



FINAL

Foundation Investigation and Design Report

Bovaird Drive Culvert Extension, Brampton, Ontario

Highway 413 Project, Ministry of Transportation, Ontario

GWP 2034-24-00

Submitted to:

Ministry of Transportation Ontario

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PART A

**FOUNDATION INVESTIGATION REPORT
BOVAIRD DRIVE CULVERT EXTENSION, CITY OF BRAMPTON, ONTARIO
HIGHWAY 413 PROJECT
MINISTRY OF TRANSPORTATION, ONTARIO
MTO GWP 2034-24-00**

1.0 INTRODUCTION

WSP Canada Inc. (WSP) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Bovaird Drive Underpass and associated Bovaird Drive West culvert extension as part of the Highway 413 Project (Early Works Contract), in the City of Brampton, Ontario. This report addresses the proposed southern extension of the existing CIP open footing culvert located at about Station 10+615.

This report summarizes the results of previous and current foundation investigations (including field investigation procedures, borehole stratigraphy, bedrock lithology, and geotechnical and analytical laboratory test results) carried out at the site, and provides a description of the interpreted subsurface soil, bedrock and groundwater conditions at the proposed culvert extension.

2.0 SITE AND PROJECT DESCRIPTION

2.1 Site Orientation and Datum

The orientation (i.e., north, south, east, and west) stated 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, the existing culvert in the vicinity of the project site is considered oriented in a north-south direction and Bovaird Drive West is considered oriented in an east-west direction.

This report has been developed based on the following horizontal and vertical datums:

- Horizontal datum: Ontario MTM Zone 10, NAD83 (CSRS), CBNV6-2010
- Vertical datum: CGVD28 (1978)

2.2 Project Scope

The purpose of the project is to construct the Bovaird Drive Underpass Structure and approach embankments to support the future Highway 413 and Bovaird Drive interchange. The scope of work includes the new Bovaird Drive Underpass Structure, the full reconstruction of Bovaird Drive from a 2-lane undivided roadway to a 6-lane divided roadway and profile grade raise of up to 11 m for the approach embankments.

The future proposed Highway 413 / Bovaird Drive interchange will be located along the existing Bovaird Drive West (Bovaird Drive) between Heritage Road and Mississauga Road in the City of Brampton, Regional Municipality of Peel, Ontario. The proposed Bovaird Drive underpass structure will cross over the future Highway 413 at about Station 10+000 and will require new approach embankments up to about 11 m in height to be constructed between about Stations 9+650 and 10+300. The proposed structure will encompass the full width of the existing roadway and extend north and south of the existing roadway into the neighbouring farmlands.

The project also includes roadway widening beyond the MTO Controlled Access Highway (CAH) limits, on behalf of the Region of Peel, and as a result includes the culvert extension at Station 10+615. The culvert extension is the focus of this report.

2.3 Site Description

The existing culvert to be extended southward, is located along Bovaird Drive West, immediately east of Coolhurst Avenue, at approximately Station 10+615, and approximately 315 m west of Mississauga Road in the City of Brampton. At the site location, the Bovaird Drive road grade is at about Elevation 241.2 m, with an existing embankment height of approximately 2.7 m relative to the ground surface at the toe of the embankment slope. The existing embankment is grass covered and inclined at about 2 Horizontal to 1 Vertical (2H:1V), with no visible signs of erosion or instability.

As per the General Arrangement drawing for the proposed culvert extension (dated April 2026), the existing CIP open footing culvert is about 30.9 m long, with an opening 0.9 m wide and 0.9 m high, with a culvert invert at about Elevation 238.0 m (at south outlet), founded on footings at about Elevation 237 m (at south outlet). The culvert carries stormwater from the north side of Bovaird Drive to the south side of Bovaird Drive. The culvert was previously extended to the north as part of the land development works in the area. No further extension to the north is required as part this project.

In general, the topography in the vicinity of the existing culvert consists of relatively flat terrain surrounded by a developing residential subdivision to the north and undeveloped farmland to the south. Photographs of the existing site conditions at the proposed southward culvert extension location are provided below. At the time of the current investigation (September 2025), the existing culvert outlet and surrounding ground surface was observed to be dry.



