



Foundation Investigation and Design Report

*Proposed Centreline Twin Culvert
Bridge Replacement and Interchange Reconfiguration at
Highway 11/12 (Old Barrie Road), Orillia
Ministry of Transportation, Ontario
GWP 2129-18-00*

Submitted to:

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19135676-CLVT-Rev0

April 10, 2024

GEOCRES No.: 31D11-005

Lat. 44.588900°

Long. -79.445721°

Distribution List

1 PDF copy - MTO - Central Region

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1 PDF copy - Egis Canada Ltd.

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PART A

**FOUNDATION INVESTIGATION REPORT
PROPOSED CENTRELINE TWIN CULVERT
BRIDGE REPLACEMENT AND INTERCHANGE RECONFIGURATION AT
HIGHWAY 11/12 (OLD BARRIE ROAD), ORILLIA
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2129-18-00**

1.0 INTRODUCTION

WSP Canada Inc. (WSP, formerly Golder Associates Ltd., amalgamated with WSP in 2023), has been retained by Egis Group (Egis, formerly McIntosh Perry Consulting Engineers Ltd.) on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary design foundation engineering services as part of the design-build ready assignment for the interchange improvements at the Highway 11 and Highway 12 (Old Barrie Road) south junction. This report presents the results of the foundation investigation for the proposed centreline twin culvert crossing Highway 11 at the Highway 11/12 (Old Barrie Road) interchange.

The purpose of this foundation investigation is to establish the subsurface conditions near the culvert location by methods of borehole drilling, in-situ testing, and laboratory testing on selected soil samples.

2.0 PROJECT AND SITE DESCRIPTION

The orientation stated (i.e., north, south, east, and west) in the text of this report is referenced to project north and therefore may differ from magnetic north shown on Drawing 1. For this report, Highway 11 (in the vicinity of the City of Orillia) is considered oriented in a south-north direction and Highway 12 (Old Barrie Road) is considered oriented in a west-east direction.

2.1 Project Description

The overall assignment includes the preparation of two separate contracts. The first contract includes the replacement of the Coldwater Road Underpass and the reconfiguration/reconstruction of the Highway 11 and Highway 12 (Coldwater Road) interchange. The second contract includes the replacement of the Old Barrie Road Underpass; the reconfiguration/reconstruction of the Highway 11 and Highway 12 (Old Barrie Road) interchange, including the construction of deep cuts and high fill embankments; construction of two retaining walls (designated as Retaining Wall No. 1 and 2); construction of two noise barrier walls (designated as Noise Barrier Walls No. 1 and 2); construction of two stormwater management ponds (designated as Pond A and Pond B), and construction of the twin centreline culvert.

The centreline twin culvert will cross Highway 11 approximately 50 m south of the Highway 12 (Old Barrie Road) underpass, as shown on Drawing 1, and will cross below the proposed new W-N Ramp and E/W-S Ramp. Based on preliminary drawing, the twin culverts are shown to be circular with each having an inside diameter of 1,050 mm and a length of 81.3 m. The upstream (west) and downstream (east) inverts are proposed to be at Elevation 256.2 m and 255.7 m, respectively. The twin culvert will outlet into the proposed stormwater management pond (Pond A) at the southeast quadrant of the interchange. The southeast quadrant will require a significant grade raise for construction of the W-N Ramp embankment and Pond A.

2.2 Site Description

At the proposed culvert location, the Highway 11 grade ranges from about Elevation 258 m to 258.5 m. The western portion of the highway embankment is up to about 2 m high and is inclined at about 5H:1V. The eastern portion of the highway embankment is up to about 6 m high and is inclined at about 2.5H:1V.

The existing ground surface at the proposed culvert inlet (west end) and outlet (east end) is at about Elevation 256.2 m and 251.5 m, respectively. The proposed inlet and outlet areas of the culvert currently consist of vegetation consisting of grasses and trees / shrubs.

Based on available historical contract drawings, there are no existing storm sewers running along the shoulders of Highway 11 at the culvert location, nor are there existing ditch inlets at the highway median at the culvert location.

However, sewer grates and existing lateral outlets are present at the shoulders of Highway 11. Although the lateral outlets do not appear to be in conflict with the proposed culvert, it is understood that some modification of the lateral outlets will be required to accommodate the new E/W-S Ramp and the new W-N Ramp.

3.0 INVESTIGATION PROCEDURE

The fieldwork for the current subsurface investigation was carried out between November 13 and 27, 2023, during which time four boreholes (designated as Boreholes CO5-1 to CO5-4) were advanced in the vicinity of the proposed twin culvert. The locations of the boreholes are shown in plan on Drawing 1.

The boreholes were advanced using D-55 track-mounted / CME 750 truck-mounted drill rigs, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. Traffic control was performed in accordance with the Ontario Traffic Manual Book 7 – Temporary Conditions. The boreholes were advanced using 200 mm to 210 mm outer diameter (OD) continuous flight hollow stem augers. Soil samples were typically obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in general accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). 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.

Water levels were observed in the open boreholes during and immediately following the drilling operations. A standpipe piezometer was installed in one borehole (Borehole CO5-4) to permit monitoring of the groundwater level. The standpipe piezometer consists of a 50 mm outer diameter Schedule 40 PVC pipe, with a slotted screen surrounded with a sand filter pack, sealed at a selected depth within the borehole. The annulus surrounding the pipe above the well screen and sand filter pack was backfilled to the ground surface with bentonite.

The boreholes, excluding Borehole CO5-4, were backfilled with bentonite upon completion of drilling operations in general accordance with Ontario Regulation 903 (*Wells*), as amended. Borehole CO5-4 is to be decommissioned by the Design-Build Contractor at the time of construction.

Prior to commencement of the field work, WSP arranged for the clearance of underground utilities. The field work was supervised by a member of WSP's engineering staff, who observed the borehole drilling, in-situ testing, and soil sampling operations, and logged the boreholes in the field. The soil samples were placed in appropriate containers, labelled, and transported to WSP's Mississauga geotechnical laboratory where the samples underwent further visual and tactile examination and geotechnical laboratory testing.

Geotechnical index testing, such as water content, Atterberg limits, and grain size distribution, was carried out on selected soil samples in accordance with MTO and/or ASTM Standards, as appropriate, and the results of which are presented in Appendix B. In addition, one soil sample was submitted for corrosivity testing, under chain-of-custody procedures, to Bureau Veritas Laboratories (a Standards Council of Canada (SCC) accredited laboratory) of Mississauga, Ontario. The sample was analyzed for a suite of corrosivity parameters which includes conductivity/resistivity, soluble chloride and soluble sulphate concentrations, sulphide concentrations, and pH. The results of the corrosivity testing are presented in Appendix C.

The as-drilled borehole locations and the corresponding ground surface elevations were surveyed by WSP using a Trimble GPS unit. The borehole survey information, including northing/easting coordinates (referenced to the NAD83 Canadian Spatial Reference System (CSRS) V6:2010 MTM Zone 10 coordinate system), latitude/longitude coordinates, and corresponding ground surface elevations (referenced to the Canadian Geodetic Vertical Datum

(CGVD) 1928:1978), as well as borehole depths are provided on the borehole records in Appendix A and summarized below.

Borehole No.	Coordinates (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
CO5-1	493877.3 (44.58899)	309057.9 (-79.446374)	260.0	11.3
CO5-2	4938789.6 (44.589101)	309073.1 (-79.446183)	259.0	14.2
CO5-3	4938772.6 (44.588948)	309083.4 (-79.446054)	259.2	14.2
CO5-4	4938767.3 (44.588900)	309109.8 (-79.445721)	253.0	9.5

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 11/12 lies within the Simcoe Lowlands, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984). The Simcoe Lowlands consist of a series of steep sided, flat-floored valleys that were flooded by glacial lake Algonquin. The surficial soils in this area of the Simcoe Lowlands typically comprise glaciolacustrine sediments of very fine to medium-grained sand, silt and minor clay; and fluvial and glaciofluvial ice-contact sediments of fine to very coarse-grained sand, gravelly sand and gravel with minor amounts of silt, clay and flowtill. Modern alluvial deposits of clay, silt, sand and gravel that may contain organics are also present.

4.2 Subsurface Conditions

The subsurface soil and groundwater conditions encountered in the boreholes advanced in the vicinity of the proposed twin culvert are presented on the borehole records in Appendix A. To assist in the interpretation of the borehole records, *Method of Soil Classification, Abbreviations and Terms Used on Records of Boreholes and Test Pits* and *List of Symbols* sheets are provided in Appendix A. The geotechnical laboratory results are included in Appendix B. The results of in-situ tests as presented on the borehole records are uncorrected for overburden pressure and energy transfers. The 'N'-values are based on SPT sampling procedures carried out with a standard weight (i.e., 63.5 kg), and an automatic hammer.

The stratigraphic boundaries shown on the borehole records and on the profile shown on Drawing 2 have been inferred from observations of drilling progress, generally non-continuous sampling and in-situ testing, and therefore represent transitions between soil types rather than exact planes of geologic change. Further, subsurface conditions will vary between and beyond the borehole locations.

The subsurface soils encountered in the vicinity of the culvert generally consist of surficial asphalt underlain by fill, which in turn is underlain by a stiff to hard / dense to very dense glacial till deposit subsequently underlain by a dense to very dense silt to silty sand deposit. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt

An approximately 150 mm and 255 mm thick layer of asphalt was encountered at ground surface in Boreholes CO5-2 and CO5-3, respectively.

4.2.2 Topsoil

An approximately 225 mm thick layer of topsoil was encountered at ground surface in Borehole CO5-4.

4.2.3 Fill

An approximately 2.0 m to 6.9 m thick layer of fill was encountered at ground surface at Borehole CO5-1, underlying the topsoil at Borehole CO5-4, and underlying the asphalt at Boreholes CO5-2 and CO5-3. The fill extends to depths ranging from 2.2 m to 7.1 m below ground surface (Elevations 250.8 m to 254.7 m). The fill generally consists of silty sand to silty sand and gravel, containing rock fragments. The fill contains organics at Boreholes CO5-1 and CO5-4 and contains asphalt fragments above 0.7 m depth in Boreholes CO5-2 and CO5-3. The split-spoon sampler was observed to be bouncing at a depth of 4.9 m below ground surface, while sampling within the fill at Borehole CO5-1 and auger grinding was encountered while advancing the borehole through the fill in Borehole CO5-4. Based on the observed rock fragments, split-spoon sampler bouncing, and auger grinding, cobbles/boulders are anticipated within the fill.

SPT 'N'-values measured within the fill range from 3 blows to 55 blows per 0.3 m of penetration, indicating a very loose to very dense state of compactness, however, the fill is generally loose to compact.

Grain size distribution testing was carried out on six samples of the fill and the results are presented on Figure B-1 in Appendix B. Atterberg Limits testing was carried out on five samples of the fill and measured liquid limits ranging from about 15% to 22%, plastic limits ranging from about 12% to 18%, and plasticity indices ranging of about 3% and 4%, suggesting the silty sand fill has slight plasticity. The results of the Atterberg Limit tests are presented on Figure B-2 in Appendix B.

The water contents measured on select samples of the fill range from about 4% to 16%.

4.2.4 Glacial Till

An approximately 1.9 m to 7.1 m thick glacial till deposit was encountered below the fill in all boreholes. The glacial till deposit was encountered at depths ranging from 2.2 m to 7.1 m below ground surface (Elevations 250.8 m to 254.7 m) and extended to depths ranging from 7.2 m to 11.6 m below ground surface (Elevations 244.6 m to 252.8 m). The glacial till generally ranges in composition from a cohesive clayey silt / sandy clayey silt-silt / clayey sand to a sandy silt to silt of slight plasticity. The upper portion of the till deposit in Borehole CO5-4 consisted of a gravelly silty sand. Auger grinding was encountered while advancing the borehole through the till in Boreholes CO5-2 and CO5-4 and rock fragments were encountered within the till at Borehole CO5-4. Based on our experience with glacial till soils in the area, and the observed auger grinding and rock fragments, cobbles and boulders are anticipated within the till deposit.

SPT-'N' values measured within the till range from 12 blows for 0.3 m of penetration to greater than 100 blows for less than 0.1 m of penetration, suggesting a stiff to hard consistency / dense to very dense state of compactness.

Grain size distribution testing was carried out on six samples of the glacial till deposit and the results are presented on Figure B-3 in Appendix B. Atterberg Limits testing was carried out on six samples of the glacial till deposit and the results are presented on Figure B-4 in Appendix B. One sample yielded non-plastic results and the remaining five samples measured liquid limits ranging from about 15% to 21%, plastic limits ranging from about 10% to 15%, and plasticity indices ranging from about 3% to 8%. The results indicate the till generally ranges from a low plasticity clayey silt / clayey silt-silt / clayey sand to a silt / sandy silt of low plasticity. The localized gravelly silty sand till layer encountered in Borehole CO5-4 was non-plastic.

Water contents measured on select samples of the till deposit range from about 7% to 13%.

4.2.5 Silt to Silty Sand

A silt to silty sand deposit was encountered underlying the glacial till deposit in all boreholes, at depths ranging from 7.1 m to 11.6 m below ground surface (Elevations 244.6 m to 252.8 m) and extending to the borehole termination depths ranging from 9.5 m to 14.2 m (Elevations 243.5 m to 248.7 m). The deposit ranges in composition from silt to silty sand, trace to some gravel, trace to some clay.

SPT 'N'-values measured within silt to silty sand deposit range from 91 blows to over 100 blows per 0.3 m of penetration, indicating a very dense state of compactness.

Grain size distribution testing was carried out on four samples of the silt to silty sand deposit and the results are presented on Figure B-5 in Appendix B. Atterberg Limits testing was carried out on two samples of the silt to silty sand deposit and yielded non-plastic results, suggesting the silt to silty sand deposit is non-plastic.

The water contents measured on select samples of the silt to silty sand deposit range from about 11% to 16%.

4.2.6 Groundwater Conditions

In general, the soil samples recovered from the boreholes were moist to wet. The groundwater levels were measured in the open boreholes upon completion of drilling operations. A standpipe piezometer was installed in Borehole CO5-4 to monitor the groundwater level. The groundwater level measurements are presented below and on the borehole records. The standpipe piezometer installation details are provided on the borehole record.

