT 19136074	RECORD OF BOREHOLE No. 10-3	Sheet 4 of 4	METRIC
G.W.P. Assignment No 2019-E-0048	LOCATION N 4887125.1; E 296260.5 NAD83 / MTM Zone 10 (LAT. 44.124071; LONG. -79.606703)		ORIGINATED BY SS
DIST Central HWY BBP- 10th SR Line	BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing		COMPILED BY AY
DATUM CGVD28 Surface Elevation:282.5 m	DATE May 05, 2021 - May 06, 2021		CHECKED BY KJB

SOIL PROFILE | SAMPLES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, × Field Vane | WATER CONTENT (%): PL W_p, NMC W, LL W_l; NP Nonplastic; 20 40 60 | UNIT WEIGHT γ kN/m³ | GR SA SI CL | REMARKS

ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	REMARKS
	SILTY SAND (SM), some clay, trace gravel to gravelly, (TILL) Very dense Grey Moist to wet						253	
			20	SS	60/0.15		252	
							251	
							250	
248.8			21	SS	100/0.12		249	
33.6	End of Borehole Notes: 1. Wet soil samples first encountered at a depth of 2.2 m before switching to mud rotary 2. Groundwater level not measured due to introduction of water during mud rotary operations.						248	
							247	
							246	
							245	
							244	

+³, ×³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario

WSP GOLDER

RECORD OF BOREHOLE No. 10-4

METRIC

PROJECT 19136074

G.W.P. Assignment No 2019-E-0048

LOCATION N 4887087.9; E 296272.1 NAD83 / MTM Zone 10 (LAT. 44.123737; LONG. -79.606558)

ORIGINATED BY SS

DIST Central HWY BBP- 10th SR Line

BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing

COMPILED BY AY

DATUM CGVD28 Surface Elevation:282.3 m

DATE May 03, 2021 - May 04, 2021

CHECKED BY KJB

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
0.0	Topsoil-ORGANIC SILT (OL) Soft Black Moist	1	SS	3	282				
281.6 / 0.7	CLAYEY SILT (CL), some organic silt pockets in the upper zone Firm to stiff Brown, iron oxide staining Moist	2	SS	4	281				
		3	SS	7	280				
		4	SS	13					
279.3 / 3.0	Sandy CLAYEY SILT (CL), some gravel (TILL) Stiff to hard Brown to grey, iron oxide staining Moist	5	SS	19	279				
	- 3.8 to 4.4 m: Silty sand seams encountered within sample.	6	SS	33	278	16	49	27	8
	- 4.6 to 5.2 m: Slow augering and grinding.	7	SS	14	277				
276.7 / 5.6	- 5.6 to 7.6 m: Slow Augering SILTY SAND (SM), some clay, trace gravel (TILL) Dense to very dense Grey Moist - 6.2 to 9.1 m: Slow Augering	8	SS	48	276				
					275				
		9	SS	72	274				
		10	SS	63	273	3	51	32	14

Column headings: SOIL PROFILE; STRATA PLOT; SAMPLES; GROUNDWATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH (kPa) ○ Unconfined ● Quick Triaxial ■ Pocket Pen ⊕ Remoulded × Field Vane; WATER CONTENT (%) PL NMC LL W_p W W_l NP Nonplastic 20 40 60; UNIT WEIGHT γ kN/m³; GR SA SI CL; REMARKS

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity ο³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT	19136074	RECORD OF BOREHOLE No. 10-4	Sheet 2 of 4	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4887087.9; E 296272.1 NAD83 / MTM Zone 10 (LAT. 44.123737; LONG. -79.606558)	ORIGINATED BY SS
DIST	Central HWY BBP- 10th SR Line	BOREHOLE TYPE	Hollow Stem Auger, Mud Rotary and Casing	COMPILED BY AY
DATUM	CGVD28 Surface Elevation:282.3 m	DATE	May 03, 2021 - May 04, 2021	CHECKED BY KJB

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, X Field Vane	WATER CONTENT (%) PL (W_p) NMC (W) LL (W_l); NP Nonplastic (20 40 60)	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	SILTY SAND (SM), some clay, trace gravel (TILL) Dense to very dense Grey Moist						272					
			11	SS	62/0.15							
							271					
			12	SS	58/0.15		270					
							269					
			13	SS	98		268					
							267					
			14	SS	73				○H		4 50 34 12	
							266					
			15	SS	87		265					
			16	SS	76		264					
							263					

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario | WSP GOLDER

PROJECT 19136074	**RECORD OF BOREHOLE No. 10-4**	Sheet 3 of 4	**METRIC**
G.W.P. Assignment No 2019-E-0048	LOCATION N 4887087.9; E 296272.1 NAD83 / MTM Zone 10 (LAT. 44.123737; LONG. -79.606558)		ORIGINATED BY SS
DIST Central HWY BBP- 10th SR Line	BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing		COMPILED BY AY
DATUM CGVD28 Surface Elevation:282.3 m	DATE May 03, 2021 - May 04, 2021		CHECKED BY KJB

ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%) PL (W_p) NMC (W) LL (W_l)	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	SILTY SAND (SM), some clay, trace gravel (TILL) Dense to very dense Grey Moist										
						262					
	- 20.7 to 21.3 m: Grinding of casing and slow advancement										
						261					
		17	SS	80							
	- 22.0 to 24.4 m: Grinding of casing and slow advancement										
						260					
						259					
						258					
		18	SS	91				o-┤		6 56 26 12	
						257					
256.1 / 26.2	- 26.2 to 27.4 m: Grinding of casing and slow advancement										
	SILTY SAND (SM), some gravel, (TILL) Very dense Grey Moist, slow augering					256					
						255					
		19	SS	100							
						254					
						253					

Legend: ○ Field Vane; ⊕ Remoulded; ■ Pocket Pen; ● Quick Triaxial; ○ Unconfined; × ; Shear strength scale 20 40 60 80 100; Water content scale 20 40 60; NP Nonplastic

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity   o³% STRAIN AT FAILURE

Ontario

WSP GOLDER

PROJECT 19136074	RECORD OF BOREHOLE No. 10-4	Sheet 4 of 4	METRIC
G.W.P. Assignment No 2019-E-0048	LOCATION N 4887087.9; E 296272.1 NAD83 / MTM Zone 10 (LAT. 44.123737; LONG. -79.606558)		ORIGINATED BY SS
DIST Central HWY BBP- 10th SR Line	BOREHOLE TYPE Hollow Stem Auger, Mud Rotary and Casing		COMPILED BY AY
DATUM CGVD28 Surface Elevation:282.3 m	DATE May 03, 2021 - May 04, 2021		CHECKED BY KJB