Figure 1: Proposed Culvert Extension Location (Looking South)



Figure 2: Proposed Culvert Extension Location (Looking West)

3.0 INVESTIGATION PROCEDURES

3.1 2020 Investigation

A previous investigation was carried out in the vicinity of the existing culvert in 2020 by SNC-Lavalin Inc. Ontario Inc., on behalf of the Region of Peel as presented in the following report:

- Geotechnical Investigation and Pavement Design for Bovaird Drive W Widening Project”, Reference No. 672432, prepared by SNC-Lavalin Inc., dated January 26, 2021.

The 2020 investigation consisted of two boreholes (designated as Boreholes BHC-5 and D-8) located near the existing culvert. Borehole BHC-5 was advanced through the eastbound Bovaird Drive road shoulder. It is noted that the Record of Borehole indicates the drilling location “westbound shoulder”, however the provided coordinates indicate the borehole was located in the eastbound shoulder. A standpipe piezometer was installed in Borehole BHC-5. Borehole D-8 was advanced to a shallow depth via a hand auger at the ditch south of Bovaird Drive near the outlet of the existing culvert.

The borehole locations, ground surface elevations and drilled depths are shown on the borehole records in Appendix A, on Drawing 1 following the text of this report, and are summarized in the table below. It is noted that the geodetic datum referenced in the 2020 investigation report has been assumed to be the project datum referenced in Section 2.1 of this report.

Borehole No.	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
BHC-5	4,836,143.3 (43.664761)	278,025.4 (-79.831995)	241.2	6.5
D-8	4,836,137.1 (43.664706)	278,034.5 (-79.831882)	237.9	0.8

3.2 Current Investigation (2025)

The current foundation investigation was carried out by WSP on September 10, 2025, during which time one borehole (designated as Borehole 25-C1) was advanced to a depth of 6.2 m at the location of the proposed culvert extension. The borehole was advanced at the toe of the road embankment (south of Bovaird Drive) near the outlet of the existing culvert.

The investigation was carried out using limited access equipment consisting of a Hilti drill rig supplied and operated by Pontil Drilling Services Inc. The borehole was advanced through the overburden via a mud-rotary drilling method using a 98 mm tri-cone bit and a manual half-weight hammer.

The field work was observed by members of WSP’s engineering and technical staff, who marked the borehole location, arranged for the clearance of underground utilities, observed the drilling, sampling, and in-situ testing operations, and logged the borehole.

Soil samples were generally obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by a manual half-weight hammer, in general accordance with the Standard Penetration Test (SPT) procedures of 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. The borehole was backfilled upon completion of drilling with bentonite in general accordance with Ontario Regulation 903 (Wells), as amended.

The soil samples were identified in the field, placed in appropriate containers, labelled and transported to WSP’s Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing in accordance with MTO and/or ASTM Standards, as appropriate. Classification testing (water content determination, grain size distributions and Atterberg limits) was carried out on select soil samples. One selected

soil sample from the current investigation was submitted to Bureau Veritas, an accredited analytical testing laboratory, for testing of a suite of parameters related to corrosivity and sulphate attack.

The as-drilled borehole location and ground surface elevation at Borehole 25-C1 was surveyed by WSP using a Trimble Catalyst DA2 GNSS Receiver. The as-drilled borehole location, ground surface elevation, and drilled depth for the current investigation is shown on the borehole record in Appendix B, on Drawing 1 following the text of this report, and is summarized in the table below.

Borehole No.	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
25-C1	4,836,135.7 (43.664693)	278,034.1 (-79.831887)	238.5	6.2

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

The site is located within the South Slope physiographic region comprised of calcareous clay till with lacustrine clay and silt reworked by glaciers, with numerous scattered drumlins and deep valley cuts caused by flowing streams towards Lake Ontario. The overburden within the majority of the South Slope region is underlain by shale bedrock of the Queenston and Georgian Bay formations which contains Limestone interbeds. The entire area has a fairly uniform slope toward Lake Ontario.