Borehole No.	Water Level		Reading Type	Date
	Depth (m)	Elevation (m)		
CO5-1	Dry	<248.7	Open borehole	November 20, 2023
CO5-2	2.0	257.0	Open borehole	November 14, 2023
CO5-3	6.1	253.1	Open borehole	November 16, 2023
CO5-4	8.4	244.6	Open borehole	November 26, 2023
	7.8*	245.2*	Piezometer*	November 27, 2023*
	6.2	246.8	Piezometer	January 19, 2024

*Reading obtained immediately following installation of standpipe piezometer.

The groundwater level observations/measurements are subject to seasonal fluctuations and precipitation events; therefore, the groundwater level should be expected to be higher during wet periods (e.g. Spring season) and during or following any period of heavy and/or sustained precipitation.

4.3 Analytical Testing

One soil sample was collected and submitted to Bureau Veritas Laboratories for analysis of parameters used to assess corrosion potential and sulphate attack. A summary of the results is presented in the following table. The Certificate of Analysis is provided in Appendix C.

Borehole No.	Sample No.	Sample Depth [Elevation] (m)	Soil Type	Parameters				
				Soluble Chloride (µg/g)	Soluble Sulphate (µg/g)	pH	Conductivity (µmho/cm)	Resistivity (ohm-cm)
CO5-3	3	1.5 – 2.1 [257.7 – 257.1]	Silty sand fill	570	31	8.0	1,260	800

The sulphide concentration measured in the soil sample noted above was also analyzed and the result was 1.8 mg/kg.

5.0 CLOSURE

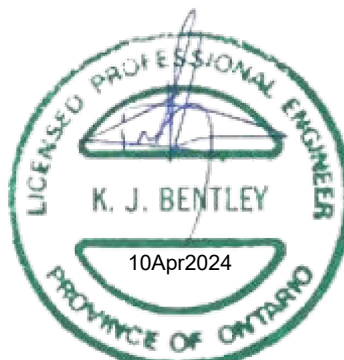
The Foundation Investigation Report was prepared by Ms. Anastasia Poliacik, P.Eng., a Senior Geotechnical Engineer with WSP and MTO Principal Foundations Contact. Mr. Kevin Bentley, P.Eng., a Senior Principal and MTO Principal Foundations Contact with WSP conducted an independent technical and quality review of this report.

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[https://wsonline.sharepoint.com/sites/gld-120052/project files/6 deliverables/2. reporting/10 - culvert/5. final/19135676-r-rev0_culvert obr fidr 10apr2024.docx](https://wsonline.sharepoint.com/sites/gld-120052/project%20files/6%20deliverables/2.%20reporting/10%20-%20culvert/5.%20final/19135676-r-rev0_culvert%20obr%20fidr%2010apr2024.docx)

PART B

**FOUNDATION DESIGN REPORT
PROPOSED CENTRELINE TWIN CULVERT
BRIDGE REPLACEMENT AND INTERCHANGE RECONFIGURATION AT
HIGHWAY 11/12 (OLD BARRIE ROAD), ORILLIA
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2129-18-00**

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides preliminary foundation engineering design recommendations for the proposed centreline twin culvert associated with the reconstruction / reconfiguration of the Highway 11 / 12 (Old Barrie Road) interchange. The discussion and recommendations are based on interpretation and analysis of the factual data obtained from the boreholes advanced during the current (2021- 2022) foundation investigation as described in the Foundation Investigation Report (Part A of this report) and the conceptual design at the time this report was prepared.

This section (Part B - Foundation Design Report) is intended for the use of the MTO and their procurement-ready designer for this assignment and shall not be relied upon for any other purpose or by any other parties. The discussion, recommendations and geotechnical/foundation aspects of any preliminary design or reference concept design are provided for information purposes only. Where comments are made on construction, they are provided only to highlight those aspects which could affect the detailed design of the project. The design-build proponent(s) shall make their own interpretations based on the factual data presented in the Foundation Investigation Report (Part A of this report) and supplement with additional information as necessary, to generate and assess foundation alternatives and develop the design of the preferred alternative. The design-build proponent is responsible for all aspects of the detailed design and construction for the preferred alternative.

6.1 General

The proposed twin culverts are 81.3 m in length and will extend below the western widening of Highway 11 (to accommodate the new E/W-S Ramp), below the existing highway embankment, and below the proposed eastern widening (to accommodate the new W-N Ramp). The culvert will outlet into the proposed stormwater management pond (Pond A) to be constructed in a fill area located at the southeast quadrant of the interchange. The proposed widened west embankment (towards the culvert inlet) is to be inclined at 3H:1V and the proposed widened east embankment (towards Pond A and the culvert outlet) is to be inclined at 2H:1V. The concept drawings indicate that a slight grade raise (less than 1 m) is anticipated near the culvert inlet, no grade raise is required above the existing Highway 11 embankment, and a grade raise (up to about 6 m) is anticipated within the footprint of the eastern half of the new culvert.

It is understood that both trenchless and conventional open cut installation methods are being considered for the centreline twin pipe culvert.

The reference concept details of the proposed centreline twin culvert, as provided by Egis in February 2024, are summarized in the table below.

Culvert Location	Station 11+142
Length (m)	81.3 (Twin)
Inside Diameter (m)	1.05 (Twin)
Estimated Outside Diameter / Tunnel Excavation Diameter (m)	1.20
Culvert Inlet (West) / Outlet (East) Elevation (m)	256.2 (West) / 255.7 (East)
Estimated Top of Culvert at Inlet (West) / Outlet (East) Elevation (m)	257.3 (West) / 256.8 (East)
Existing Highway 11 Grade Elevation (m)	258.1 (SBL) / 257.5 (Median) / 258.4 (NBL)
Approximate Soil Cover Below Highway Grade (m)	0.8 (SBL) / 0.5 (Median) / 1.3 (NBL)

Note: SBL denotes "Southbound Lanes" and NBL denotes "Northbound Lanes" of Highway 11.

Based on the information provided, the complexity rating for a trenchless crossing is “High”, as per Table 1 of the *Guidelines for Foundations Engineering – Tunnelling Specialty For Corridor Encroachment Permit Application* (MTO, February 2021). The ratio of soil cover to estimated tunnel excavation diameter is about 0.7 to 1.1 below the Highway 11 SBL and NBL, and about 0.4 within the median ditch. Typically, a minimum ratio of soil cover to tunnel excavation diameter equal to 3 (or a minimum soil cover thickness of 1.5 m) is considered acceptable for conventional MTO tunnelling projects. As a result, unless the profile of the proposed culvert(s) can be lowered by more than 1.7 m in order to achieve a minimum soil cover to excavation diameter ratio of at least 2 to 3, conventional trenchless installation is not considered feasible as discussed further in Section 6.3.

Based on the information provided, open cut installation is considered feasible and is the preferred alternative if the culvert profile cannot be lowered to accommodate conventional trenchless installation. At this preliminary stage, it is envisaged that the twin culvert would be installed in stages with temporary lane closures and roadway protection systems required for the western half the installation below the existing Highway 11 NBL and SBL. The eastern half of the construction will require advanced embankment construction to the culvert subgrade such that the proposed new culvert can be constructed as part of new embankment widening, followed by completion of the grade raise above the culvert to complete the W-N Ramp embankment geometry and stormwater pond side-slope.

6.2 Design Considerations

6.2.1 Consequence and Site Understanding Classification

As Highway 11 and Highway 12 both carry a relatively large amount of traffic and both have the potential to impact alternative transportation corridors, a “typical consequence level” is considered appropriate for this project, as outlined in Section 6.5 of the *Canadian Highway Bridge Design Code* (CHBDC 2019) and its *Commentary*. Further, given the scope of work of this foundation investigation program, as presented in Sections 3.0 and 4.0 of this report, a “typical degree of site and prediction model understanding” has been assumed. Accordingly, the appropriate corresponding ULS and SLS consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} , from Tables 6.1 and 6.2 of the CHBDC have been used at this stage of design.

6.2.2 Seismic Design

The seismic hazard values associated with the design earthquakes are those established for the National Building Code of Canada (NBCC 2020) by the Geological Survey of Canada (GSC). The current seismic hazard maps (referred to as the 6th generation seismic hazard maps) were developed by the GSC and were made available for public use in December 2020.

6.2.2.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the current and surrounding foundation investigations for this project. Based on the energy-corrected average standard penetration resistance, \bar{N}_{60} , below the estimated founding level and assuming similar soils exist down to 30 m below the design founding level, the site may be classified as Site Class C “very dense soil” in accordance with Clause 4.4.3.2 and Table 4.1 of CHBDC (2019), in the absence of site-specific geophysical testing. The Site Class should be confirmed during detail design. In this regard, consideration could be given to carrying out geophysics testing such as Multi-Channel Analysis of Surface Waves (MASW) or vertical seismic profiling during detail design to confirm the site-specific shear wave velocity.

6.2.2.2 Spectral Response Values

In accordance with Section 4.4.3.1 of the CHDBC and based on the location of the proposed culvert, the peak seismic hazard values for Site Class C were obtained from the Earthquakes Canada website (www.earthquakescanada.nrcan.gc.ca) as referenced in the NBCC and are provided below.

Parameter	2% Probability of Exceedance in 50 Years (2,475-year return period) (g)
Sa(0.2)	0.217
Sa(0.5)	0.156
Sa(1.0)	0.090
Sa(2.0)	0.044
Sa(5.0)	0.012
Sa(10.0)	0.004
PGA	0.095
PGV [m/s]	0.101

The values given above should be checked and modified as appropriate if the Site Class changes during detailed design. The culvert should be designed in accordance with the latest version of the NBCC and CHBDC, and the more conservative approach used for design as applicable.

6.2.2.3 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”.

Based on the compactness of the soils at the proposed culvert location, the soils at this location are considered to have a low potential for liquefaction during a seismic event.

6.3 Assessment of Culvert Installation Options

It is understood that the proposed twin culvert will be replaced using either conventional open cut installation methods or conventional trenchless installation methods. A comparison of trenchless vs. open cut methods is provided in Table 1 and summarized below.

Trenchless installation is not considered feasible for the proposed centreline twin pipe culvert based on the geometry and details described in Section 6.1. Given that the soil cover to tunnel diameter ratio is about 0.6 at the southbound lanes, about 0.4 at the highway median, and about 1.1 at the northbound lanes, the limited amount of cover (0.5 m to 1.3 m thick) over the culvert poses significant high risk of ground movements and excessive soil loss that could lead to sinkholes or major depressions forming at the highway grade, especially when two separate culvert installations adjacent to each other is being considered. Advanced pretreatment of the ground (e.g. grouting) could be considered to reduce the risks associated with tunnelling, although lowering of the culvert profile is

considered to still be needed in order to make trenchless installation a feasible option. Given that the proposed trenchless installation will extend through existing embankment fill containing construction debris and rock fragments, and anticipated to contain cobbles and boulders, there is an additional risk that encountering these obstructions could deflect the installation away from the design alignment / profile, impede or halt the trenchless installation, and/or lead to over-excavation of soils below the travelled portion of the highway that could result in rapid formation of sinkholes / depressions prior to detection by any settlement monitoring plan.

Open cut / New Embankment installation is considered a feasible option for the proposed centreline twin pipe culvert, although staging and temporary lane closures will be required on Highway 11. Temporary protection systems are anticipated to be required and considered feasible in the existing soils and to the proposed excavation depths. The presence of rock fragments and potential construction debris in the fill and potential cobbles and boulders within the till deposits could be challenging and/or impede installation of the temporary protection systems. Therefore, use of appropriately sized equipment and guidance methods, pre-drilling and/or removal of localized obstructions may be required to facilitate installation of the temporary protection systems. The eastern half of the new culvert will be constructed on new engineered fill to be placed as part of the embankment widening and new stormwater pond configuration.

The following sections of the report provide foundation recommendations for open cut / new embankment installation of the twin circular pipe culvert. During detail design, consideration may be given to using other geometries such as box or arch culvert options provided sufficient foundation investigation and design is carried out by the design-build proponent. Given that trenchless installation is not considered feasible at this stage, no further discussion of trenchless installation is provided herein.

6.4 Open Cut / New Embankment Culvert Installation

6.4.1 Subgrade

Based on the information provided, the twin pipe culverts and associated bedding will be founded on the existing loose to dense silty sand fill for the western half of the installation and founded on new engineered fill for the eastern half of the installation. The existing silty sand fill is considered competent to support the new pipe culverts and associated bedding, provided any existing very loose / soft soils and any existing fills containing pockets of excessive organic materials or deleterious materials are removed and replaced with approved engineered fill.

The following table provides a summary of the anticipated founding subgrade soil along the length of the twin culvert based on the existing borehole information and concept drawings, and any anticipated sub-excavation requirements.

Location	Approximate Existing Ground Surface Elevation (m)	Design Invert Elevation (m)	Estimated Excavation Depth or Fill Thickness to Subgrade / Elevation ¹ (m)	Founding Subgrade Soil (Reference Borehole)	Estimated Sub-excavation Depth / Elevation (m)
Culvert Inlet and below Highway 11 SBL	256.2 to 258.1	256.2 to 256.1	Excavation 0.3 to 2.0 (255.9 to 255.8)	Loose to Compact Silty Sand Fill (CO5-1 & CO5-2)	-
Highway 11 Median	257.5 to 258.2	256.1	Excavation 1.9 to 2.4 (255.8)	Compact Silty Sand Fill (CO5-2 & CO5-3)	-
Highway 11 NBL	258.2 to 258.4	256.1 to 255.9	Excavation 2.4 to 2.8 (255.8 to 255.6)	Compact Silty Sand Fill (CO5-3)	-

Location	Approximate Existing Ground Surface Elevation (m)	Design Invert Elevation (m)	Estimated Excavation Depth or Fill Thickness to Subgrade / Elevation ¹ (m)	Founding Subgrade Soil (Reference Borehole)	Estimated Sub-excavation Depth / Elevation (m)
Between Highway 11 NBL and New W-N Ramp	258.3 to 254.7	255.9 to 255.8	Excavation 2.6 to 0.3 / Fill 0.3 to 3.3 (255.6 to 255.5)	Compact Silty Sand Fill / New Engineered Fill supported on Compact Silty Sand Fill (CO5-3)	-
New W-N Ramp / Pond Berm	254.7 to 251.5	255.8 to 255.7	Fill 0.0 to 3.9 (255.5 to 255.4)	New Engineered Fill supported on Compact Silty Sand Fill (CO5-4)	1.5 m (251.5 m) ²

¹ Assume pipe and bedding thickness of 0.3 m.