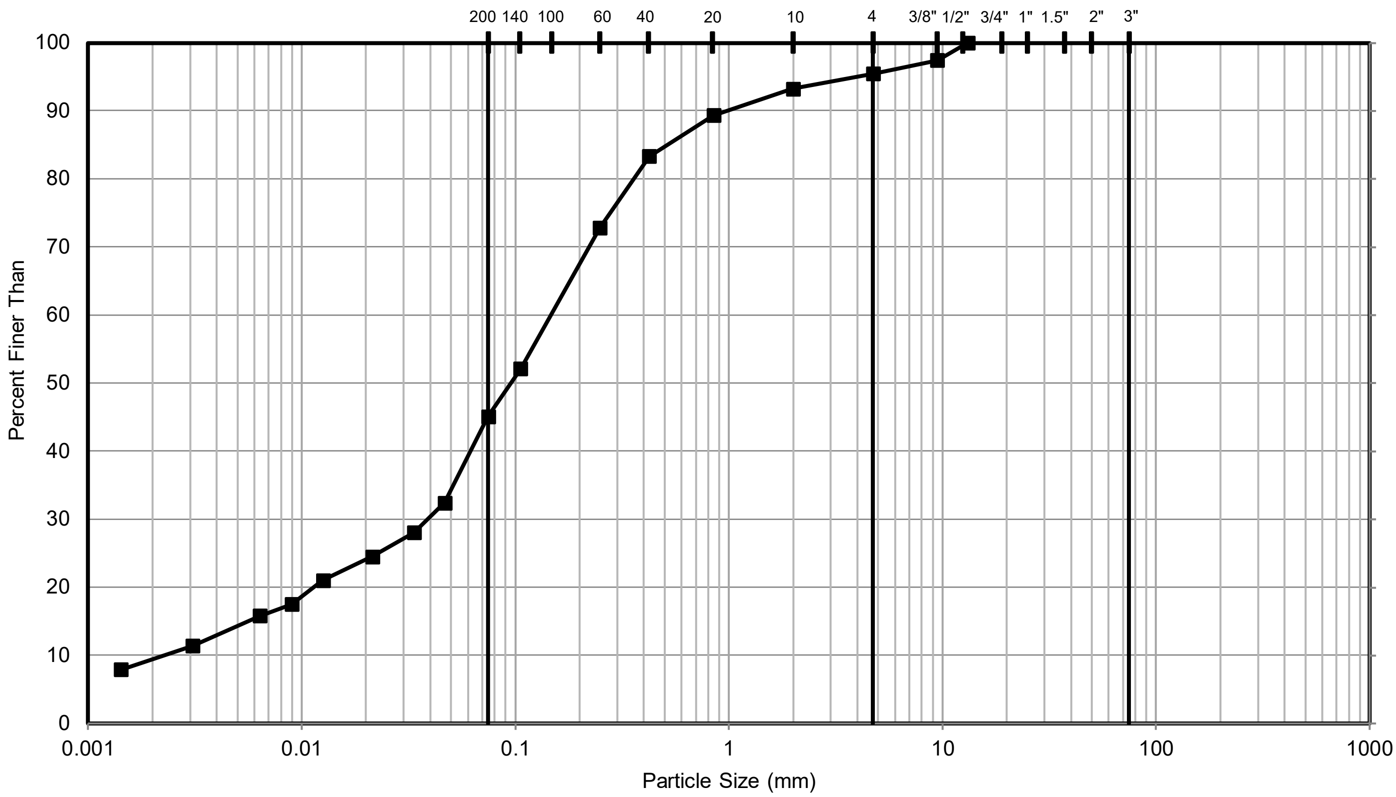
ELEV. / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ Unconfined, ● Quick Triaxial, ■ Pocket Pen, ⊕ Remoulded, X Field Vane 20 40 60 80 100	WATER CONTENT (%) PL W_p NMC W LL W_l NP Nonplastic 20 40 60	UNIT WEIGHT γ kN/m³	GR SA SI CL	REMARKS
	SILTY SAND (SM), some gravel, (TILL) Very dense Grey Moist, slow augering		20	SS	100/0.17		252					
251.6 30.7	End of Borehole Notes: 1. Water level measured at a depth of 2.24 m (Elev. 280.1 m) prior to introducing water for mud rotary . 2. Water Level measured at a depth of 0.61 m (El. 281.7 m) after the installation of monitoring well.						251 250 249 248 247 246 245 244					

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION - SILTY SAND (SM) - FILL



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	10-2	2	0.8 - 1.4	284.5 to 283.9

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass 10th Sideroad interchange