Surficial geology maps indicate the surficial material at the site is composed of glacial clay and silt till deposits. Water well records show the subsurface conditions consist of a layer of cohesive soil underlain by shale bedrock encountered at about 6 m below ground surface.

Bedrock Geology maps indicate that the bedrock at the site is described to consist of red shale of the Queenston Formation.

4.2 Subsurface Conditions

The subsurface soil, bedrock, and groundwater conditions as encountered in the boreholes advanced during the previous and current investigations are presented on the borehole records in Appendix A and B, respectively. "Method of Soil Classification", "Abbreviations and Terms Used on Records of Boreholes and Test Pits", "List of Symbols" and "Lithological and Geotechnical Rock Description Terminology" sheets are provided in Appendix B to assist in the interpretation of the borehole records from the current investigation. The results of the geotechnical laboratory testing and the results of the analytical laboratory testing from the current investigation are provided in Appendix C and D, respectively.

The results of the in-situ tests (i.e., SPT 'N'-values) as presented on the borehole records and in Section 4.2 are uncorrected for overburden pressure and energy transfers. The 'N'-values obtained at Borehole 25-C1 are based on SPT sampling procedures carried out with a half-weight (i.e., 31.8 kg) manual hammer. As such, the 'N'-values presented on the Record of Borehole 25-C1 have been halved to account for the half-weight hammer. The 'N'-values presented on the borehole records for Boreholes BHC-5 are based on SPT sampling procedures carried out with a standard weight (i.e., 63.5 kg) automatic hammer.

The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile on Drawing 1 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change and are simplifications of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes exists and is to be expected.

In summary, the subsurface conditions at the site consist of surficial topsoil / granular fill, underlain by either clayey silt fill (below the Bovaird Drive embankment) or a native sandy clayey silt deposit (at the toe of the Bovaird Drive embankment). The fill / native clayey silt is underlain by a glacial till deposit, a residual soil deposit, and

finally shale bedrock. A more detailed description of the subsurface conditions encountered in the boreholes during the field investigations is provided in the following sections.

4.2.1 Topsoil

An approximately 100 mm and 150 mm thick layer of surficial topsoil was encountered at ground surface in Boreholes D-8 and 25-C1, respectively. These materials were classified solely on visual and textural evidence. Testing of organic content or other nutrients was not carried out.

4.2.2 Gravelly Sand Fill

An approximately 0.9 m thick layer of gravelly sand fill was encountered at ground surface in Borehole BHC-5, extending to about Elevation 240.2 m.

The SPT 'N'-value measured within the gravelly sand fill was 36 blows per 0.3 m of penetration, indicating a dense state of compactness.

The natural water content measured on two samples of the granular fill was about 8% and 21%.

4.2.3 Silty Clay Fill

An approximately 1.4 m thick layer of silty clay fill was encountered below the gravelly sand fill in Borehole BHC-5. The silty clay fill was encountered at a depth of about 0.9 m below ground surface (Elevation 240.2 m) and extends to a depth of about 2.3 m below ground surface (Elevation 238.9 m).

Two SPT 'N' values measured within the silty clay fill were 12 blows per 0.3 m of penetration and 50 blows per 0.15 m, indicating a stiff to hard consistency.

The natural water content measured on two samples of the silty clay fill was 14% and 4%.

4.2.4 Sandy Clayey Silt

An approximately 1.2 m thick deposit of sandy clayey silt, trace gravel was encountered below the surficial topsoil in Borehole 25-C1. The cohesive deposit was encountered at a depth of about 0.2 m below ground surface (Elevation 238.3) and extends to a depth of about 1.4 m below ground surface (Elevation 237.1 m). The cohesive deposit was observed to contain rootlets and mottling, as noted on the borehole record.

The SPT 'N' values measured within the sandy clayey silt deposit were 2 blows and 6 blows per 0.3 m of penetration, indicating a soft to firm consistency.

As part of the current investigation, grain size distribution testing and Atterberg limits testing was carried out on one sample of the sandy clayey silt deposit and the results are presented on Figure C-1 and C-2 in Appendix C, respectively. The Atterberg limit testing measured a liquid limit of 29%, plastic limit of 17%, and plastic index of 12%, indicating that the deposit is of low plasticity. The natural water content measured on one sample of the sandy clayey silt was about 20%, which is above the materials plastic limit.