² Subexcavation recommended due to presence of topsoil and surficial silty sand fill containing organics within this high fill area within the culvert footprint.

The twin pipe culvert subgrade should be inspected to ensure that any loosened / softened soils, organic material, other unsuitable material have been removed. Where sub-excavation is required, the width of the sub-excavation area should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert bedding, projected outward and downward at 1H:1V. Sub-excavated areas should be backfilled with granular material meeting OPSS.PROV 1010 (Aggregates) Granular A, Granular B, or Select Subgrade Material placed and compacted in accordance with OPSS.PROV 501 (Compacting).

Typically, it is not necessary to found pipe culverts below the depth of frost penetration, as the pipes are generally tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur.

The eastern portion of the culvert will be founded on / within new engineered fill that is to be placed and compacted in general accordance with OPSS.PROV 206 (Grading) and OPSS.PROV 501 (Compacting). The new embankment fill should be benched into the existing embankment in general accordance with OPSD 208.010.

If the subgrade is to be left exposed and the culvert and embedment / cover soils are not placed on the same day, a 100 mm thick concrete working slab should be placed on the approved subgrade to protect it from degradation. The working slab should be placed within four hours after preparation, inspection and approval of the subgrade. An example NSSP for a working slab is provided in Appendix E.

6.4.2 Bedding and Cover / Embedment

Consideration can be given to using flexible or rigid pipe materials for the twin culvert installation, provided they are designed in general accordance with the MTO Gravity Pipe Design Guideline (MTO, 2014).

Pipe culverts are to be constructed in accordance with OPSS.PROV 421 (Pipe Culvert Installation in Open Cut) and OPSS.PROV 401 (Trenching, Backfilling, and Compacting). The bedding, embedment, and cover material should be placed and compacted in accordance with OPSS.PROV 501 (Compacting), as amended by Special Provision (SP) 105S22.

Circular, concrete pipe culverts installed by open cut method should be in accordance with Ontario Provincial Standard Drawing (OPSD) 802.031 (Rigid Pipe Bedding, Cover and Backfill in Excavation) and OPSD 802.034 (Rigid Pipe Bedding, Cover and Backfill in Embankment) for the western half (in excavation) and eastern half (in new embankment fill) of the installation, as applicable.

Circular, flexible pipe culverts consisting of Corrugated Steel Pipe (CSP) or plastic (HDPE or PVC) pipe installed by open cut method should be in accordance with OPSD 802.010 (Flexible Pipe Embedment and Backfill Earth Excavation) for Type 3 Soil and OPSD 802.014 (Flexible Pipe Embedment in Embankment) for the western half (in excavation) and eastern half (in new embankment fill) of the installation, as applicable.

It is recommended that the rigid or flexible pipe culverts be placed on a minimum thickness of 150 mm of granular bedding. The bedding material shall meet Ontario Provincial Standard Specification (OPSS.PROV) 1010 (Aggregates) Granular A or Granular B Type II.

6.4.3 Cover and Backfill

Based on the conceptual profile of the culvert, there will generally be about 1 m to 1.5 m of soil cover between the top of the pipes and highway / ramp ground surface. As a result, the cover and backfill soils will likely consist predominantly of the highway pavement structure. Where additional cover / backfill is required, it is recommended to use OPSS.PROV 1010 (Aggregates) Granular A or Granular B Type II soils.

As per the current conceptual plans, at the location between the Highway 11 NBL and the new W-N Ramp, the cover decreases to zero, such that the top of culvert is exposed. It is recommended that a minimum of 0.3 m of soil cover be provided at this location, and erosion protection be provided in general accordance with Section 6.6.5 of this report.

As per OPSS.PROV 401 (Trenching, Backfilling, and Compacting), native soils may also be used for cover and backfill in areas outside of the highway / ramp pavement structure. Based on the boreholes advanced at the site, the excavated cohesive and non-cohesive fills are considered geotechnically suitable for reuse as trench backfill, provided they are free of topsoil, organic material or other deleterious materials. If water contents of the site soils at the time of construction are too high, or if there is a shortage of suitable in-situ material, then an approved imported material which meets the requirements for OPSS.PROV 1010 (Aggregates) Select Subgrade Material (SSM) or Granular 'B' Type I could also be used.

The cover and backfill should be placed and compacted in accordance with OPSS.PROV 501 (Compacting). Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice, and backfilling with fine grained (i.e., silts and/or clays) materials should not be undertaken.

The culvert should be designed for the full overburden and hydrostatic pressures, and live load, assuming that the embankment fill has a unit weight of 22 kN/m³ for Granular A, 21 kN/m³ for Granular B Type II or 20 kN/m³ for select earth fill above and/or surrounding the culvert.

The design frost depth in the area is estimated to be 1.7 m below ground surface, as interpreted from OPSD 3090.101 (Frost Penetration Depths for Southern Ontario). To avoid undue differential movements of the ground surface adjacent to and over the trench due to frost action, the general backfill materials should match as practically as possible to the existing soils exposed in the trench walls between the design frost depth and the underside of the highway road subbase. If imported granular materials are used as backfill within the frost penetration depth, frost tapers should be provided between the design frost penetration depth and the underside of the subbase, in accordance with OPSD 803.031 / 803.030 (Frost Treatment – Pipe Culverts).

Settlement of the compacted trench backfill should be anticipated, and the majority of such settlement should take place within about 6 months following the completion of trench backfilling operations. This settlement will be reflected at the ground surface and may be compensated for, where necessary, by placing additional granular material as required. Alternatively, if the asphalt binder course is placed shortly following the completion of trench

backfilling operations in these areas, any settlement that may be reflected by subsidence of the surface of the binder asphalt should be compensated for by placing an additional thickness of binder asphalt or by padding.

6.5 Settlement and Global Stability

As previously mentioned, the proposed twin culvert will be located below the proposed E/W-S Ramp which is anticipated to be less than 1 m high, below the existing Highway 11 NBL and SBL where no change in grade is proposed, and below the proposed east embankment widening (to accommodate the W-N Ramp and Pond A) which is anticipated to be up to a 6 m grade raise. Based on the concept drawing and proposed works, the settlement and global stability of the embankment at the proposed twin culvert location was assessed at this preliminary stage.

6.5.1 Parameter Selection

The foundation engineering parameters for the existing soil encountered in the boreholes near the culvert location and for the proposed new engineered fill that will support the new culvert along the eastern half of the alignment, used in the settlement and stability analyses, are presented in the table below. The parameters were determined based on correlations with the SPT 'N'-values, published literature and engineering judgement from experience with similar soils in this region of Ontario. The groundwater level used in the analyses was taken to be at Elevation 257.0 m as measured in Borehole CO5-2 located within the existing highway embankment, and consistent with the proposed approximate culvert invert elevation. For the settlement and stability analyses, it is assumed that all loosened / softened soils, topsoil, and soils containing excessive organics or deleterious materials have been removed below the footprint of the proposed new embankment widening and replaced with new engineered fill.

Idealized Stratigraphy	Unit Weight (kN/m ³)	Friction Angle (degrees)	Modulus of Deformation, E (MPa)
New Engineered Fill (Granular A or B Type II)	21 – 22	35	-
New Engineered Fill (Select Subgrade Material)	20	33	35
Existing Silty Sand Fill (loose to very dense)	20	31	12
Sandy Clayey Silt to Silt Till (stiff to hard / dense to very dense)	21	35	100
Gravelly Silty Sand Till (dense to very dense)	21	35	100
Silt to Silty Sand (very dense)	20	35	75

6.5.2 Settlement Results

The proposed E/W-S Ramp (at the culvert inlet) will consist of raising the existing site grade less than 1 m. Given the proposed culvert pipe diameter is about 1 m, settlement at the west highway widening / culvert inlet is considered negligible as the net loading would be zero.

The proposed W-N Ramp and Pond A (at the eastern portion of the culvert and near the outlet) will consist of raising the existing site grade by up to 6 m, with the proposed W-N Ramp grade at about Elevation 258.4 m to 258.9 m and the proposed Pond A top of berm at Elevation 257.3 m. The culvert will be founded about 3.0 m below the highest embankment grade (at the new W-N Ramp) and will have minimal cover at the outlet into the stormwater pond. The estimated maximum settlement is anticipated to be about 20 mm below the new W-N Ramp.

Considering the existing Highway 11 NBL / SBL embankment will not be raised, the differential settlement along the proposed culvert is estimated to range from 0 mm (below the existing highway embankment) to about 20 mm (below the new W-N ramp embankment), over a distance of about 5 m.

The majority of the estimated settlement is expected to occur during or shortly after construction of the embankment. Based on the MTO Embankment Settlement Criteria for Design (MTO, 2010), settlement mitigation measures are not anticipated to be required. Conventional culvert pipe material and joints are anticipated to be able to accommodate the estimated differential settlements and must be checked and confirmed during detail design.

6.5.3 Global Stability Results

A global stability analysis was carried out at the proposed culvert inlet and outlet. Two-dimensional limit equilibrium slope stability analyses were performed using the commercially available program Slide2 (Version 9.017), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factors of Safety of numerous potential failure surfaces were computed to establish the minimum Factor of Safety. The Factor of Safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. For the purpose of the stability analyses, the Factor of Safety is equal to the inverse of the product of the consequence factor, Ψ , and the geotechnical resistance factor, ϕ_{gu} . (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$) as defined in the CHBDC (2019).

A minimum Factor of Safety of 1.5 has been targeted for the design of the proposed permanent embankment side slopes for long-term (drained) conditions as per Table 6.2 of the CHBDC, 2019. The temporary (undrained) condition was not assessed at this preliminary stage given the majority of soils are sandy and generally considered non-cohesive. Temporary conditions should be checked during detail design when staging and geometry is known.

The stability analyses results indicate the proposed E/W-S ramp embankment, up to 2 m high and inclined at 3H:1V, and the proposed W-N ramp embankment, up to 4.0 m high above base of Pond A and inclined at 2H:1V meet the target minimum factor of safety. The results of the stability analyses are presented on Figures D-1 and D-2 in Appendix D.

During detailed design, the static global stability should be checked and any seismic analyses performed as applicable. Additionally, a global stability analysis at the W-N ramp embankment (near the proposed culvert outlet) should be carried out during detailed design to consider the effects of rapid drawdown that may be experienced at Pond A (e.g. during future pond maintenance).

6.6 Construction Considerations

6.6.1 Groundwater / Surface Water Control During Construction

Although the measured stabilized groundwater level (as measured in the standpipe piezometer in Borehole CO5-4) is below the proposed excavation depths, perched groundwater above the till layer and within the existing fill (as observed in Boreholes CO5-2 and CO5-3) is anticipated. Given the permeable nature of the fill, dewatering is anticipated to be required to facilitate construction in dry conditions for open cut construction.

The Contractor is responsible for all dewatering requirements, which depends on their chosen methods of design, permitting, construction, operation, maintenance and decommissioning. The contractor is also responsible for confirming that the radius of groundwater drawdown does not impact the existing highway embankment and any surrounding features. It is recommended that the groundwater level at the site be assessed / measured closer to the time of construction, in order for the contractor to assess the dewatering / surface water infiltration flow dewatering and/or diversion requirements during construction. It is noted that the existing stormwater drainage system at the site consists of a median drainage ditch (filled with rip-rap), drainage ditches at the west and east toes of the existing embankment, and lateral storm sewers (grates and pipe network) at the east and west shoulders of the current highway.

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 and stormwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MECP Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a PTTW for water taking and a Section 53 approval for discharge of water to the environment. A "Water Taking Plan" and a "Discharge Plan" are required by the MECP if water is taken in accordance with an EASR. In all cases, discharge under the EASR must be in accordance with a Discharge Plan (to be developed by qualified professional). The Contractor will be responsible for obtaining any required discharge approvals and EASR registration. A Category 3 PTTW would be required for water takings in excess of 400,000 L/day.

Dewatering operations must be in accordance with OPSS.PROV 517 (Dewatering) and MTO's SP 517F01 (Temporary Flow Passage System). Provided adequate flow diversion is provided, limited dewatering efforts are anticipated to be required for construction at this site. Referring to the fill-ins in SP 517F01, a preconstruction survey is not considered to be required for this work. It is recommended that the design engineer have a minimum of 5 years' experience in designing systems of similar nature and scope to the required work and therefore the fill-in in Table A should indicate "Yes" for the "Design Engineer Requirements". The remaining fill-ins of Special Provision 517F01 should be provided by the drainage engineer. A copy of SP 517F01 with the geotechnical related fill-ins is provided in Appendix E.

Surface water should be directed away from all excavation areas, to prevent ponding of water that could result in disturbance and weakening of the subgrade soils. Any existing drainage paths / ditches will need to be diverted around the proposed excavation footprints to reduce surface infiltration / seepage.

6.6.2 Excavations

Temporary excavations for open cut culvert installation will extend through the very loose to very dense existing silty sand to silty sand and gravel fill and potentially into the underlying stiff to hard / dense to very dense glacial till soils.

All excavations must be carried out in accordance with Ontario Regulation 213 of the Ontario Occupational Health and Safety Act for Construction Projects (OHSA), as amended. According to the OHSA, the overburden soils above the groundwater level are classified as Type 3 and the overburden soils below the groundwater level are classified as Type 4. Unsupported temporary excavations within Type 3 soils should be made with side slopes no steeper than 1 Horizontal: 1 Vertical (1H:1V) and unsupported temporary excavations within Type 4 soils should be made with side slopes no steeper than 3H:1V. However, depending upon the construction procedures, season of year, weather conditions and groundwater seepage conditions at the time of construction / excavation, some local flattening of the slopes may be required, especially in looser zones or where localized seepage is encountered. Permanent excavations should be in accordance with OPSS.PROV 206 (*Grading*).

All excavated material should be stockpiled away from the sides of the excavation as per the OHSA. Care must also be taken during excavation to ensure that adequate support is provided for any existing structures, roadways and underground services located adjacent the excavation.

6.6.3 Temporary Protection Systems

Temporary protection systems will be required to facilitate staged open cut installation within and adjacent to the existing Highway 11 embankment. The selection and design of the temporary protection systems will be the responsibility of the Contractor. The temporary protection systems should be designed and constructed in

accordance with OPSS.PROV 539 (Temporary Protection Systems), as amended by SP 105S09. As a general guide, the lateral movement should meet Performance Level 2 within the highway and near any active ramps or traffic, and the performance level may need to be enhanced if adjacent utilities / operations cannot tolerate this magnitude of deformation.