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

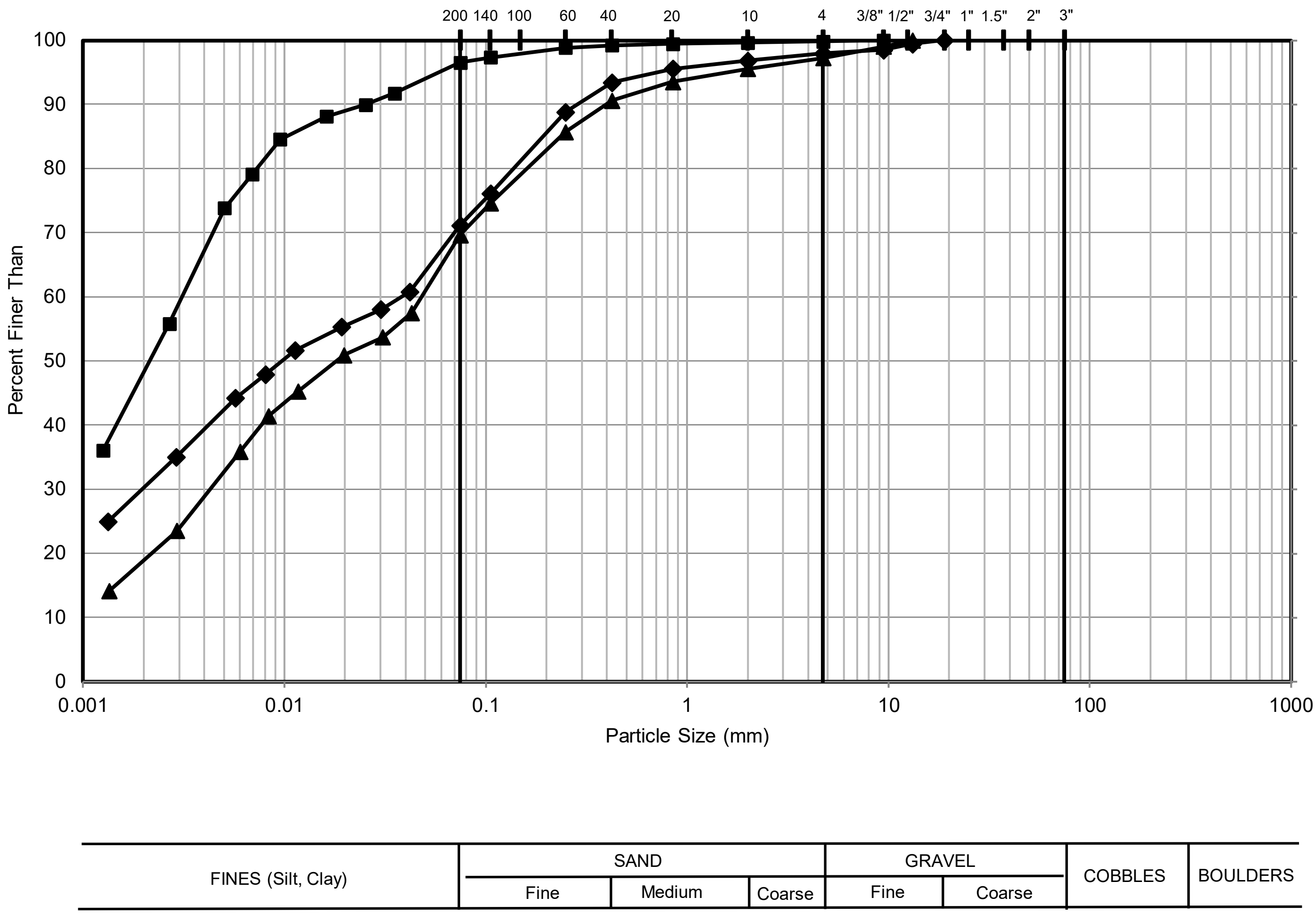
TITLE

GRAIN SIZE DISTRIBUTION - SILTY SAND - FILL

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B1

PATH: https://golderassociates.sharepoint.com/sites/120387/Project Files/6 Deliverables/Foundations/10th Sideroad/Appendix B - Lab Results | FILE NAME: Laboratory Particle Size Distribution MTO - 10th Sideroad.xlsm

GRAIN SIZE DISTRIBUTION - CLAYEY SILT (CL)



Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	10-1	3	1.5 - 2.1	281.5 to 280.9
◆	10-2	6	3.8 - 4.4	281.4 to 280.8
▲	10-3	3	1.5 - 2.1	281.0 to 280.3

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass 10th Sideroad interchange

CONSULTANT

WSP GOLDER

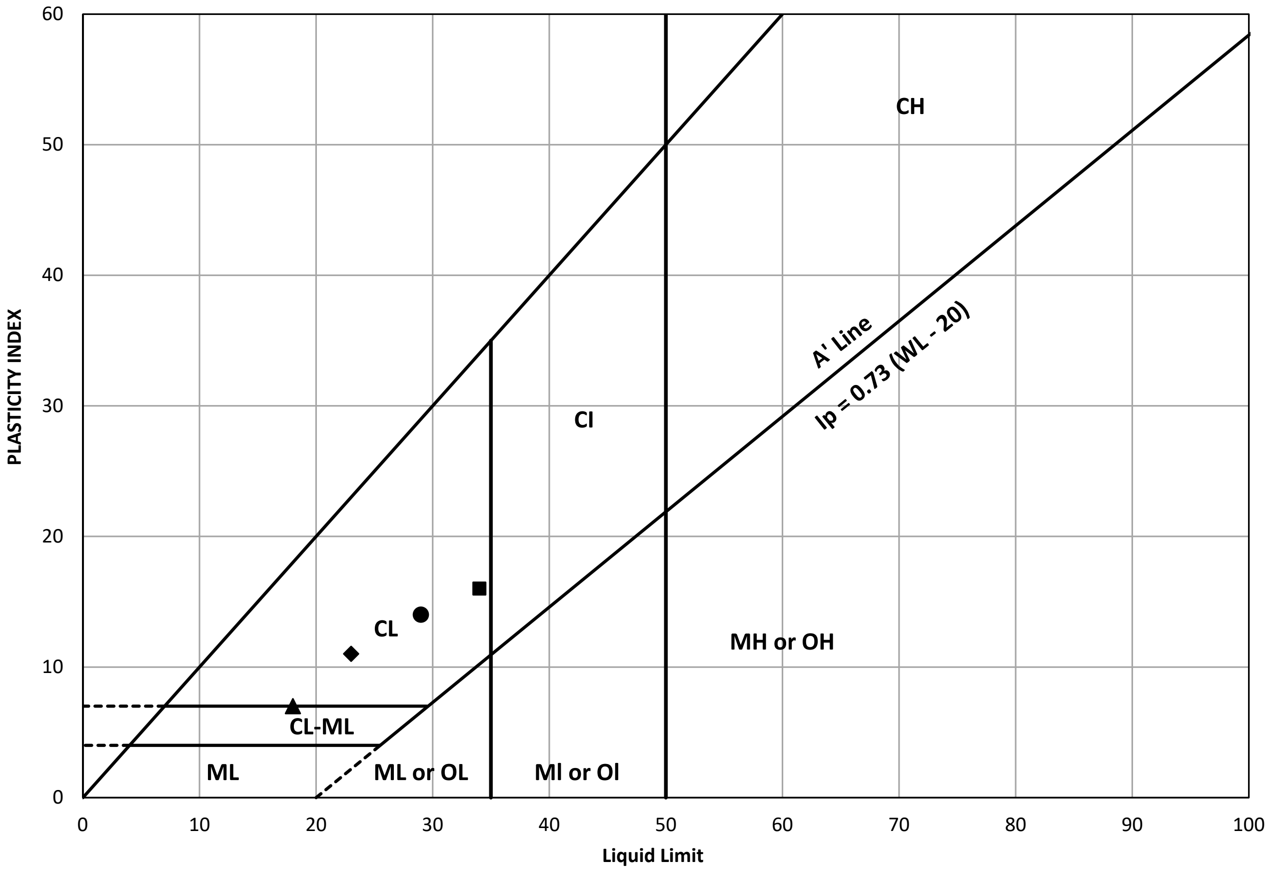
YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE

GRAIN SIZE DISTRIBUTION - CLAYEY SILT (CL)

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B2

PLASTICITY CHART - CLAYEY SILT (CL)



Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	10-1	3	281.5 to 280.9	22.2	34	18	16
◆	10-2	6	281.4 to 280.8	14.8	23	12	11
▲	10-3	3	281.0 to 280.3	12.5	18	11	7
●	10-4	3	280.8 to 280.2	20.8	29	15	14