4.2.5 Glacial Till

An approximately 1.5 m to 1.8 m thick glacial till deposit was encountered underlying the surficial topsoil in Borehole D-8, underlying the granular fill in Borehole BHC-5, and underlying the sandy clayey silt deposit in Borehole 25-C1. The till deposit was encountered at depths ranging from about 0.1 m to 2.3 m below ground surface (Elevations 238.9 m to 237.1 m) and, where fully penetrated, extends to depths of about 2.9 m and 4.1 m below ground surface (Elevations 237.0 m and 235.6 m). Borehole D-8 was terminated within the till deposit, penetrating it for a thickness of about 0.7 m. The till deposit ranges from sandy silt to silty sand, trace to some gravel, trace clay to sandy clayey silt, trace to some gravel. At Borehole 25-C1 an approximately 0.2 m thick interlayer of sand was encountered within the glacial till deposit at a depth of about 2.0 m below ground surface (Elevation 236.5 m).

The SPT 'N' values measured within the till deposit range from about 11 blows to 28 blows per 0.3 m of penetration, indicating a compact state of compactness / very stiff consistency.

As part of the current investigation, grain size distribution testing was carried out on one sample of the glacial till deposit and the results are presented on Figure C-3 in Appendix C. The natural water content measured on six samples of the glacial till deposit ranged from about 14% to 25%.

4.2.6 Residual Soil

A deposit of residual soil consisting of clayey silt-silt to clayey silt with shale fragments was inferred from split spoon sampling below the glacial till deposit in Boreholes 25-C1 and BHC-5. It is noted that this deposit is classified as “silty clay some sand to sandy, trace weathered shale fragments” at Borehole BHC-5, however, based on WSP’s interpretation of the grain size distribution results and understanding of the site conditions, it is inferred to be residual soil.

The residual soil deposit was encountered at depths of about 2.9 m and 4.1 m below ground surface (Elevation 235.6 m and 237.0 m) and, where fully penetrated, extends to a depth of about 5.3 m below ground surface (Elevation 233.2 m). Borehole BHC-5 was terminated within the residual soil deposit, penetrating it for a thickness of about 2.4 m.

The SPT 'N' values measured within the residual soil deposit range from about 15 blows per 0.3 m to 92 blows per 275 mm of penetration, indicating a very stiff to hard (but generally hard) consistency.

As part of the previous investigation, grain size distribution testing was carried out on two samples of the residual soil and Atterberg Limit testing was carried out on one sample of the residual soil. The previous investigation laboratory results are presented on the Record of Borehole BHC-5 in Appendix A. As part of the current investigation, Atterberg limits testing was carried out on one sample of the residual soil and the results are presented on Figure C-4 in Appendix C. The previous and current Atterberg limit testing results measured liquid limits of 19% and 21%, plastic limits of 14%, and plastic indices of 5% and 7%, indicating that the clayey silt is of low plasticity. The natural water content measured six samples of the residual soil deposit range from about 7% to 14%.

4.2.7 Shale Bedrock

Shale Bedrock (inferred from split spoon sampling and auger grinding) was encountered below the residual soil in Borehole 25-C1 at a depth of about 5.3 m (Elevation 233.2 m).

4.3 Groundwater Conditions

The groundwater levels were generally measured within the open boreholes, and a monitoring well was installed in Borehole BHC-5 from the previous investigation. The groundwater conditions are summarized on the borehole records and the water levels measured inside the standpipe piezometer are presented in the table below. It is noted that the 2020 groundwater levels were obtained by others, and the 2025 groundwater level at BHC-5 was measured by WSP. Groundwater and surface water levels in the area are subject to season fluctuations and variations due to precipitation events.