For conceptual design purposes, either a driven, interlocking sheetpile system or a soldier pile and timber lagging system would be suitable at the twin culvert site, based on the subsurface soil and groundwater conditions and anticipated excavation depth up to 3 m below the existing highway grade. The presence of cobbles / boulders / gravelly soils within the fill and till could impede installation of the temporary protection systems, although pre-drilling and/or removal of localized obstructions to facilitate construction of the temporary protection systems is considered feasible. An interlocking sheetpile system would contribute to both ground and perched groundwater control. For the soldier pile and lagging system, it would be necessary to lower the groundwater level perched within the fill to control seepage from the non-cohesive fill, or include measures to mitigate loss of soil particles through the lagging boards.

Temporary protection systems may be designed using the soil parameters provided in the table below. The system must be designed to accommodate the loads applied from earth pressures, water pressures and surcharge pressures from area, line or point loads, as well as the effects of sloping ground behind the system. The loading from construction equipment as well as any material stockpiles within a distance defined by a 1H:1V line drawn from the bottom of the excavation to the existing ground surface should be included as a surcharge in the design of the temporary protection system.

Stratigraphy	γ (kN/m ³)	ϕ' (°)	K_o	K_a	K_p
Existing Silty Sand to Silty Sand and Gravel Fill (very loose to very dense)	20	31	0.48	0.32	3.12
Sandy Clayey Silt to Clayey Silt-Silt / Silt Till to Gravelly Silty Sand Till (stiff to hard / dense to very dense)	21	35	0.43	0.27	3.69
Silt to Silty Sand (very dense)	20	35	0.43	0.27	3.69

The geotechnical design parameters are defined as follows:

- γ = bulk unit weight ($\frac{\text{kN}}{\text{m}^3}$)
- ϕ' = effective (drained) friction angle (°)
- K_a = active earth pressure coefficient
- K_p = passive earth pressure coefficient
- K_o = earth pressure coefficient at rest

6.6.4 Obstructions

The Design-Build Contractor should be alerted to the potential presence of cobble and boulder obstructions within the existing fill and native soils as noted on the borehole records. The potential presence of cobble and boulder obstructions has been inferred based on the presence of rock fragments within the collected soil samples and several instances of auger grinding and split-spoon refusal. Further, glacially derived till deposits, such as those encountered at this site, should be expected to contain coarse gravel, cobbles and/or boulders. Note that the extent and depth of the cobble and boulder obstructions may vary beyond and between the borehole locations.

The presence of obstructions (i.e., cobbles and/or boulders) may affect excavation operations and installation of temporary protections systems. The Design-Build Contractor must be prepared with suitable equipment and procedures to remove/penetrate through any obstructions that may be encountered during construction.

6.6.5 Erosion Protection

To prevent surface water from flowing either beneath the twin culvert (potentially causing undermining and scouring) or around the culverts (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a concrete headwall and cut-off wall, a clay seal, or a combination thereof should be considered at the culvert inlets and outlets. However, the final decision on the requirement for a concrete headwall / cut-off wall and/or clay seal at the culvert inlet and outlet should be made by the hydraulic design engineer.

If a concrete cut-off wall is required, it should extend from the near the bottom of the culvert to below the design scour level (minimum 1.2 m), for at least one diameter either side and between the culverts. The concrete cut-off wall should be founded on a minimum 100 mm thick granular pad comprised of OPSS 1010 (Aggregates) Granular "A" and should be similar to OPSD 804.040 (Concrete Headwall for Sewer or Culvert Pipe Outlet).

If a clay seal is considered, it should extend from the high-water level to below the scour level (minimum 1.2 m) and extend a minimum horizontal distance of 2 m on either side and between the twin culvert inlet opening. The clay seal material should meet the requirements of OPSS.PROV 1205 (Clay Seal) and have a thickness of 1 m.

The requirements for and design of erosion protection measures for the culvert inlet and outlet should be assessed by the hydraulic design engineer. However, as a minimum, rip-rap treatment for the culvert outlet should be consistent with the standard Treatment Type A presented in OPSD 810.010 (Rip-Rap Layout for Sewer and Culvert Outlets), with the rip-rap placed up to the top of culvert level.

6.6.6 Construction Materials Based on Analytical Testing

The results of analytical testing completed on one soil sample are summarized in Section 4.3 and presented in Appendix C. The potential for sulphate attack and corrosion are discussed below. However, it is the responsibility of the culvert designer to determine the appropriate construction materials, including the exposure class and ensuring that all aspects of CSA A23.1-24 Section 4.1.1 "*Durability Requirements*" are followed when designing concrete elements.

The potential for sulphate attack on concrete was determined by comparing analytical test results to CSA A23.1-14 Table 3 "*Additional Requirements for Concrete Subjected to Sulphate Attack*". The water-soluble sulphate concentration measured in the soil sample is below 0.1%, which is below the exposure class of S-3 (Moderate) and is considered "Negligible" as per Table 7.2 of the MTO Gravity Pipe Guidelines (2014). Therefore, based on the test results from the sample, the effects of the sulphates may not need to be considered when the designer is selecting the exposure class for the structure. However, consideration should be given to the de-icing salts which may be used on the highway when selecting the exposure class and cement type.

The soil samples measured a pH value 8.0 and a resistivity of 800 ohm-cm. According to the MTO Gravity Pipe Guidelines, the pH is not considered detrimental to concrete, steel or plastic durability. The resistivity results indicate that the soil corrosiveness is generally "Severe" ($R < 2,000$ ohm-cm), as per Table 3.2 "*Soil Corrosiveness and Resistivity*" of the MTO Gravity Pipe Guidelines (2014), and an appropriate class concrete and/or adequate steel pipe design should be used to meet durability requirements, as applicable.

6.6.7 Piezometer Decommissioning

A piezometer was installed in Borehole CO5-4 to monitor the groundwater levels at the location of the culvert. The piezometer has been left in place to allow the Design-Build Contractor to obtain additional groundwater level readings during the detailed design stage and prior to / during construction. The existing standpipe piezometer shall be decommissioned by the Design-Build Contractor according to applicable law (O. Reg. 903, as amended) following the initial works.

7.0 CLOSURE

The Foundation Design Report was prepared by Ms. Anastasia Poliacik, P.Eng., a Senior Geotechnical Engineer with WSP and MTO Principal Foundations Contact. Mr. Kevin Bentley, P.Eng., a Senior Principal with WSP and MTO Principal Foundations Contact for Tunnelling conducted an independent technical and quality review of this report.

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[https://wsonline.sharepoint.com/sites/gld-120052/project files/6 deliverables/2. reporting/10 - culvert/5. final/19135676-r-rev0_culvert obr fidr 10apr2024.docx](https://wsonline.sharepoint.com/sites/gld-120052/project%20files/6%20deliverables/2.%20reporting/10%20-%20culvert/5.%20final/19135676-r-rev0_culvert%20obr%20fidr%2010apr2024.docx)

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- Canadian Standard Association (CSA) Group. *Canadian Highway Bridge Design Code (CHBDC (2019)) and Commentary on CAN/CSA-S6:19*.
- MTO, July 2, 2010. *Embankment Settlement Criteria for Design*.

Ontario Provisional Standard Drawings (OPSD)

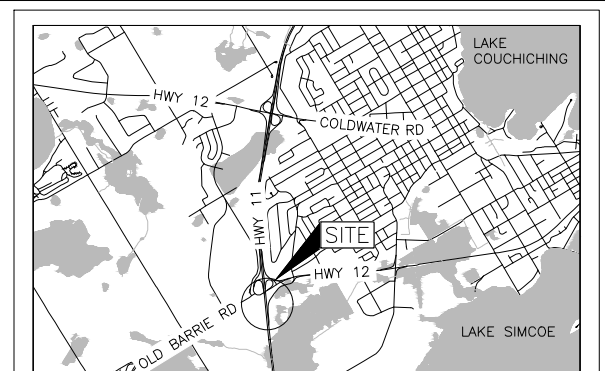
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 802.014	Flexible Pipe Embedment in Embankment
OPSD 802.031	Rigid Pipe Bedding, Cover and Backfill in Excavation
OPSD 802.034	Rigid Pipe Bedding, Cover and Backfill in Embankment
OPSD 803.030	Frost Treatment – Pipe Culverts Frost Penetration Line Below Bedding Grade
OPSD 803.031	Frost Treatment – Pipe Culverts Frost Penetration Line Between Top of Pipe and Bedding Grade
OPSD 804.040	Concrete Headwall for Sewer or Culvert Pipe Outlet
OPSD 810.010	Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS.PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1010	Material Specification for Aggregates
OPSS.PROV 1205	Material Specification for Clay Seal

Ontario Water Resources Act

Ontario Regulation 903 Wells (as amended)



LEGEND	
	Borehole - Current Investigation

Design plan provided in digital format by McIntosh Perry, drawing file no. 197147-c2_hwy 011_-dph-ncp-interim.dwg, received November 30, 2023.
Drainage plan in digital format by EGIS, drawing file no. 2494-15_c2_Hwy 11_ south _cuvliert -Crosssection v2.dwg, received February 21, 2024.
Base plan provided in digital format by McIntosh Perry, drawing file no. x_197147_BASE.dwg, received May 19, 2021.

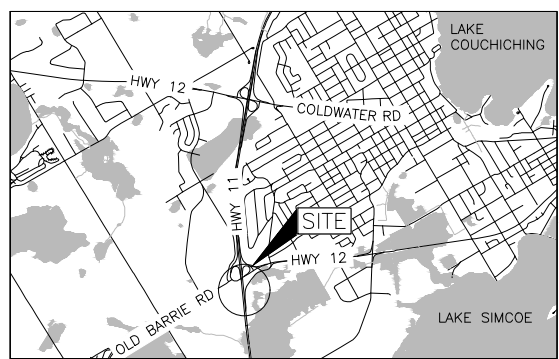
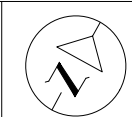
NO.	DATE	BY	REVISION
Geocres No. 31D11-005			
HWY. 11 AND 12		PROJECT NO. 19135676	DIST. .
SUBM'D. MH	CHKD. MH	DATE: 04/10/2024	SITE:
DRAWN: DD/ZS/SA	CHKD. AMP	APPD. KJB	DWG. 1

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

CONT No. .
GWP No. 2129-18-00

HIGHWAY 11/12 INTERCHANGE
TWIN CULVERT

SOIL STRATA



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 January 19, 2024
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD 83 MTM ZONE 10

No.	ELEVATION	NORTHING	EASTING
C05-1	260.0	4938777.3	309057.9
C05-2	259.0	4938789.6	309073.1
C05-3	259.2	4938772.6	309083.4
C05-4	253.0	4938767.3	309109.8

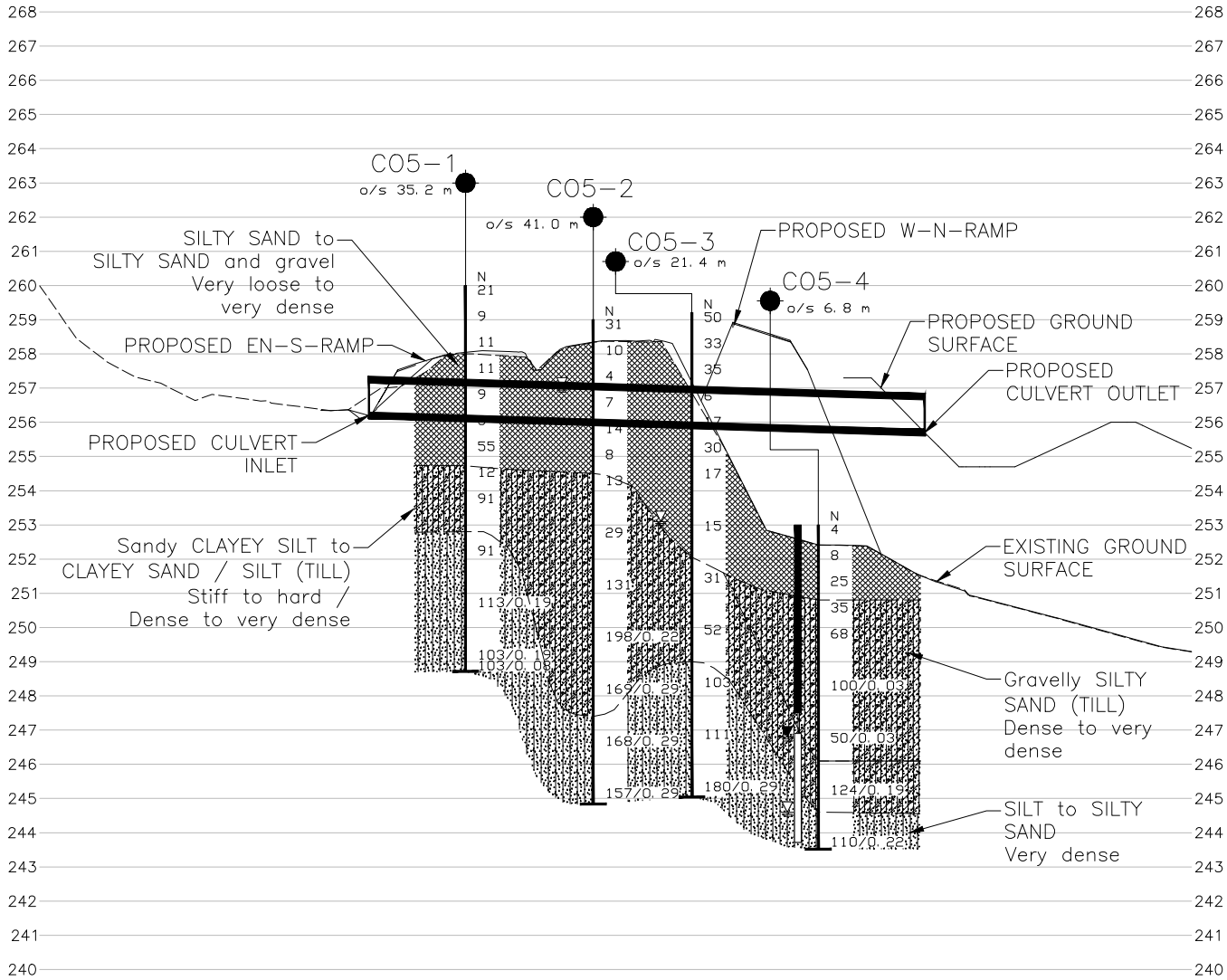
NOTES

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.