CLIENT
AECOM / MTO

PROJECT
Bradford Bypass - 10th sideroad Interchange

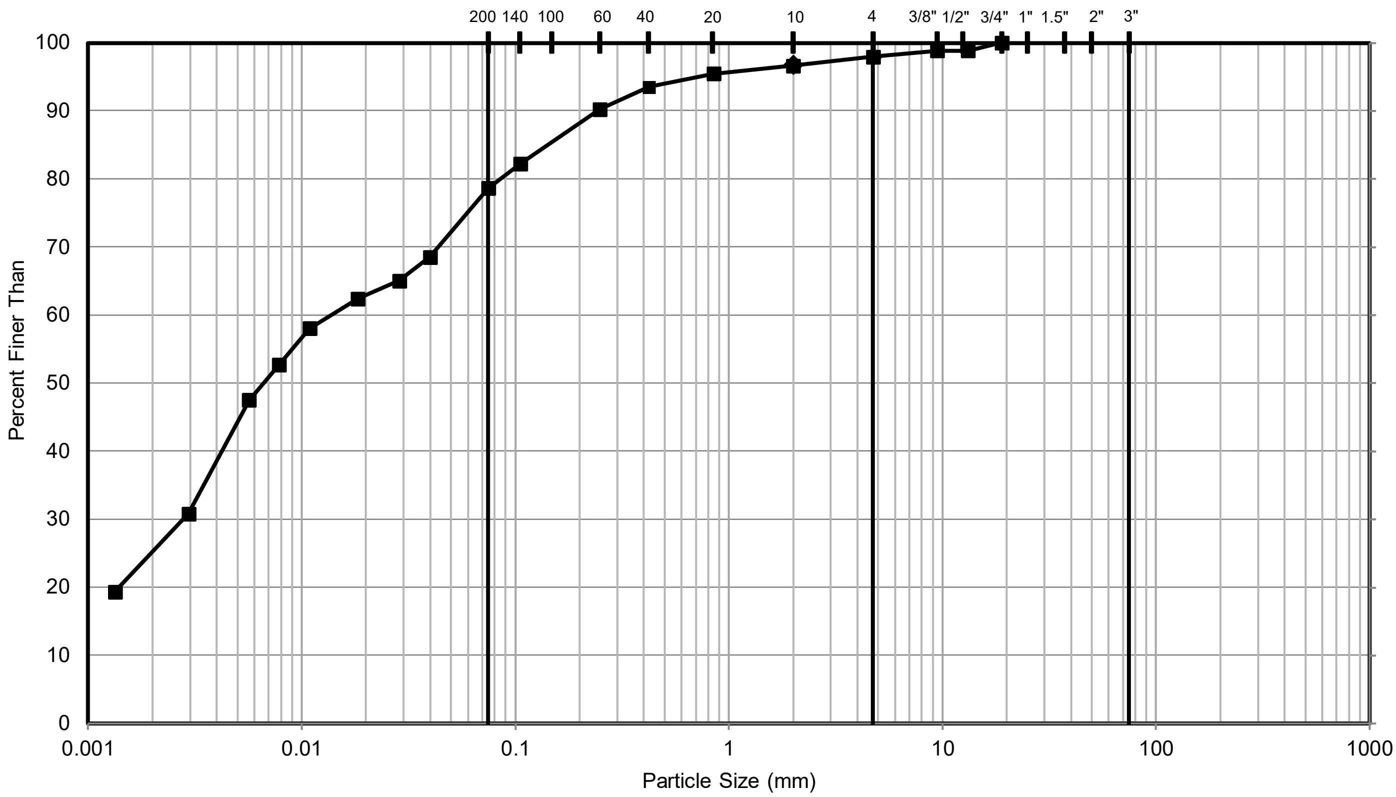
CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE
PLASTICITY CHART - CLAYEY SILT (CL)

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B3

GRAIN SIZE DISTRIBUTION - CLAYEY SILT to CLAYEY SILT - SILT(CL/CL-ML) - TILL



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	10-1	7	4.6 - 5.2	278.4 to 277.8

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass 10th Sideroad interchange

CONSULTANT

WSP GOLDER

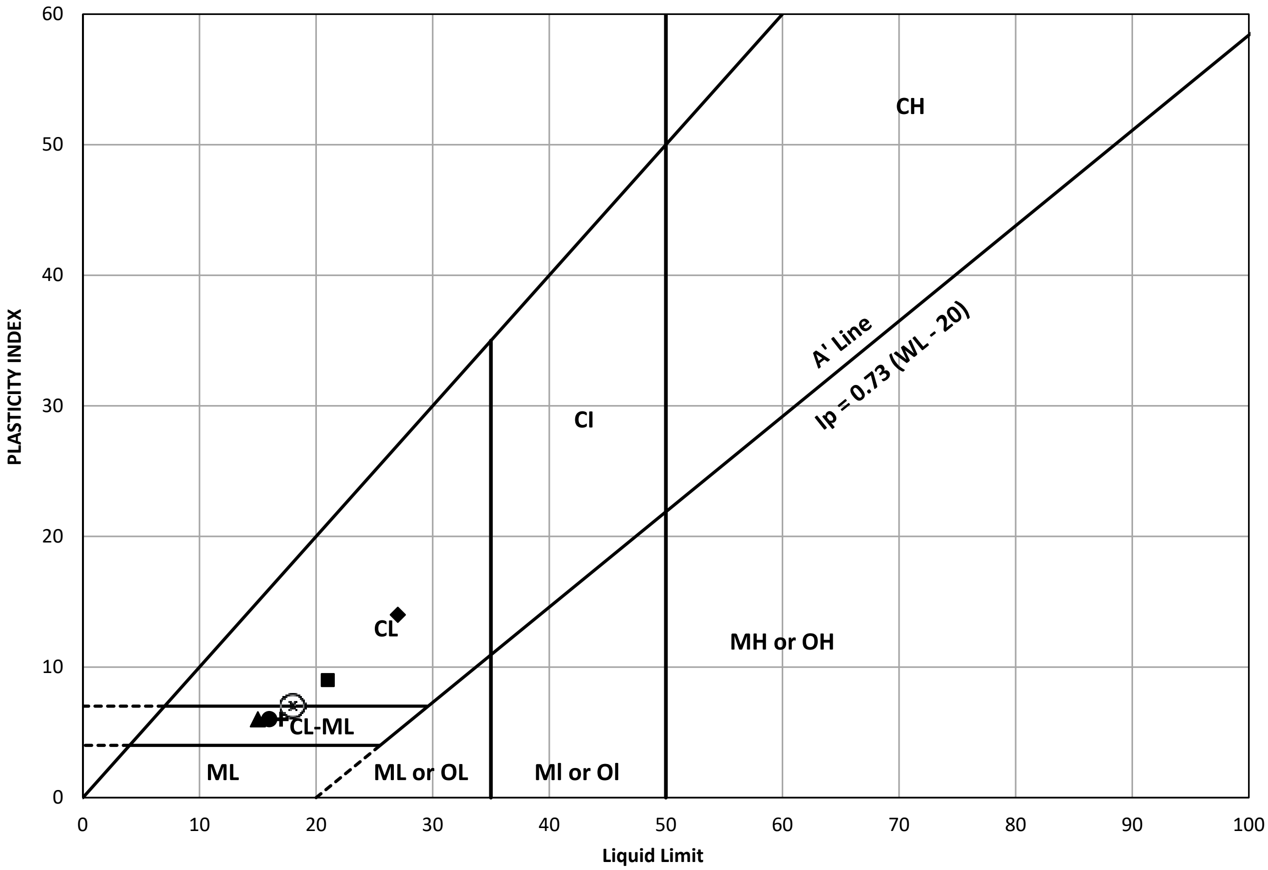
YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE

GRAIN SIZE DISTRIBUTION - CLAYEY SILT to CLAYEY SILT - SILT(CL/CL-ML) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B4

PLASTICITY CHART - CLAYEY SILT to CLAYEY SILT - SILT (CL / CL-ML) - TILL



Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	10-1	7	278.4 to 277.8	14.3	21	12	9
◆	10-2	8	279.1 to 278.5	17.8	27	13	14
▲	10-2	10	276.1 to 275.5	7.9	15	9	6
●	10-3	5	279.4 to 278.8	10.6	16	10	6
+	10-3	6	278.7 to 278.1	11.1	17	11	6
⊗	10-3	7	277.9 to 277.3	10.9	18	11	7

CLIENT
AECOM / MTO

PROJECT
Bradford Bypass - 10th sideroad Interchange

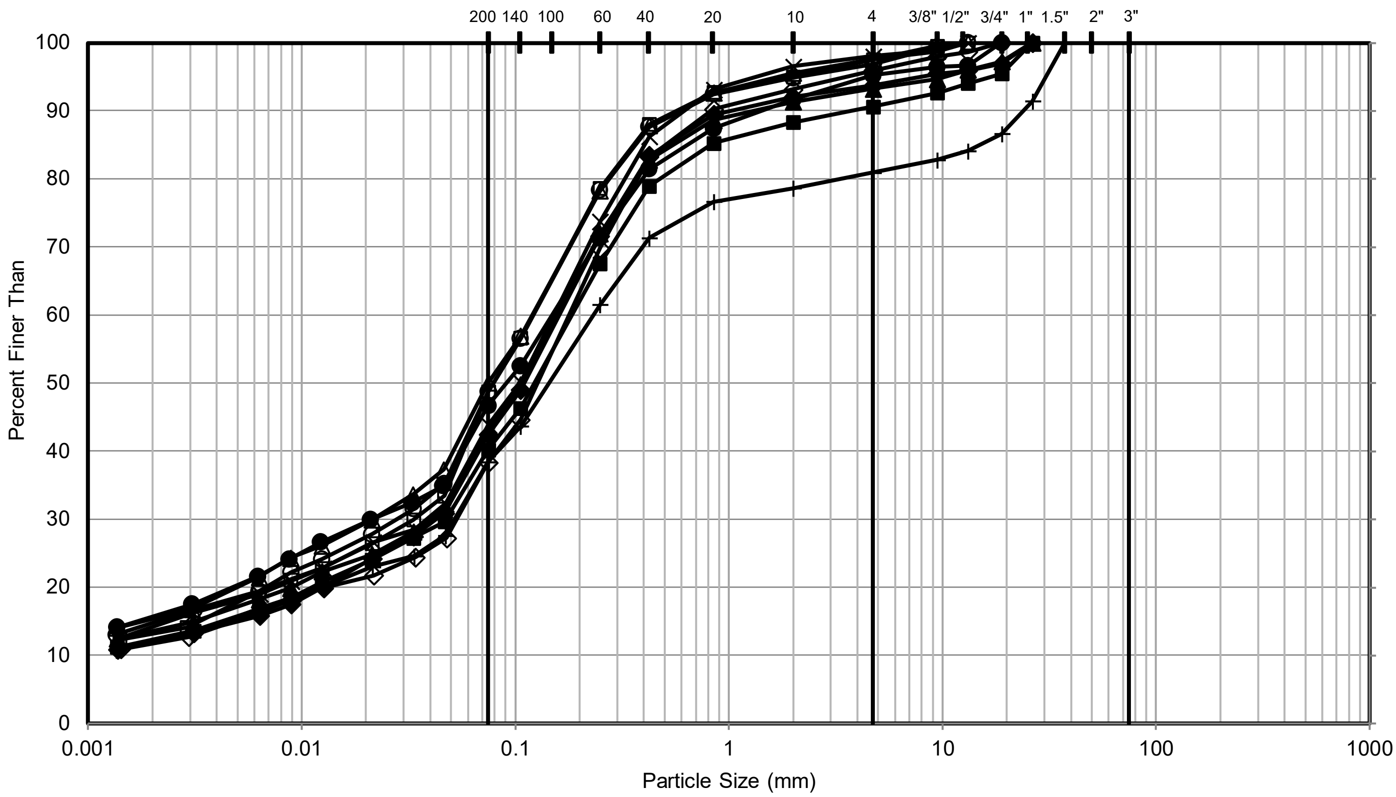
CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE
PLASTICITY CHART - CLAYEY SILT to CLAYEY SILT - SILT (CL / CL-ML) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B5

GRAIN SIZE DISTRIBUTION - SILTY SAND (SM) - TILL



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	10-1	10	9.1 - 9.6	273.9 to 273.4
◆	10-1	12	12.2 - 12.8	270.8 to 270.2
▲	10-1	15	16.8 - 17.2	266.2 to 265.8
●	10-2	12	12.2 - 12.6	273.0 to 272.7
□	10-2	16	18.3 - 18.9	266.9 to 266.4
◇	10-2	19	27.4 - 27.9	257.8 to 257.4
△	10-3	12	12.2 - 12.6	270.3 to 269.9
○	10-3	15	16.8 - 17.3	265.7 to 265.2
×	10-3	19	27.4 - 28.0	255.0 to 254.5
+	10-3	9	7.6 - 8.0	274.9 to 274.4