Borehole No.	Date of Water Level Reading	Depth of Water Level (m)	Water Level Elevation (m)	Notes
BHC-5	Sep 22, 2020	4.1	237.1	Upon completion of drilling
	Oct 7, 2020	Dry	-	Measured in Standpipe Piezometer
	Sept 30, 2025	3.1	238.1	Measured in Standpipe Piezometer

4.4 Analytical Testing

One soil sample obtained from Borehole 25-C1 was submitted to Bureau Veritas (an accredited analytical laboratory) for corrosivity testing to assess the potential for the soil to cause corrosion to buried steel and

concrete. Detailed laboratory test reports (Certificate of Analysis) are included in Appendix D and are summarized in the table below.

Borehole and Sample No.	Sample Depth / Elevation (m)	Soil Type	Parameters						
			Redox Potential (mv)	Sulphide (mg/kg)	Chloride (µg/g)	Sulphate (µg/g)	pH	Conductivity (µmho/cm)	Resistivity (ohm-cm)
25-C1 Sample 1	0.40 / 238.1	Clayey Silt	190	1.16	120	120	7.4	533	1900

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Maor Levy, an Engineer-In-Training with WSP, and was reviewed by Ms. Anastasia Poliacik, P.Eng., a Senior Geotechnical Engineer with WSP and an MTO Principal Foundations Contact. Mr. David Staseff, P.Eng., a Senior Principal and MTO Principal Foundations Contact with WSP conducted a technical review of this report. Mr. Kevin Bentley, P.Eng. and MTO Principal Foundations Contact with WSP provided an independent quality control review of this report.

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[https://wsonline.sharepoint.com/sites/ca-14m-00321-01/technical/07_early works - contract 3 - bovaird dr/04-foudations/7_deliverables/culvert extension fidr/5_final/14m-00321-01-hwy 413 bovaird culvert ext-fidr-rev0-08may2026.docx](https://wsonline.sharepoint.com/sites/ca-14m-00321-01/technical/07_early%20works%20-%20contract%203%20-%20bovaird%20dr/04-foudations/7_deliverables/culvert%20extension%20fidr/5_final/14m-00321-01-hwy%20413%20bovaird%20culvert%20ext-fidr-rev0-08may2026.docx)

PART B

**FOUNDATION DESIGN REPORT
BOVAIRD DRIVE CULVERT EXTENSION, CITY OF BRAMPTON, ONTARIO
HIGHWAY 413 PROJECT
MINISTRY OF TRANSPORTATION, ONTARIO
MTO GWP 2034-24-00**

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation engineering design recommendations for the southward extension of the existing CIP open footing culvert located along Bovaird Drive West, immediately east of Coolhurst Avenue, at about Station 10+615, in the City of Brampton, Ontario. The recommendations provided herein are based on interpretation of the factual data obtained from the boreholes advanced during the previous and current subsurface explorations. The discussion and recommendations presented are intended to provide the designers with information to assess the feasible foundation alternatives and carry out the design of the culvert extension.

The Foundation Design Report (Part B of this report), discussion and recommendations are intended for the use of the MTO and their designers and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor or design-build proponents. Contractors undertaking the work must make their own interpretation based on the data presented in the Foundation Investigation Report (Part A of this report). Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the data provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

The general Highway 413 project scope and the Highway 413 / Bovaird Drive interchange project scope are summarized in Section 2.2. As noted, the Highway 413 / Bovaird Drive interchange project includes roadway widening beyond the MTO Controlled Access Highway (CAH) limits, on behalf of the Region of Peel, and as a result includes the southward extension of the existing culvert at Station 10+615.

Based on the General Arrangement of the proposed culvert extension (dated April 2026), it is understood that the existing CIP open footing culvert (30.9 m long, with an opening 0.9 m wide and 0.9 m high), founded at about Elevation 237.8 m (north inlet) to 237 m (south outlet), will be extended southward, on a skew and the embankment widening fill will be constructed with a 3 Horizontal to 1 Vertical (3H:1V) slope. Further, the proposed culvert extension consists of a 4.6 m long cast-in-place rigid frame box culvert with an opening 0.9 m wide and 0.9 m high (with an outside concrete width and height of about 1.3 and 1.4 m respectively) founded at about Elevation 237.7 m, with an apron wall anticipated to extend to about Elevation 236.8 m.