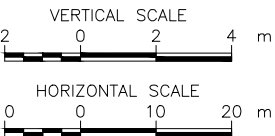
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Design plan provided in digital format by McIntosh Perry, drawing file no. 197147-c2_hwy011_dph-ncp-interim.dwg, received November 30, 2023.
Drainage plan in digital format by EGIS, drawing file no. 2494-15_c2_Hwy 11_ south _culvert -Crosssection v2.dwg, received February 21, 2024.
Base plan provided in digital format by McIntosh Perry, drawing file no. x_197147_BASE.dwg, received May 19, 2021.
Proposed culvert plan and profile provided by EGIS, drawing file no. x_drainage_plan_v4.dwg, received February 21, 2024.



PROFILE A-A'



NO.	DATE	BY	REVISION
1	04/10/2024	DD/ZS/SA	PROJECT NO. 19135676
2	04/10/2024	CHKD. AMP	DIST. .
3	04/10/2024	APPD. KJB	SUBM'D. MH
4	04/10/2024		CHKD. MH
5	04/10/2024		DATE: 04/10/2024
6	04/10/2024		SITE:
7	04/10/2024		DWG. 2

Table 1 - Comparison of Open Cut vs. Trenchless Installation Methods

Foundation Option	Feasibility	Advantages	Disadvantages	Risks
Open Cut	Feasible	<ul style="list-style-type: none"> ■ Risks of ground losses affecting traffic are better controlled than for the trenchless method. ■ Excavations are less than about 3 m depth and are therefore within typical limits for conventional excavation support for open-cut, using common construction methods. ■ Equipment and skilled construction force available. ■ Less expensive than trenchless installations. ■ Obstructions could be removed with conventional equipment, if encountered. 	<ul style="list-style-type: none"> ■ Traffic disruption (staging of crossing construction). ■ Roadway protection will be required for staged excavation. 	<ul style="list-style-type: none"> ■ Delays in construction could increase length of time for traffic disruptions (increased cost). ■ Low risk of differential settlements being a concern between the length of new culvert installed below the existing embankment and the length of new culvert installed below the new/widened embankment.
Trenchless	Not Feasible	<ul style="list-style-type: none"> ■ Minimal traffic disruption; however limited soil cover results in high risk of settlement / sink holes on highway and danger to public. 	<ul style="list-style-type: none"> ■ Not feasible using conventional utility tunnelling methods due to limited soil cover. ■ Unconventional methods using pretreatment of ground and advanced tunnelling techniques are marginally feasible and would result in higher costs. ■ Inadequate soil cover below existing Highway 11 unless profile can be lowered significantly, which is likely not feasible for gravity flow system. 	<ul style="list-style-type: none"> ■ Risk of ground losses and sudden formation of sinkholes / settlement leading to highway closure and danger to travelling public. ■ Risk is "doubled" with a twin culvert crossing. ■ Obstructions (if encountered) can misalign, impede or halt bore. ■ Potential for differential settlements between the length of the trenchless culvert installed below the existing embankment and the open cut culvert installation on new/widened embankment.

APPENDIX A

Record of Borehole Sheets

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	19 to 75	0.75 to 3
	Fine	4.75 to 19	(4) to 0.75
		2.00 to 4.75	(10) to (4)
SAND	Coarse	0.425 to 2.00	(40) to (10)
	Medium	0.075 to 0.425	(200) to (40)
	Fine		
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>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , 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 cm² 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, G _s)
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

Compactness¹

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 grain size. 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.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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

I. GENERAL

π	3.1416
$\ln x$	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)

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

III. SOIL PROPERTIES

(a) Index Properties

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

* 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
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	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 $= \tan \delta$
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
2

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



PROJECT		19135676		RECORD OF BOREHOLE No C05-1		SHEET 1 OF 1		METRIC								
G.W.P.		2129-18-00		LOCATION		N 4938777.3; E 309057.9 MTM NAD 83 ZONE 10 (LAT. 44.588990; LONG. -79.446374)		ORIGINATED BY KR								
DIST		Central HWY 11/12		BOREHOLE TYPE		203 mm O.D. Hollow Stem Augers		COMPILED BY ML								
DATUM		Geodetic		DATE		November 20, 2023		CHECKED BY AMP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
260.0	GROUND SURFACE															
0.0	SILTY SAND (SM), some gravel, trace clay (FILL) Very loose to very dense Brown Moist to wet		1	SS	21											
			2	SS	9											
			3	SS	11											
			4	SS	11											
			5	SS	9											
			6	SS	3											
	- Containing organics below 4.6 m depth		7	SS	55											
254.7																
5.3	Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL) Stiff to hard Greyish brown Moist		8	SS	12											
			9	SS	91											
252.8																
7.2	SILT (ML), trace to some sand Very dense Greyish brown Moist to wet		10	SS	91											
			11	SS	113/0.19											
			12	SS	103/0.19											
			-	-	103/0.08											
248.7																
11.3	END OF BOREHOLE															
	NOTE: 1. Borehole open and dry upon completion of drilling and removal of augers.															



PROJECT		19135676		RECORD OF BOREHOLE No C05-2		SHEET 1 OF 2		METRIC					
G.W.P.		2129-18-00		LOCATION		N 4938789.6; E 309073.1 MTM NAD 83 ZONE 10 (LAT. 44.589101; LONG. -79.446183)		ORIGINATED BY KR					
DIST		Central HWY 11/12		BOREHOLE TYPE		203 mm O.D. Hollow Stem Augers		COMPILED BY ML					
DATUM		Geodetic		DATE		November 13 to 14, 2023		CHECKED BY AMP					
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL		
259.0	GROUND SURFACE												
0.0	ASPHALT (150 mm)												
0.2	SILTY SAND (SM) and gravel, trace clay, containing asphalt fragments (FILL)		1	SS	31								
258.3	Dense Brown Moist		2	SS	10	258					17 53 24 6		
0.7	SILTY SAND (SM) some gravel, trace clay, containing rock fragments. (FILL) Loose to compact Brown Moist to wet		3	SS	4	257							
			4	SS	7								
			5	SS	14	256					14 48 30 8		
			6	SS	8	255							
254.5	CLAYEY SAND (SC), trace gravel (TILL) Stiff to hard Grey Moist		7	SS	13	254							
4.5	- Auger grinding from 5.5 m to 5.8 m depth (Elev. 253.5 m to 253.2 m)		8	SS	29	253					15 43 29 13		
			9	SS	131	252							
250.4	Sandy CLAYEY SILT (CL), trace gravel (TILL) Hard Grey Moist		10	SS	198/0.22	250					1 22 60 17		
8.6	- Auger grinding from 10.1 m to 10.5 m depth (Elev. 248.9 m to 248.5 m)		11	SS	169/0.29	249							
247.4	SILTY SAND (SM), trace gravel, trace clay Very dense Grey Moist to wet		12	SS	168/0.29	248							
11.6			13	SS	157/0.29	247							
244.8	END OF BOREHOLE					246					6 73 18 3		
14.2						245							

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

GTA-MTO 001 R:\ONTARIO\SIMCLIENTS\IMTOHWY_11&12_OLD_BARRIE_RD_TO_COLDWATER_RD\02_DATA\GINTHWY_11&12_OLD_BARRIE_RD_TO_COLDWATER_RD.GPJ GAL-GTA.GDT 4/10/24

GTA-MTO 001 R:ONTARIO\SIMCLIENTS\MTOWHY 11&12 OLD BARRIE RD TO COLDWATER RD.GPJ GAL-GTA.GDT 4/10/24

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



PROJECT		19135676		RECORD OF BOREHOLE No C05-3		SHEET 1 OF 2		METRIC									
G.W.P.		2129-18-00		LOCATION		N 4938772.6; E 309083.4 MTM NAD 83 ZONE 10 (LAT. 44.588948; LONG. -79.446054)		ORIGINATED BY		MN							
DIST		Central HWY 11/12		BOREHOLE TYPE		203 mm O.D. Hollow Stem Augers		COMPILED BY		ML							
DATUM		Geodetic		DATE		November 15 to 16, 2023		CHECKED BY		AMP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
								20 40 60 80 100				10 20 30					
								20 40 60 80 100									
259.2	GROUND SURFACE																
0.0	ASPHALT (255 mm)																
0.3	SILTY SAND (SM) and gravel, trace clay, containing asphalt fragments. (FILL)		1	SS	50											36 46 14 4	
258.5	Very dense Brown Moist		2	SS	33												
0.7	SILTY SAND (SM), some gravel, trace to some clay, containing rock fragments (FILL)		3	SS	35												
	Loose to dense Brown to greyish brown Moist		4	SS	6												
			5	SS	17											19 45 25 11	
			6	SS	30												
			7	SS	17												
			8	SS	15												
252.1	Sandy SILT (ML), some clay, trace gravel (TILL)		9	SS	31											5 31 49 15	
7.1	Dense to very dense Brown Moist		10	SS	52												
249.0	SILT (ML) some sand, trace clay		11	SS	103												
10.2	Very dense Brown Wet		12	SS	111												
			13	SS	180/0.29											0 17 81 2	
245.0	END OF BOREHOLE																
14.2																	

Continued Next Page

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



PROJECT 19135676		RECORD OF BOREHOLE No C05-3				SHEET 2 OF 2		METRIC					
G.W.P. 2129-18-00		LOCATION N 4938772.6; E 309083.4 MTM NAD 83 ZONE 10 (LAT. 44.588948; LONG. -79.446054)				ORIGINATED BY MN							
DIST Central HWY 11/12		BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers				COMPILED BY ML							
DATUM Geodetic		DATE November 15 to 16, 2023				CHECKED BY AMP							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	--- CONTINUED FROM PREVIOUS PAGE ---												
	NOTE: 1. Water level measured in open borehole at a depth of about 6.1 m below ground surface (Elevation 253.1 m) upon completion of drilling and removal of augers.												

GTA-MTO 001 R:\ONTARIO\SMCLIENTS\IMTOHWY_11&12_OLD_BARRIE_RD_TO_COLDWATER_RD\02_DATA\GINTHWY_11&12_OLD_BARRIE_RD_TO_COLDWATER_RD.GPJ GAL-GTA.GDT 4/10/24



PROJECT		19135676		RECORD OF BOREHOLE		No C05-4		SHEET 1 OF 1		METRIC							
G.W.P.		2129-18-00		LOCATION		N 4938767.3; E 309109.8 MTM NAD 83 ZONE 10 (LAT. 44.588900; LONG. -79.445721)		ORIGINATED BY		KR							
DIST		Central HWY 11/12		BOREHOLE TYPE		110 mm ID / 210 mm OD Hollow Stem Augers		COMPILED BY		ML							
DATUM		Geodetic		DATE		November 24 to 27, 2023		CHECKED BY		AMP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
253.0	GROUND SURFACE																
0.0	TOPSOIL (225 mm)																
0.2	SILTY SAND (SM), trace gravel, trace clay, containing organics and rock fragments (FILL) Loose to compact Brown Moist		1	SS	4												
			2	SS	8												
	- Augers grinding above 1.5 m depth		3	SS	25												
250.8	Gravelly SILTY SAND (SM), trace clay, containing rock fragments (TILL) Dense to very dense Brown Moist to wet		4	SS	35												
2.2			5	SS	68												
	- Augers grinding between 3.8 m and 4.1 m depth.		6	SS	100/0.03												
	- Wet below 6.1 m depth		7	SS	50/0.03												
246.1	SILT (ML) some gravel, some sand, some clay (TILL) Very Dense Brown Moist		8	SS	24/0.19												
6.9																	
244.6	SILTY SAND (SM), trace clay Very dense Brown Moist																
8.4																	
243.5	END OF BOREHOLE		9	SS	10/0.22												
9.5																	
NOTES:																	
1. Water level measured in open borehole at a depth of about 8.4 m below ground surface (Elevation 244.6 m) upon completion of drilling (November 26, 2023).																	
3. Water measured in piezometer as follows:																	
Date Depth (m) Elev. (m)																	
27-Nov-23 7.8 245.2																	
19-Jan-24 6.2 246.8																	