CLIENT
AECOM / MTO

PROJECT
Bradford Bypass 10th Sideroad interchange

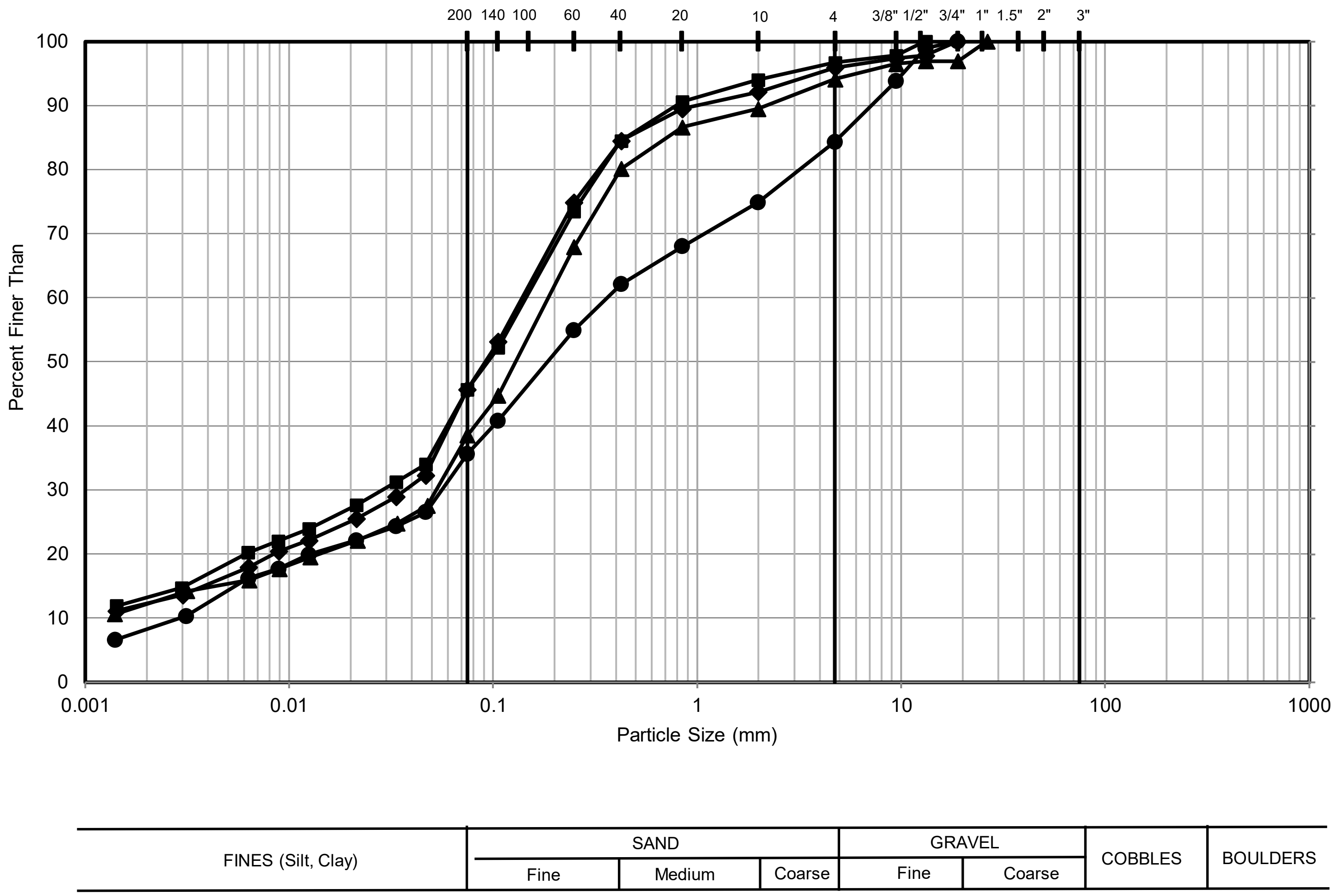
CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE
GRAIN SIZE DISTRIBUTION - SILTY SAND (SM) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B6A

GRAIN SIZE DISTRIBUTION - SILTY SAND (SM) - TILL



Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	10-4	10	9.1 - 9.7	273.2 to 272.6
◆	10-4	14	15.2 - 15.9	267.1 to 266.5
▲	10-4	18	24.4 - 25.0	257.9 to 257.3
●	10-4	6	3.8 - 4.4	278.5 to 277.9

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass 10th Sideroad interchange

CONSULTANT

WSP GOLDER

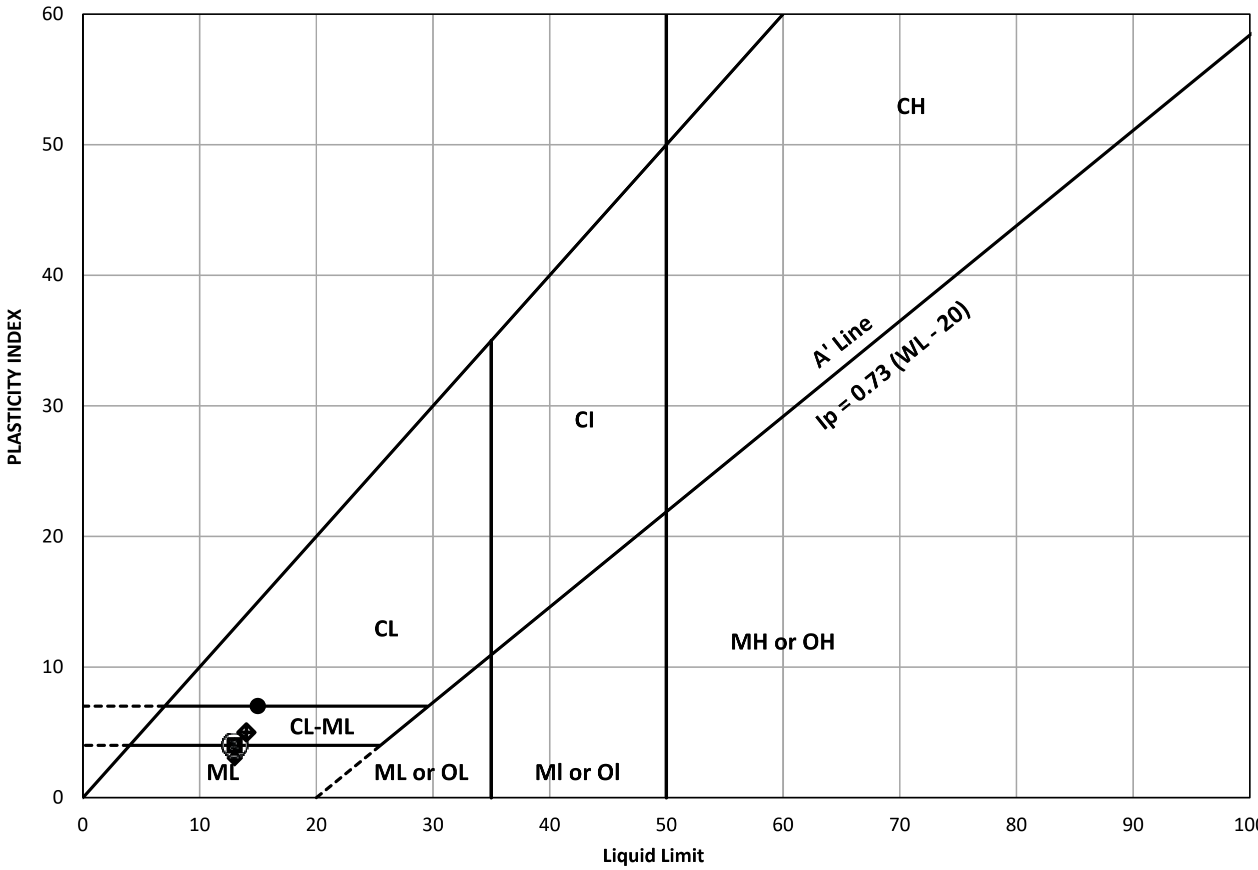
YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE

GRAIN SIZE DISTRIBUTION - SILTY SAND (SM) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B6B

PLASTICITY CHART - SILTY SAND (SM) - TILL



Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	10-1	10	273.9 to 273.4	6.5	13	9	4
◆	10-1	12	270.8 to 270.2	7	13	10	3
▲	10-1	15	266.2 to 265.8	6.8	13	9	4
●	10-2	12	273.0 to 272.7	6.9	15	8	7
+	10-2	19	257.8 to 257.4	7.4	14	9	5
⊗	10-4	6	278.5 to 277.9	8	13	9	4
□	10-4	14	267.1 to 266.5	6.4	13	9	4
◇	10-4	18	257.9 to 257.3	6.2	14	9	5

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass - 10th sideroad Interchange

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-11-28
DESIGNED	AY
PREPARED	AY
REVIEWED	KJB
APPROVED	KJB

TITLE

PLASTICITY CHART - SILTY SAND (SM) - TILL

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	0	A	B7

APPENDIX C

Analytical Laboratory Test Results

Your Project #: 19136074
Site Location: BRADFORD BYPASS
Your C.O.C. #: 827733-01-01

Attention: Carter Comish

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

Report Date: 2021/06/25
Report #: R6692694
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1H2336
Received: 2021/06/22, 16:30

Sample Matrix: Soil
Samples Received: 12

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	12	2021/06/24	2021/06/24	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	12	2021/06/25	2021/06/25	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	12	2021/06/24	2021/06/24	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	12	2021/06/22	2021/06/25	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	12	2021/06/24	2021/06/24	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas 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. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas 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 Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 19136074
Site Location: BRADFORD BYPASS
Your C.O.C. #: 827733-01-01

Attention: Carter Comish

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

Report Date: 2021/06/25
Report #: R6692694
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1H2336
Received: 2021/06/22, 16:30

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: emese.gitej@bureauveritas.com
Phone# (905)817-5829
===
This report has been generated and distributed using a secure automated process.
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

BV Labs Job #: C1H2336
Report Date: 2021/06/25

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: CC

RESULTS OF ANALYSES OF SOIL

BV Labs ID		PXF832		PXF833		PXF834	PXF835		
Sampling Date		2021/05/27		2021/05/03		2021/05/17	2021/04/13		
COC Number		827733-01-01		827733-01-01		827733-01-01	827733-01-01		
	UNITS	**B-2 SS3**	**QC Batch**	**10-4 SS2**	**QC Batch**	**Y-1 SS3**	**10-2 SS3**	**RDL**	**QC Batch**
Calculated Parameters									
Resistivity	ohm-cm	1500	7421780	2400	7421780	4500	1400		7421780
Inorganics									
Soluble (20:1) Chloride (Cl-)	ug/g	270	7426573	180	7426733	65	330	20	7426573
Conductivity	umho/cm	651	7429034	416	7429034	220	700	2	7429034
Available (CaCl2) pH	pH	7.66	7426977	7.77	7426977	7.70	7.95		7426977
Soluble (20:1) Sulphate (SO4)	ug/g	<20	7426738	<20	7426744	<20	<20	20	7426738

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

BV Labs ID		PXF835		PXF836		PXF837		PXF838		
Sampling Date		2021/04/13		2021/04/11		2021/06/02		2021/04/12		
COC Number		827733-01-01		827733-01-01		827733-01-01		827733-01-01		
	UNITS	**10-2 SS3 Lab-Dup**	**QC Batch**	**Y-4 SS2**	**RDL**	**L-3 SS3**	**RDL**	**9-1 SS3**	**RDL**	**QC Batch**
Calculated Parameters										
Resistivity	ohm-cm			3400		380		11000		7421780
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g			130	20	1700	100	<20	20	7426573
Conductivity	umho/cm			295	2	2660	2	90	2	7429034
Available (CaCl2) pH	pH	8.05	7426977	7.81		7.56		7.91		7426977
Soluble (20:1) Sulphate (SO4)	ug/g			<20	20	<20	20	<20	20	7426738

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

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

BV Labs Job #: C1H2336
Report Date: 2021/06/25

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: CC

RESULTS OF ANALYSES OF SOIL

BV Labs ID		PXF839	PXF840	PXF841	PXF842	PXF843		
Sampling Date		2021/04/29	2021/04/19	2021/04/19	2021/04/30	2021/04/21		
COC Number		827733-01-01	827733-01-01	827733-01-01	827733-01-01	827733-01-01		
	UNITS	**10-1 SS2**	**PDD-1 SS3**	**PDD-2 SS2**	**10-3 SS3**	**B-1 SS3**	**RDL**	**QC Batch**
Calculated Parameters								
Resistivity	ohm-cm	4100	7800	7600	6900	8700		7421780
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	100	<20	<20	25	<20	20	7426573
Conductivity	umho/cm	246	128	131	146	115	2	7429034
Available (CaCl2) pH	pH	7.83	7.74	7.63	7.84	7.88		7426977
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	<20	<20	<20	20	7426738

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

BV Labs ID		PXF843		
Sampling Date		2021/04/21		
COC Number		827733-01-01		
	UNITS	**B-1 SS3 Lab-Dup**	**RDL**	**QC Batch**
Inorganics				
Conductivity	umho/cm	113	2	7429034

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

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

BUREAU VERITAS

BV Labs Job #: C1H2336
Report Date: 2021/06/25

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: CC

TEST SUMMARY

BV Labs ID: PXF832 **Collected:** 2021/05/27
Sample ID: B-2 SS3 **Shipped:**
Matrix: Soil **Received:** 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF833 **Collected:** 2021/05/03
Sample ID: 10-4 SS2 **Shipped:**
Matrix: Soil **Received:** 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426733	2021/06/24	2021/06/24	Alina Dobreanu
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426744	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF834 **Collected:** 2021/05/17
Sample ID: Y-1 SS3 **Shipped:**
Matrix: Soil **Received:** 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF835 **Collected:** 2021/04/13
Sample ID: 10-2 SS3 **Shipped:**
Matrix: Soil **Received:** 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF835 Dup **Collected:** 2021/04/13
Sample ID: 10-2 SS3 **Shipped:**
Matrix: Soil **Received:** 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake

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Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

BV Labs Job #: C1H2336
Report Date: 2021/06/25

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: CC

TEST SUMMARY

BV Labs ID: PXF836
Sample ID: Y-4 SS2
Matrix: Soil

Collected: 2021/04/11
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF837
Sample ID: L-3 SS3
Matrix: Soil

Collected: 2021/06/02
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF838
Sample ID: 9-1 SS3
Matrix: Soil

Collected: 2021/04/12
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF839
Sample ID: 10-1 SS2
Matrix: Soil

Collected: 2021/04/29
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF840
Sample ID: PDD-1 SS3
Matrix: Soil

Collected: 2021/04/19
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan

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Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

BV Labs ID: PXF840
Sample ID: PDD-1 SS3
Matrix: Soil

Collected: 2021/04/19
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF841
Sample ID: PDD-2 SS2
Matrix: Soil

Collected: 2021/04/19
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF842
Sample ID: 10-3 SS3
Matrix: Soil

Collected: 2021/04/30
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF843
Sample ID: B-1 SS3
Matrix: Soil

Collected: 2021/04/21
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7426573	2021/06/24	2021/06/24	Avneet Kour Sudan
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel
pH CaCl2 EXTRACT	AT	7426977	2021/06/24	2021/06/24	Neil Dassanayake
Resistivity of Soil		7421780	2021/06/25	2021/06/25	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7426738	2021/06/24	2021/06/24	Avneet Kour Sudan

BV Labs ID: PXF843 Dup
Sample ID: B-1 SS3
Matrix: Soil

Collected: 2021/04/21
Shipped:
Received: 2021/06/22

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	7429034	2021/06/25	2021/06/25	Khushbu Vijay kumar Patel

BUREAU VERITAS

BV Labs Job #: C1H2336
Report Date: 2021/06/25

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: CC

GENERAL COMMENTS

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

Package 1	4.0°C

Results relate only to the items tested.

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Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

BV Labs Job #: C1H2336
Report Date: 2021/06/25

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: CC

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7426573	Soluble (20:1) Chloride (Cl-)	2021/06/24	NC	70 - 130	105	70 - 130	<20	ug/g	3.5	35
7426733	Soluble (20:1) Chloride (Cl-)	2021/06/24	NC	70 - 130	104	70 - 130	<20	ug/g	4.4	35
7426738	Soluble (20:1) Sulphate (SO4)	2021/06/24	112	70 - 130	102	70 - 130	<20	ug/g	NC	35
7426744	Soluble (20:1) Sulphate (SO4)	2021/06/24	NC	70 - 130	103	70 - 130	<20	ug/g	19	35
7426977	Available (CaCl2) pH	2021/06/24			100	97 - 103			1.3	N/A
7429034	Conductivity	2021/06/25			100	90 - 110	<2	umho/cm	1.6	10

N/A = Not Applicable

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

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

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

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

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

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

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Brad Newman, B.Sc., C.Chem., Scientific Service Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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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:	Golder	Quotation #:	B80683	BV Labs Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:	Carter Comish	P.O. #:	~~172630~~		827733
Address:	6925 Century Ave Suite 100	Address:		Project:	19131074	COC #:	Project Manager:
	Mississauga ON L5N 7K2			Project Name:	Bradford Bypass	C#827733-01-01	Ema Gitej
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	Fax:	Site #:			
Email:	CanadaAccountsPayableInvoices@golder.com	Email:	Carter_Comish@golder.com	Sampled By:			

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS 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 / Reg 406 Table / Other

Special Instructions

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

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; Corrosity pkh short(Cl, SO4, pH, EC/Resistivity)

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	Corrosity pkh short	# of Bottles	Comments
1		B-2 SS3	21/05/27 ~~21/05/18~~	AM	Soil			✓		
2		10-4 SS2	21/05/03	↓	↓			✓		
3		Y-1 SS3	21/05/17					✓		
4		10-2 SS3	21/04/13					✓		
5		Y-4 SS2	21/04/11					✓		
6		L-3 SS3	21/06/02					✓		
7		9-1 SS3	21/04/12					✓		
8		10-1 SS2	21/04/29					✓		
9		PDD-1 SS3	21/04/19					✓		
10		PDD-2 SS2	21/04/19					✓		

22-Jun-21 16:30
Ema Gitej
C1H2336
LDR ENV-920

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Laboratory Use Only
Carter Comish	21/06/22	4:00pm		2021/06/22	16:30			Temperature (°C) on Receipt: 5/3/4

Custody Seal: Present Yes ✓ / Intact Yes ✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' 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.BVLABS.COM/TERMS-AND-CONDITIONS.

* 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 WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

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

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name:	#1326 Golder Associates Ltd	Company Name:	Golder	Quotation #:	B80683
Attention:	Accounts Payable	Attention:	Carter Comish	P.O. #:	
Address:	6925 Century Ave Suite 100	Address:		Project:	19136074
	Mississauga ON L5N 7K2			Project Name:	Bradford Bypass
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	Fax:	Site #:	
Email:	CanadaAccountsPayableInvoices@golder.com	Email:	Carter_Comish@golder.com	Sampled By:	

Laboratory Use Only:

BV Labs Job #:	Bottle Order #:
	827733
COC #:	Project Manager:
C#827733-02-01	Ema Gitej

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

Regulation 153 (2011)	Other Regulations	Special Instructions
☐ Table 1 ☐ Res/Park ☐ Medium/Fine	☐ CCME ☐ Sanitary Sewer Bylaw	
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ Reg 558 ☐ Storm Sewer Bylaw	
☐ Table 3 ☐ Agri/Other ☐ For RSC	☐ MISA Municipality	
☐ Table ___	☐ PWQO ☐ Reg 406 Table	
	☐ Other	

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

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Corrosity pkh short(Cl, SO4, pH, EC/Resistivity)	# of Bottles	Comments
1		10-3 SS3	21/04/30	AM	Soil		✓		
2		B-1 SS3	21/04/21				✓		
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
Carter Comish	21/06/22	4:00pm		21/06/22	16:30	

Laboratory Use Only				
Time Sensitive	Temperature (°C) on Recei	Custody Seal	Yes	No
	5/3/4	Present	✓	
		Intact	✓	

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' 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.BVLABS.COM/TERMS-AND-CONDITIONS.

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** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

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

White: BV Labs Yellow: Client

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