6.2 Design Considerations

6.2.1 Consequence and Site Understanding Classification

As Bovaird Drive carries a relatively moderate volume of traffic and has the potential to impact alternative transportation routes, 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*.

In addition, given the project-specific foundation investigation carried out at this site (as presented in the Foundation Investigation Report (Part A of the report)), in comparison to the degree of site understanding in Section 6.5 of 2019 *CHBDC*, the level of confidence for design is considered to be a “typical degree of site and prediction model understanding.” Accordingly, the appropriate corresponding ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} , from Tables 6.1 and 6.2 of the *CHBDC, 2019* have been used for design. Similarly, the corresponding consequence factor Ψ , and geotechnical resistance factor, ϕ_{gu} from Table 6.3 of the *CHBDC, 2019* shall be used for seismic 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.

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy below the founding elevation and/or the underside of the pile cap elevation. Based on the energy-corrected average standard penetration resistance, \bar{N}_{60} and average undrained shear strength, s_u within the upper 30 m of the overburden below the founding level (assumed to be existing ground surface), the site may be classified as Site Class C in accordance with Table 4.1 of the CHBDC (2019).

It is noted that geophysical testing (MASW) was carried out at the proposed Bovaird Drive Underpass location, located approximately 600 m west of the culvert extension. The results of the MASW are presented in WSP's Foundation Investigation and Design Report for the Bovaird Drive Underpass and indicate the average shear wave velocity within 30 m below ground surface is 667 m/s at the proposed bridge location (i.e. a Site Class C designation). However, given the 600 m distance from the culvert location, the measured average shear wave velocity is not considered applicable at the culvert extension location.

In accordance with Section 4.4.3.1 of the CHBDC and based on the location of the proposed structure, the Site Class C peak seismic hazard values based on data obtained from Earthquakes Canada (www.earthquakescanada.nrcan.gc.ca) are provided below.

PARAMETER	2%, PROBABILITY OF EXCEEDANCE IN 50 YEARS (2,475-YEAR RETURN PERIOD) (g)
Sa(0.20)	0.261
Sa(0.5)	0.168
Sa(1.0)	0.0915
Sa(2.0)	0.0431
Sa(5.0)	0.0114
Sa(10.0)	0.0039
PGA [m/s]	0.136
PGV [m/s]	0.109

6.3 Culvert Foundations

6.3.1 Foundation Options

A concrete box culvert and a concrete open footing culvert have been considered for the proposed culvert extension. It is preferred for culvert extensions to have consistency between the existing and extended culvert foundations (i.e. type/founding elevation). It is noted that a concrete pipe culvert is not considered practical due to the connection requirements with the existing open footing culvert and therefore has not been considered further in this regard.

A summary of the advantages and disadvantages associated with an open footing and box culvert extension is provided in the table below.

Foundation Option	Advantages	Disadvantages
Box Culvert	<ul style="list-style-type: none"> ■ Minimizes the depth of excavation, excavation support and dewatering requirements compared to an open footing culvert. ■ More tolerant of total and differential settlement related to embankment widening at the culvert site than an open footing culvert. ■ Pre-cast box sections could be used for faster construction. 	<ul style="list-style-type: none"> ■ Lower geotechnical resistances compared to open footing culvert. ■ May not satisfy fisheries requirements related to channel substrate.
Open Footing Culvert	<ul style="list-style-type: none"> ■ Type of culvert matches to existing culvert type. ■ Can satisfy fisheries requirements related to channel substrate. ■ Higher geotechnical resistance compared to box culvert. 	<ul style="list-style-type: none"> ■ Deeper excavations, requiring additional excavation support and dewatering, compared to box culverts. ■ Given the relatively small culvert span (0.9 m inside / 1.3 m outside), excavation for footings would likely require excavation of most of the substrate. ■ An open footing culvert is less tolerant of total and differential settlement. ■ Culvert joints may be required to accommodate total and differential settlement (if applicable). ■ Excavations/sub-excavations to prepare the subgrade could undermine the existing footings.

Based on the above considerations, the preferred option from a geotechnical/foundations perspective is to construct the culvert extension as a box culvert.