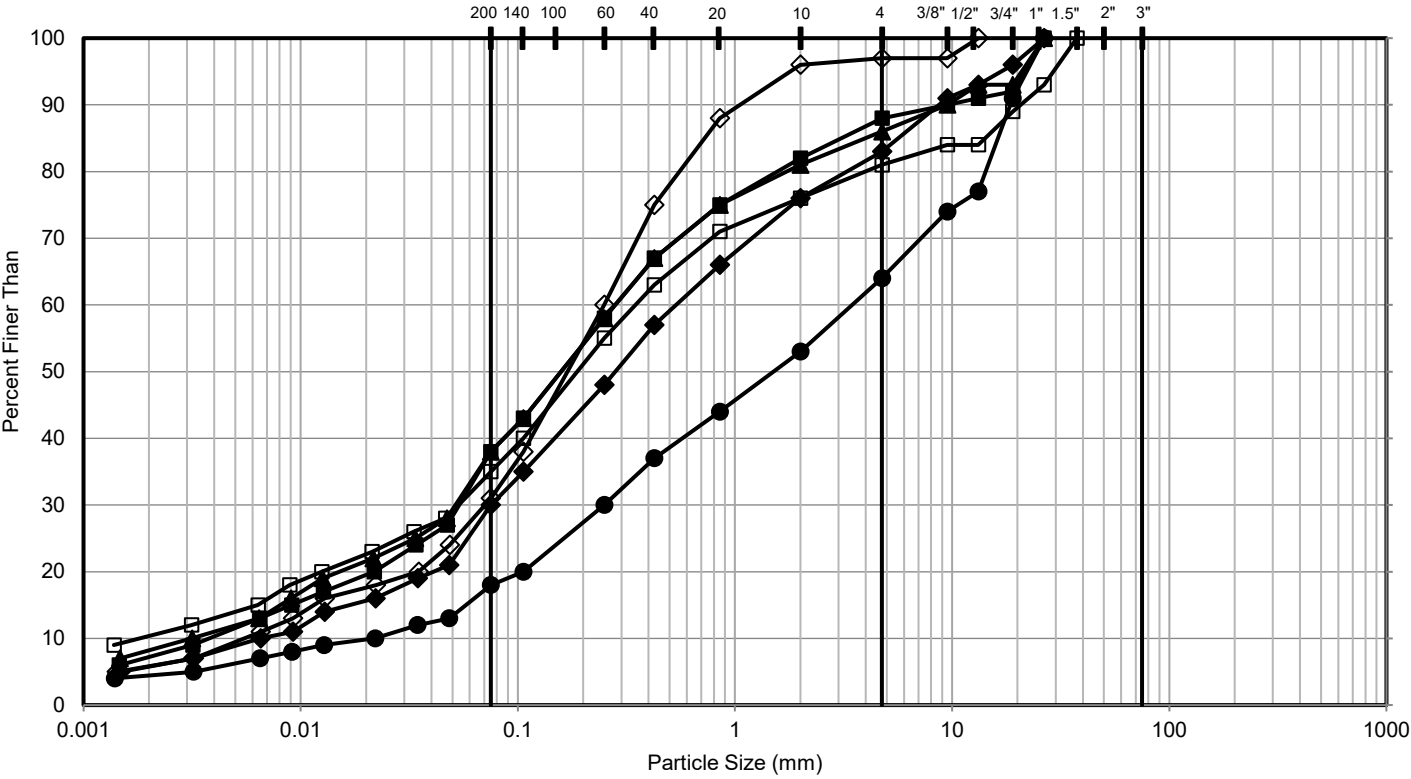


PROJECT		19135676		RECORD OF BOREHOLE No C05-5				SHEET 1 OF 1		METRIC									
G.W.P.		2129-18-00		LOCATION				N 4938765.4; E 309160.8 MTM NAD 83 ZONE 10 (LAT. 44.588883; LONG. -79.445079)				ORIGINATED BY		KR					
DIST		Central		HWY		11/12		BOREHOLE TYPE				110 mm ID / 210 mm OD Hollow				COMPILED BY		ML	
DATUM		Geodetic		DATE		November 23 to 24, 2023		CHECKED BY				AMP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L				
249.0	GROUND SURFACE																		
0.0	TOPSOIL (305 mm)																		
248.7			1	SS	24														
248.3	SILTY SAND (SM), some gravel, some clay, containing cobbles (FILL)		2	SS	14														
0.7	Compact Brown Moist																		
246.8	CLAYEY SILT-SILT (CL-ML) some sand, trace gravel, containing organics and rock fragments (FILL)		3	SS	8														
2.2	Stiff Brown Moist to wet		4	SS	51														
	SILT (ML), trace to some sand, trace to some clay, trace gravel		5	SS	101														
	Very dense Brown Moist to wet		6	SS	104/0.25														
			7	SS	87														
243.4	SILTY SAND (SM), trace clay		8	SS	100														
5.6	Very dense Brown Moist to wet																		
	- Wet below 7.6 m depth		9	SS	67														
	- About 0.3 m of sand heave was measured inside the augers after drilling to 9.1 m depth		10	SS	29*														
	- About 1.1 m of sand heave was measured inside the augers after drilling to 10.7 m depth		-	-	88*														
237.7	END OF BOREHOLE																		
11.3	NOTES:																		
	1.*Indicates "N" value may be disturbed due to sand heave.																		
	2. Water level measured inside augers at a depth of 11.3 m below ground surface (Elev. 237.7 m) upon completion of drilling.																		
	3. Water level and cave measured at depths of 7.1 m and 7.7 m below ground surface, (Elev. 241.9 m and 241.3 m), respectively, upon completion of drilling and removal of augers.																		

APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION



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

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	CO5-1	3	1.5 - 2.1	258.5 to 257.9
◆	CO5-2	2	0.8 - 1.4	258.3 to 257.7
▲	CO5-2	5	3.0 - 3.7	256.0 to 255.4
●	CO5-3	1	0.0 - 0.6	259.2 to 258.6
□	CO5-3	5	3.0 - 3.7	256.2 to 255.6
◇	CO5-4	2	0.8 - 1.4	252.2 to 251.6

CLIENT

MCINTOSH PERRY / MINISTRY OF TRANSPORTATION
ONTARIO (MTO)

CONSULTANT



YYYY-MM-DD 2024-01-23

DESIGNED ML

PREPARED ML

REVIEWED AMP

APPROVED KJB

PROJECT

HIGHWAY 11/12 (OLD BARRIE ROAD)
CENTRELINE TWIN CULVERT

TITLE

Grain Size Distribution - SILTY SAND (SM) (FILL)

PROJECT NO.

19135676

CONTROL

0

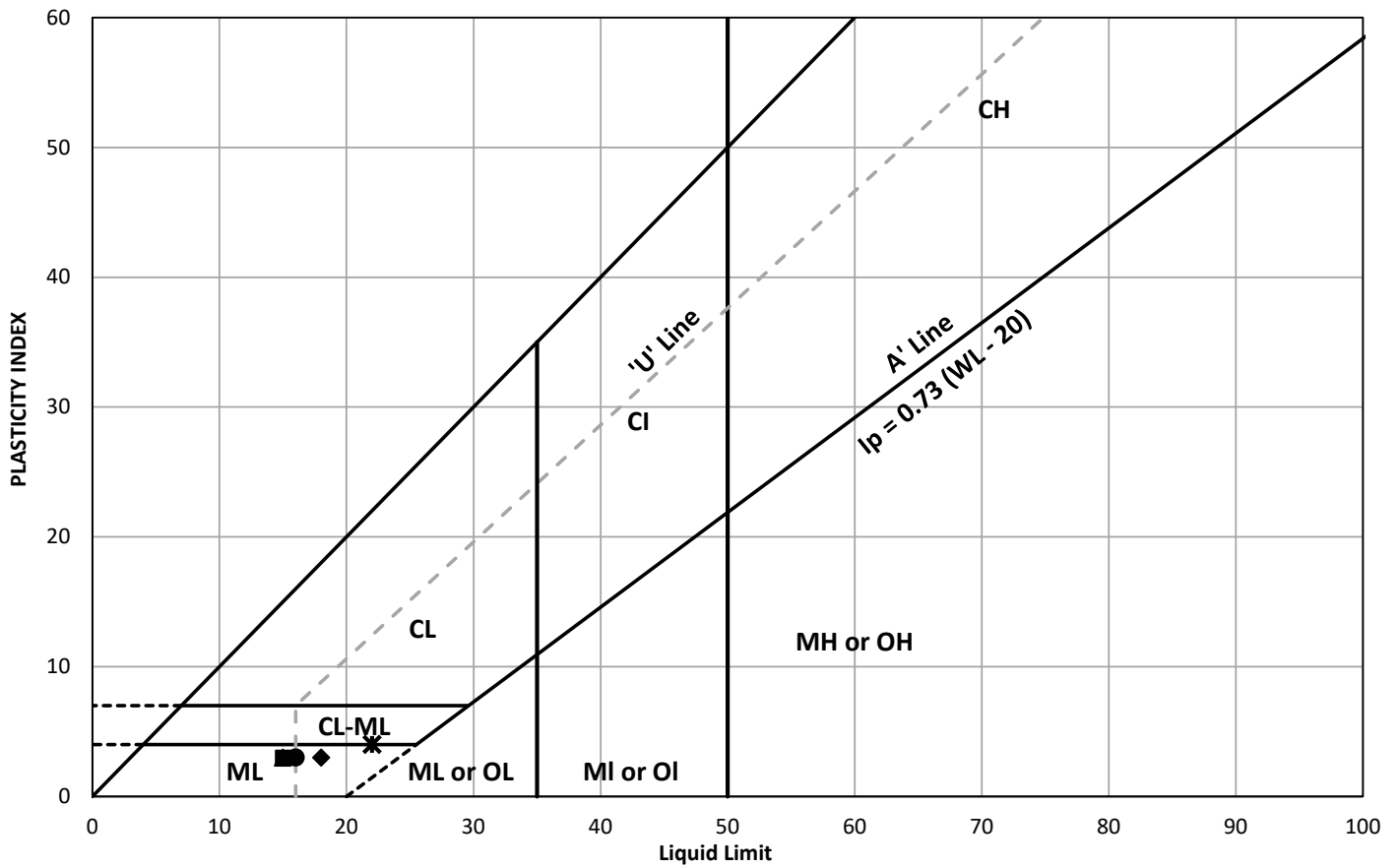
REV.

0

FIGURE


B-1

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	CO5-1	3	1.5 - 2.1	7.7	15	12	3	-1.43
◆	CO5-2	2	0.8 - 1.4	8.9	18	15	3	-2.03
▲	CO5-2	5	3.0 - 3.7	8.5	15	12	3	-1.17
●	CO5-3	5	3.0 - 3.7	7.4	16	13	3	-1.87
*	CO5-4	2	0.8 - 1.4	12.8	22	18	4	-1.30

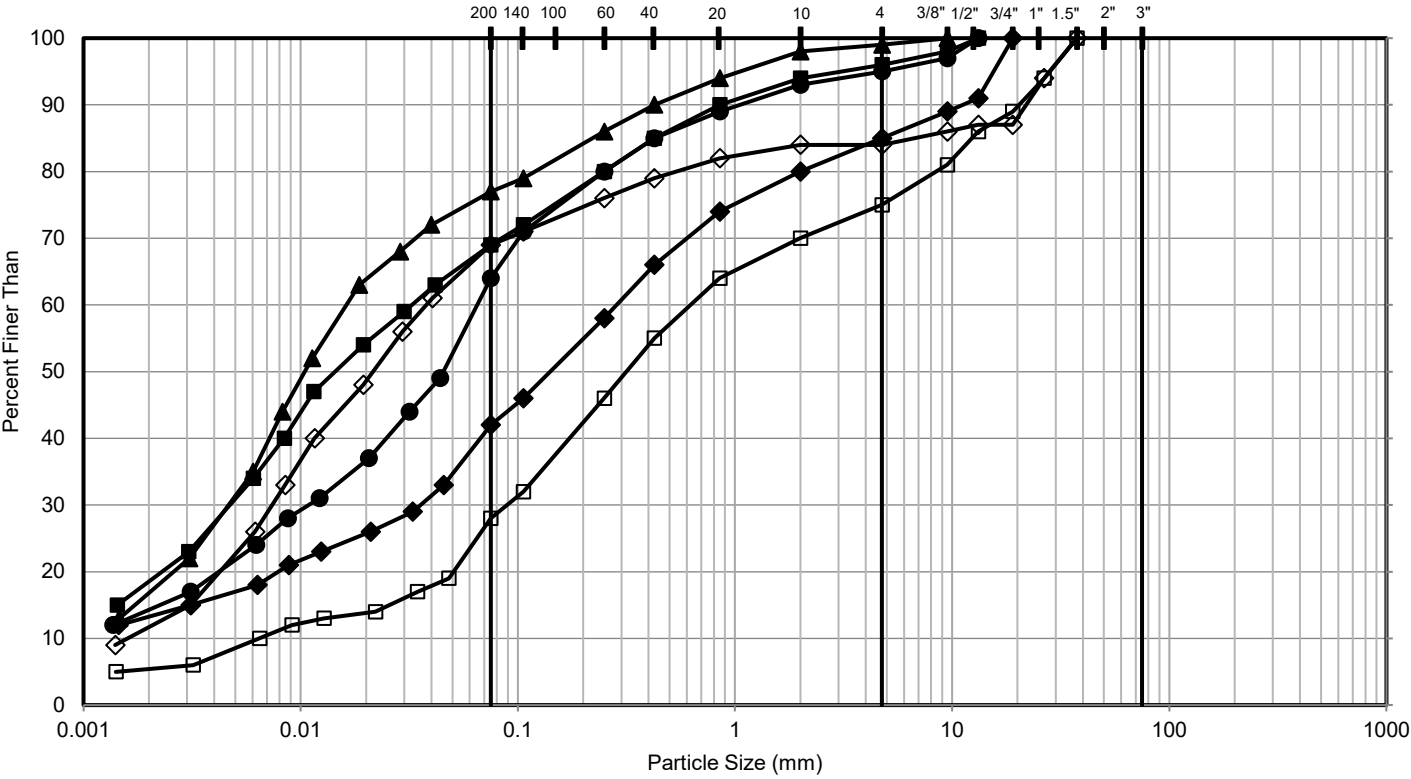
CLIENT
MCINTOSH PERRY / MINISTRY OF TRANSPORTATION ONTARIO (MTO)

CONSULTANT

YYYY-MM-DD 2024-01-23
DESIGNED ML
PREPARED ML
REVIEWED AMP
APPROVED KJB

PROJECT
HIGHWAY 11/12 (OLD BARRIE ROAD)
CENTRELINE TWIN CULVERT

TITLE
Plasticity Chart - SILTY SAND (SM) (FILL)
PROJECT NO. 19135676
CONTROL 0
REV. 0
FIGURE B-2

GRAIN SIZE DISTRIBUTION



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

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	CO5-1	9	6.1 - 6.7	253.9 to 253.3
◆	CO5-2	8	6.1 - 6.7	252.9 to 252.3
▲	CO5-2	10	9.1 - 9.5	249.9 to 249.5
●	CO5-3	9	7.6 - 8.2	251.6 to 251.0
□	CO5-4	5	3.0 - 3.7	249.9 to 249.3
◇	CO5-4	8	7.6 - 8.0	245.4 to 245.0

CLIENT

MCINTOSH PERRY / MINISTRY OF TRANSPORTATION
ONTARIO (MTO)

CONSULTANT



YYYY-MM-DD 2024-03-28

DESIGNED ML

PREPARED ML

REVIEWED AMP

APPROVED KJB

PROJECT

HIGHWAY 11/12 (OLD BARRIE ROAD)
CENTRELINE TWIN CULVERT

TITLE

Grain Size Distribution - Sandy CLAYEY SILT (CL) to CLAYEY SAND
(SC) / SILT (ML) to Gravelly SILTY SAND (SM) (TILL)

PROJECT NO.