Given the relatively short extension length, limited embankment height and loading in the vicinity of the extension, proposed structural detail to include dowels at the connection between the existing culvert and extension and design invert gradient, differential settlement is not anticipated to be a concern and a camber is not considered to be required (to be confirmed by the structural design team during detail design).

6.3.2 Box Culvert Extension

6.3.2.1 Founding Elevations and Subgrade Preparation

It is generally considered not necessary to found box culverts at or below the standard depth of frost penetration for frost protection purposes, as box culverts are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur. Based on the current GA, it is understood that the proposed box culvert is to be founded at about Elevation 237.7 m, with an apron wall anticipated to extend to about Elevation 236.8 m.

The box culvert extension should be provided with a minimum 0.3 m thick granular bedding pad, consisting of OPSS.PROV 1010 (Aggregates), Granular 'A' or Granular B 'Type II' compacted to 100% of the materials Standard Proctor Maximum Dry Density (SPMDD) in accordance with OPSS.PROV 501 (Compacting). Where pre-cast box culverts are used, a 75 mm thick levelling course, consisting of OPSS.PROV 1010 (Aggregates), Granular 'A' or OPSS.PROV 1002 (Aggregates, Concrete) Concrete Fine Aggregate, shall be placed between the Granular 'A' bedding pad and the underside of the culvert to provide a levelling pad.

Prior to placing the granular pad, all organic soils, and any disturbed/loosened native soils should be sub-excavated to expose the undisturbed native subgrade soil within the limits of the culvert extension. The subgrade shall be inspected by qualified geotechnical personnel. Any sub-excavation required at the time of construction shall be backfilled with OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular B 'Type II' compacted to 95% of the materials Standard Proctor Maximum Dry Density (SPMDD), in accordance with OPSS.PROV 501 (Compacting). The sub-excavation area should be defined by lines extending from 0.3 m beyond the outside

edges of the proposed culvert base slab, outward and downward at 1H:1V. Following inspection and approval by qualified geotechnical personnel of the exposed subgrade, the granular pad shall be placed within 4 hours of subgrade approval.

Box culverts should be constructed in accordance with OPSS 422 (Box Culverts and Box Sewers in Open Cut) and OPSS 902 (Excavating and Backfilling Structures), amended by SP 109S61.

6.3.2.2 Geotechnical Resistances

The box culvert extension placed on the properly prepared subgrade as noted above should be designed based on the recommended factored ultimate and serviceability geotechnical resistances provided in the table below. The provided geotechnical resistances are based on the culvert dimensions provided on the GA dated April 2026. The geotechnical resistances should be reviewed if the founding elevation and/or the culvert width differ from those given below.

Culvert Type	Culvert Extension Dimensions	Founding Elevation (m)	Founding Condition	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance for 25 mm of Settlement (kPa)
Box Culvert	1.3 m outside width / 4.6 m long	237.7	0.3 m thick Compacted Granular Bedding Pad over firm sandy clayey silt	150	Does Not Govern ¹
			0.6 m thick Compacted Granular Bedding Pad over compact till	250	Does Not Govern ¹

Note: 1. The serviceability geotechnical resistances do not apply as the factored serviceability geotechnical resistance for 25 mm of settlement is greater than the factored ultimate axial geotechnical resistance.

The factored geotechnical resistances provided in the table above are based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.5 and Section C6.10.5 of the CHBDC (2019) and its Commentary.

Horizontal resistance is generated by the friction between the concrete box culvert (either cast-in-place concrete or precast concrete) and the underlying compacted granular bedding pad. Resistance to lateral forces or sliding resistance should be calculated in accordance with Section 6.10.4 of CHBDC (2019), applying a consequence factor of 1.0 and a geotechnical resistance factor of 0.8. The factored coefficient for sliding resistance for a cast in-place box culvert and a precast box culvert are provided in the table below.