19135676

CONTROL

0

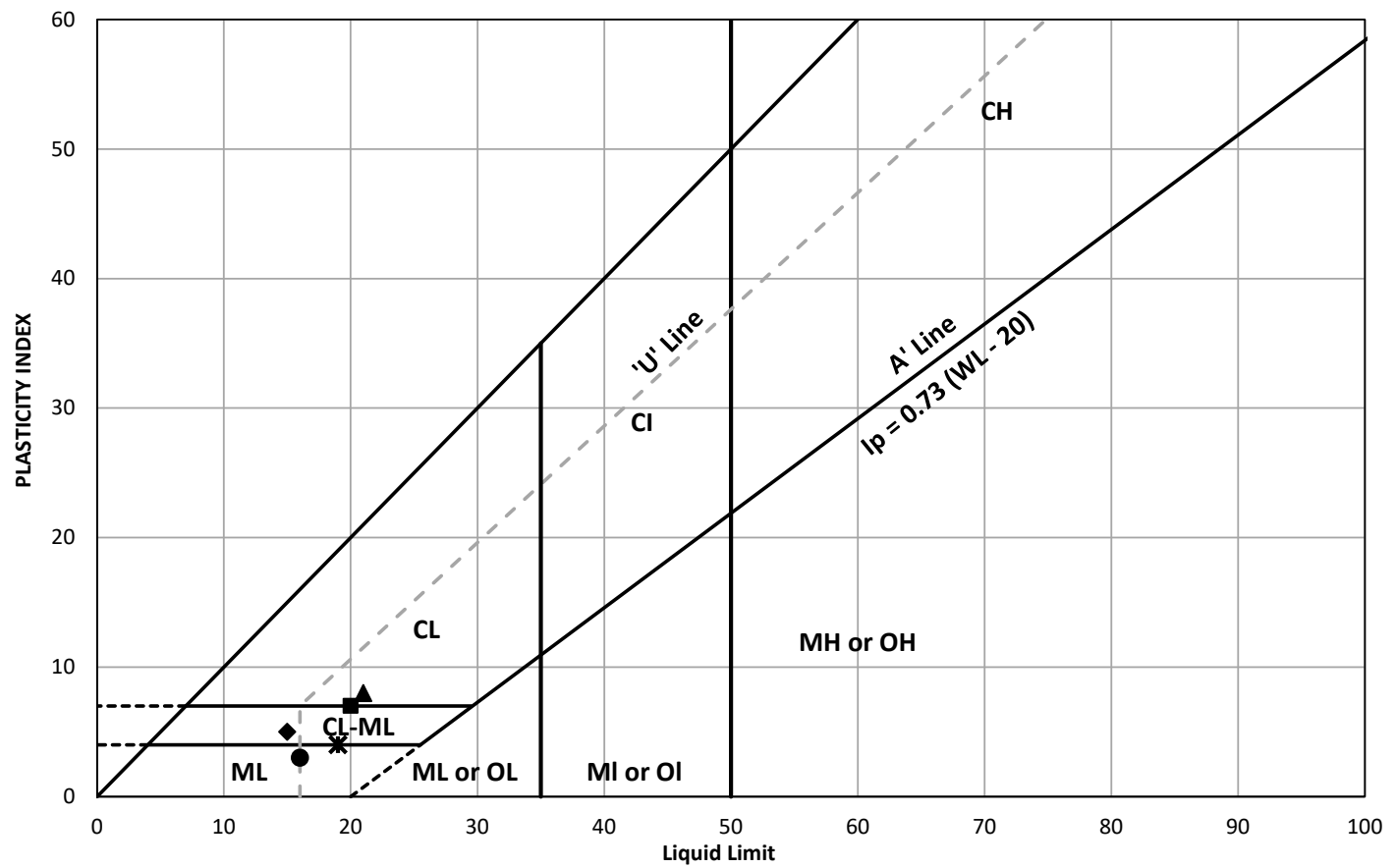
REV.

0

FIGURE

B-3

PLASTICITY CHART



	Sample Location	Sample / Specimen Number	Depth (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
■	CO5-1	9	6.1 - 6.7	6.6	20	13	7	-0.91
◆	CO5-2	8	6.1 - 6.7	6.7	15	10	5	-0.66
▲	CO5-2	10	9.1 - 9.5	10.6	21	13	8	-0.30
●	CO5-3	9	7.6 - 8.2	12.5	16	13	3	-0.17
*	CO5-4	8	7.6 - 8.0	11.1	19	15	4	-0.98

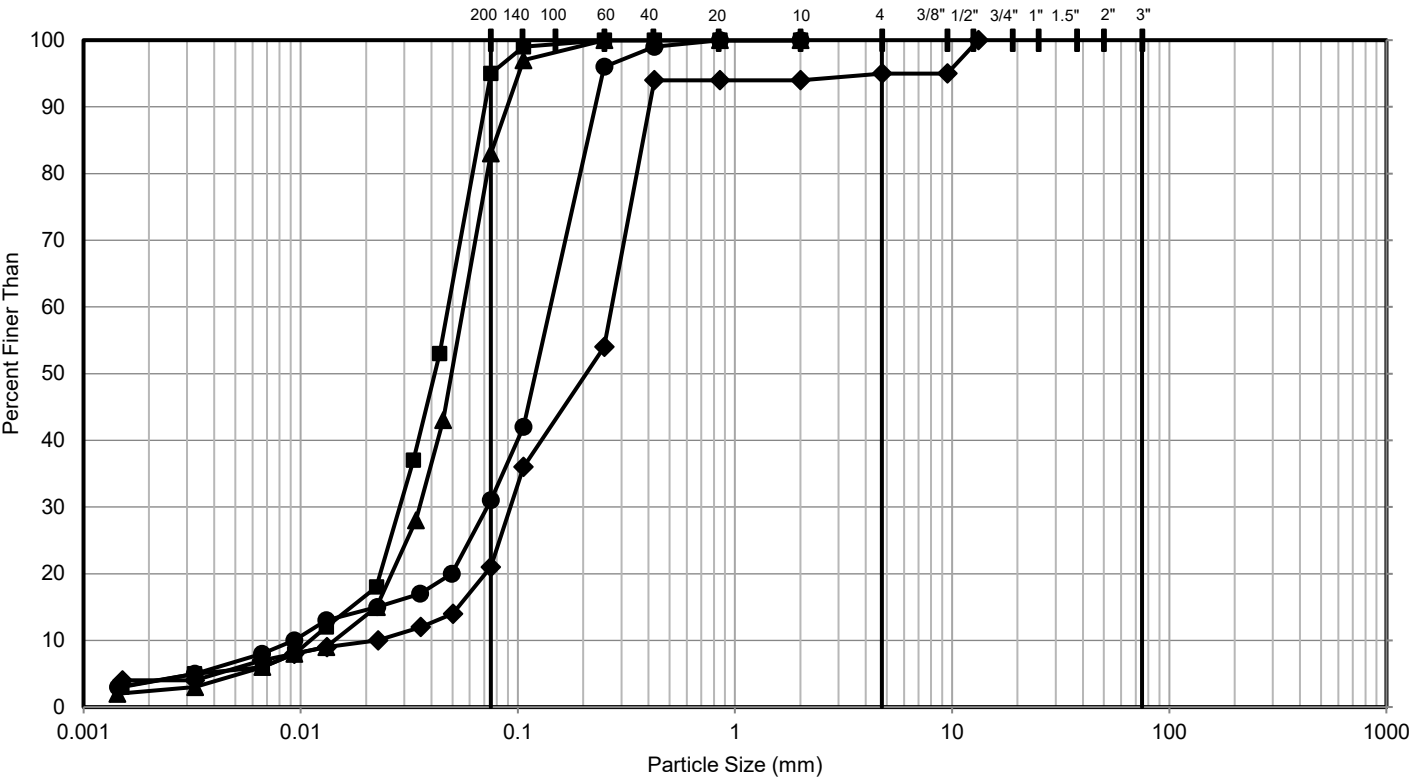
CLIENT
MCINTOSH PERRY / MINISTRY OF TRANSPORTATION ONTARIO (MTO)

CONSULTANT
wsp
YYYY-MM-DD
2024-03-28
DESIGNED
ML
PREPARED
ML
REVIEWED
AMP
APPROVED
KJB

PROJECT
HIGHWAY 11/12 (OLD BARRIE ROAD)
CENTRELINE TWIN CULVERT

TITLE
Plasticity Chart - Sandy CLAYEY SILT (CL) to CLAYEY SAND (SC) / SILT (ML) to Sandy SILT (ML) (TILL)
PROJECT NO.
19135676
CONTROL
0
REV.
0
FIGURE
B-4

GRAIN SIZE DISTRIBUTION



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

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	CO5-1	12	10.7 - 11.0	249.3 to 249.0
◆	CO5-2	13	13.7 - 14.2	245.3 to 244.9
▲	CO5-3	12	12.2 - 12.8	247.0 to 246.4
●	CO5-4	9	9.1 - 9.5	243.8 to 243.5

CLIENT

MCINTOSH PERRY / MINISTRY OF TRANSPORTATION
ONTARIO (MTO)

CONSULTANT



YYYY-MM-DD 2024-01-23

DESIGNED ML

PREPARED ML

REVIEWED AMP

APPROVED KJB

PROJECT

HIGHWAY 11/12 (OLD BARRIE ROAD)
CENTRELINE TWIN CULVERT

TITLE

Grain Size Distribution - SILT (ML) to SILTY SAND (SM)

PROJECT NO.

19135676

CONTROL

0

REV.

0

FIGURE

B-5

APPENDIX C

Analytical Laboratory Test Results



Your Project #: 19135676
Site Location: HWY 11/12 ORILLIA
Your C.O.C. #: n/a

Attention: Mark Henderson

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2023/12/12
Report #: R7952178
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AS548

Received: 2023/12/01, 11:09

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2023/12/06	2023/12/06	CAM SOP-00463	MOE E3013 m
Conductivity	1	2023/12/06	2023/12/06	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2023/12/11	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2023/12/09	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2023/12/06	2023/12/06	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	1	2023/12/07	2023/12/08	CAM SOP-00421	SM 24 2580 B
Resistivity of Soil	1	2023/12/02	2023/12/06	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2023/12/06	2023/12/06	CAM SOP-00464	MOE E3013 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, MELCCFP, 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.

(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE, Calgary, AB, T2E 6P8

(2) Offsite analysis requires that subcontracted moisture be reported.



Your Project #: 19135676
Site Location: HWY 11/12 ORILLIA
Your C.O.C. #: n/a

Attention: Mark Henderson

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2023/12/12
Report #: R7952178
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AS548

Received: 2023/12/01, 11:09

(3) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode. The test is therefore, not SCC accredited for this matrix.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:

Ankita Bhalla, Project Manager

Email: Ankita.Bhalla@bureauveritas.com

Phone# (905) 817-5700

=====

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SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		XTT380			XTT380	
Sampling Date		2023/11/15			2023/11/15	
COC Number		n/a			n/a	
	UNITS	BH-3-SS-3	RDL	QC Batch	BH-3-SS-3 Lab-Dup	QC Batch
Calculated Parameters						
Resistivity	ohm-cm	800		9087359		
CONVENTIONALS						
Redox Potential	mV	220	N/A	9097488		
Inorganics						
Soluble (20:1) Chloride (Cl-)	ug/g	570	20	9093919		
Conductivity	umho/cm	1260	2	9093957		
Available (CaCl2) pH	pH	8.00		9094231	7.97	9094231
Soluble (20:1) Sulphate (SO4)	ug/g	31	20	9093930		
Sulphide	mg/kg	1.8	0.5	9103814		
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate N/A = Not Applicable						



BUREAU
VERITAS

Bureau Veritas Job #: C3AS548
Report Date: 2023/12/12

WSP Canada Inc.
Client Project #: 19135676
Site Location: HWY 11/12 ORILLIA
Sampler Initials: TT

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		XTT380		
Sampling Date		2023/11/15		
COC Number		n/a		
	UNITS	BH-3-SS-3	RDL	QC Batch
Physical Testing				
Moisture-Subcontracted	%	5.3	0.30	9105149
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				



BUREAU
VERITAS

Bureau Veritas Job #: C3AS548
Report Date: 2023/12/12

WSP Canada Inc.
Client Project #: 19135676
Site Location: HWY 11/12 ORILLIA
Sampler Initials: TT

TEST SUMMARY

Bureau Veritas ID: XTT380
Sample ID: BH-3-SS-3
Matrix: Soil

Collected: 2023/11/15
Shipped:
Received: 2023/12/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9093919	2023/12/06	2023/12/06	Massarat Jan
Conductivity	AT	9093957	2023/12/06	2023/12/06	Leily Karimi
Moisture (Subcontracted)	BAL	9105149	N/A	2023/12/11	Ashley Henderson
Sulphide in Soil	SPEC	9103814	N/A	2023/12/09	Ly Vu
pH CaCl2 EXTRACT	AT	9094231	2023/12/06	2023/12/06	Kien Tran
Redox Potential	COND	9097488	2023/12/07	2023/12/08	Leily Karimi
Resistivity of Soil		9087359	2023/12/06	2023/12/06	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9093930	2023/12/06	2023/12/06	Massarat Jan

Bureau Veritas ID: XTT380 Dup
Sample ID: BH-3-SS-3
Matrix: Soil

Collected: 2023/11/15
Shipped:
Received: 2023/12/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	9094231	2023/12/06	2023/12/06	Kien Tran



GENERAL COMMENTS

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

Package 1	0.7°C
-----------	-------

Results relate only to the items tested.



BUREAU
VERITAS

Bureau Veritas Job #: C3AS548

Report Date: 2023/12/12

QUALITY ASSURANCE REPORT

WSP Canada Inc.

Client Project #: 19135676

Site Location: HWY 11/12 ORILLIA

Sampler Initials: TT

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9093919	Soluble (20:1) Chloride (Cl ⁻)	2023/12/06	NC	70 - 130	89	70 - 130	<20	ug/g	8.8	35
9093930	Soluble (20:1) Sulphate (SO ₄)	2023/12/06	NC	70 - 130	90	70 - 130	<20	ug/g	2.7	35
9093957	Conductivity	2023/12/06			103	90 - 110	<2	umho/cm	2.6	10
9094231	Available (CaCl ₂) pH	2023/12/06			100	97 - 103			0.35	N/A
9097488	Redox Potential	2023/12/08			100	95 - 105			2.0	35
9103814	Sulphide	2023/12/09	92	75 - 125	98	75 - 125	<0.5	mg/kg	22	30
9105149	Moisture-Subcontracted	2023/12/11					<0.30	%	0	20

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)



BUREAU
VERITAS

Bureau Veritas Job #: C3AS548

Report Date: 2023/12/12

WSP Canada Inc.

Client Project #: 19135676

Site Location: HWY 11/12 ORILLIA

Sampler Initials: TT

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

Ghayasuddin Khan, M.Sc., P.Chem., QP, Scientific Specialist, Inorganics

Janet Gao, B.Sc., QP, Supervisor, Organics

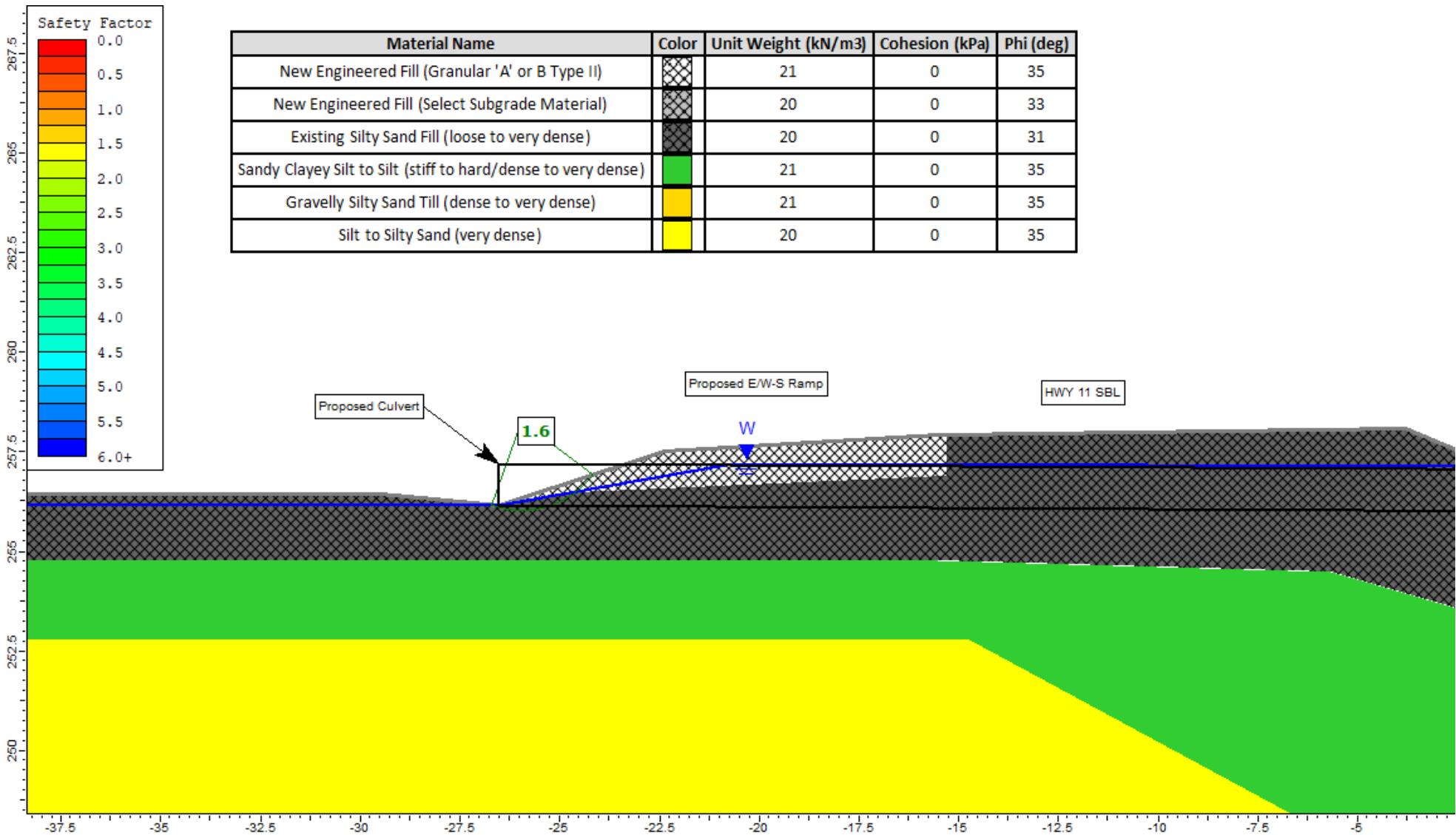
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APPENDIX D

Global Stability Figures

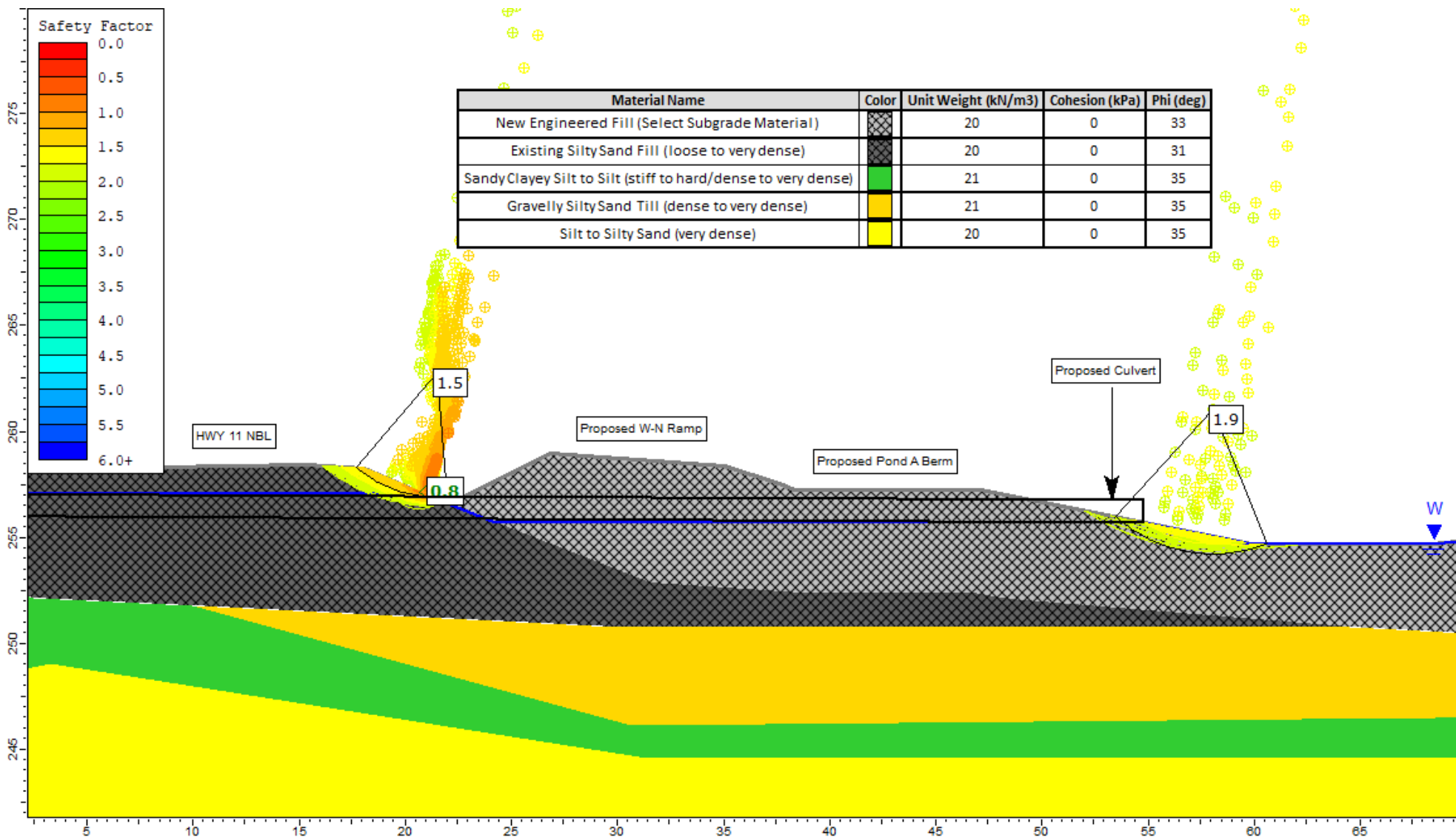
PROPOSED E/W-S RAMP AT CULVERT INLET
Embankment Slope 3H:1V – Permanent Condition (Drained Analysis)

Figure D-1



PROPOSED W-N RAMP / POND BERM AT CULVERT OUTLET
Embankment Slope 2H:1V – Permanent Condition (Drained Analysis)

Figure D-2



APPENDIX E

Special Provisions

WORKING SLAB – Item No.

Special Provision

1.0 SCOPE

This special provision covers the requirements for the supply and placement of a concrete working slab under structure foundations and for trenchless installation shaft construction.

2.0 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 902 Excavating and Backfilling - Structure

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – Not Used

5.0 MATERIALS

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

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

7.01 Excavation

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

7.02 Protection of Founding Soil

Following inspection and approval of the prepared subgrade, a working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade, as specified in the Contract Documents.

7.03 Dewatering

Dewatering shall be carried out according to OPSS 902.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT – Not Used

10.0 BASIS OF PAYMENT

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

DEWATERING SYSTEM - Item No.
TEMPORARY FLOW PASSAGE SYSTEM - Item No.

Special Provision No. 517F01

February 2024

Amendment to OPSS 517, November 2023

Return Period Flow and Preconstruction Survey Distance

517.04 DESIGN AND SUBMISSION REQUIREMENTS

517.04.01 Design Requirements

Clause 517.04.01.01 of OPSS 517 is amended by deleting the second last paragraph in its entirety and replacing it with the following:

The temporary flow passage system shall allow the work to be conducted as specified in the Contract Documents. Design flow shall include groundwater discharge and flow resulting from a minimum 2 year return period design storm, except for the work specified in Table 1. For the work specified in Table 1, design flow shall include groundwater discharge and flow resulting from a design storm of the minimum return period specified in Table 1. A longer return period shall be used when determined appropriate for the work.

The flow estimates as specified in Table 1 do not include flow volumes from groundwater discharge.

The Owner specifically excludes flow estimates from the warranty in the Reliance on Contract Documents subsection of OPSS 100, MTO General Conditions of Contract.

TABLE 1
Site Location and Reference Information

TEMPORARY FLOW PASSAGE SYSTEMS							
Source of Return Period Flow Estimates:							
Site Name / Station Reference	Minimum Return Period (Years)	Return Period Flow Estimates (m³/s) (Note 1)				Design Engineer Requirements (Note 2)	Fish Passage Required (Note 3)
		2 Year	5 Year	10 Year	25 Year		
Centreline Twin Culvert	5					No	
DEWATERING SYSTEMS							
Site Name / Station Reference	Preconstruction Survey Distance (m) (Note 4)	Minimum Lowered Groundwater Depth Below Base of Excavation or Work Area (m) (Note 5)			Design Engineer Requirements (Note 2)		
Centreline Twin Culvert	N/A	0.6			No		
Notes:							
1. a) The Design Engineer is to satisfy themselves to the accuracy and applicability of the provided flows. b) The intensity-duration-frequency (IDF) information can be accessed through MTO’s IDF Curve Lookup web-based application tool at https://idfcurlines.mto.gov.on.ca/ c) The design, operation and maintenance of the temporary flow passage system is the sole responsibility of the Contractor.							
2. “Yes” means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. “No” means a minimum experience level is not required for the design Engineer and design-checking Engineer.							
3. “Yes” means that the design Engineer must design the temporary flow passage system to meet the fish passage requirements. “No” means fish passage is not required.							
4. “N/A” means a preconstruction survey is not required.							
5. Groundwater shall be lowered within the excavation or work area to below this minimum depth.							

[* Designer Fill-Ins for Table 1, See Notes to Designer]

NOTES TO DESIGNER:

Designer Fill-Ins for Table 1:

1. Fill-in the source of the return period flow estimates.
2. Fill-in the site name, work, and station reference as appropriate for the dewatering system and/or temporary flow passage system item locations. Add additional rows as necessary.
3. For temporary flow passage system item locations, fill-in the minimum return period flow for each site based on MTO Drainage Design Standard TW-1. The return period flow shall not be less than 2 years.
4. For temporary flow passage system item locations, fill-in the design flow rate estimates for the various return periods.
5. Fill-in "Yes" under Design Engineer Requirements when recommended by the Foundation Engineer. Fill-in "No" otherwise.
6. For temporary flow passage system item locations, fill-in "Yes" under Fish Passage Required, when maintaining fish passage is a condition of a permit/ authorization or as recommended by the MTO Fisheries Assessment Specialist, in consultation with the MTO Environmental Planner. Fill-in "No" otherwise.
7. Fill-in the required distance under Preconstruction Survey Distance, when recommended by the Foundation Engineer. Fill-in "N/A" if not recommended.
8. Fill-in the Minimum Lowered Groundwater Depth Below Base of Excavation or Work Area provided by the Foundation Engineer.
9. When applicable, add a point d) to Note 1 of the table notes to indicate when Return Period Flow Estimates do not include base flows, for example:
 - d) The Return Period Flow Estimates do not include base flows.
 - d) The Return Period Flow Estimates at [enter Site Name/Description] do not include base flows.

Example Table 1

TABLE 1
Site Location and Reference Information

TEMPORARY FLOW PASSAGE SYSTEMS							
Source of Return Period Flow Estimates: Longwood Channel Drainage Report (MTO 2017)							
Site Name / Station Reference	Minimum Return Period (Years)	Return Period Flow Estimates (m³/s) (Note 1)				Design Engineer Requirements (Note 2)	Fish Passage Required (Note 3)
		2 Year	5 Year	10 Year	25 Year		
Woods Creek Culvert Rehabilitation	2	0.7	3.5	7.5	10.9	No	No
Site 32-145 Robbs Creek Culvert Replacement	10	1.6	7.6	17.4	25.2	Yes	Yes
DEWATERING SYSTEMS							
Site Name / Station Reference	Preconstruction Survey Distance (m) (Note 4)	Minimum Lowered Groundwater Depth Below Base of Excavation or Work Area (m) (Note 5)			Design Engineer Requirements (Note 2)		
Site 32-145 Robbs Creek Culvert Replacement	300	1.0			Yes		
Notes:							
1. a) The Design Engineer is to satisfy themselves to the accuracy and applicability of the provided flows. b) The intensity-duration-frequency (IDF) information can be accessed through MTO’s IDF Curve Lookup web-based application tool at https://idfcurlves.mto.gov.on.ca/ c) The design, operation and maintenance of the temporary flow passage system is the sole responsibility of the Contractor. d) The Return Period Flow Estimates at Site 32-145, Robbs Creek Culvert Replacement, do not include base flows.							
2. “Yes” means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. “No” means a minimum experience level is not required for the design Engineer and design-checking Engineer.							
3. “Yes” means that the design Engineer must design the temporary flow passage system to meet the fish passage requirements. “No” means fish passage is not required.							
4. “N/A” means a preconstruction survey is not required.							
5. Groundwater shall be lowered within the excavation or work area to below this minimum depth.							

WARRANT: Always with these tender items.



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