Material Interface	Coefficient of Friction, $\tan \phi'$
Cast-In-Place box culvert on compacted Granular 'A' or 'B' Type II	0.60
Precast box culvert on compacted Granular 'A' or 'B' Type II	0.45

6.3.3 Open Footing Culvert Extension

6.3.3.1 Founding Elevations and Subgrade Preparation

The strip footing for an open footing culvert extension should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection against frost protection, as per OPSD 3090.101 (Foundation Frost Penetration Depths for Southern Ontario). Based on the current GA, the underside of the proposed culvert is at about Elevation 237.7 m and the lowest surrounding grade is at about Elevation 238.3 m. As such, strip footings for an open footing culvert should be founded at about Elevation 237.1 m on compact sandy silt till.

All organic soils and any disturbed/loosened native soils should be sub-excavated to expose the undisturbed native subgrade soil within the limits of the culvert extension. The subgrade shall be inspected by qualified

geotechnical personnel. Any sub-excavation required at the time of construction shall be backfilled with OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular B 'Type II' compacted to 95% of the materials Standard Proctor Maximum Dry Density (SPMDD), in accordance with OPSS.PROV 501 (Compacting). Following inspection and approval by qualified geotechnical personnel of the exposed subgrade, the concrete footings shall be placed within 4 hours of subgrade approval.

Open footing culverts shall be constructed in accordance with OPSS 902 (Excavating and Backfilling Structures), amended by SP 109S61.

6.3.3.2 Geotechnical Resistances

Strip footings placed on the properly prepared subgrade, at or below the founding elevation, should be designed based on the factored ultimate geotechnical resistance at ULS and the factored serviceability geotechnical resistance at SLS for 25 mm of settlement, as given in the table below. The provided geotechnical resistances are based on an assumed strip footing width of 0.6 m. The geotechnical resistances should be reviewed if the founding elevation and/or the footing dimensions differ from those given below.

Culvert Type	Footing Dimensions	Founding Elevation (m)	Founding Condition	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance for 25 mm of Settlement (kPa)
Open Footing	0.6 m wide / 4.62 m long	237.1	Compact Sandy Silt Till	250	Does Not Govern ¹

Note: 1. The serviceability geotechnical resistances do not apply as the factored serviceability geotechnical resistance for 25 mm of settlement is greater than the factored ultimate axial geotechnical resistance.

The factored geotechnical resistances provided above are based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.5 and Section C6.10.5 of the CHBDC (2019) and its Commentary.

Horizontal resistance is generated by the friction between the strip footing and the underlying till deposit. Resistance to lateral forces or sliding resistance should be calculated in accordance with Section 6.10.4 of CHBDC (2019), applying a consequence factor of 1.0 and a geotechnical resistance factor of 0.8. The factored coefficient for sliding resistance for cast in-place footings are provided in the table below.

Material Interface	Coefficient of Friction, $\tan \phi'$
Cast-In-Place concrete open footing culvert on sandy silt till	0.55

6.4 Lateral Earth Pressures for Design of Walls

The lateral earth pressures acting on the culvert walls will depend on the type and method of placement of backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. The following recommendations are made concerning the design of the culvert walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II, should be used as backfill behind the walls. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting). A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with Section 6.12.3 and Figure 6.8 of CHBDC (2019). Hand-operated compaction equipment should be used to compact the backfill soils immediately behind the walls as per OPSS.PROV 501. Other surcharge loadings should be accounted for in the design, as required.

- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.2 m behind the back of the wall as shown on Figure C6.31(a) of the Commentary to the CHBDC (2019).
- For unrestrained walls, granular fill should be placed within the wedge-shaped zone defined by a line flatter than 1H:1V extending up and back from the rear face of the footing or pile cap as shown on Figure C6.31(b) of the Commentary to the CHBDC (2019).
- The parameters (unfactored) summarized below may be used for wall design. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the Commentary to the CHBDC (2019).

Fill Type	Unit Weight of Material (kN/m ³)	Internal Angle of Friction, Φ (°)	Coefficients of Static Lateral Earth Pressure ¹		
			At-Rest, K_o	Active, K_a	Passive, K_p ²
Granular 'A' (compacted)	22	35	0.43	0.27	3.69
Granular 'B' Type II (compacted)	21	35	0.43	0.27	3.69

Notes:

1. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the abutment walls. If sloped surfaces are expected, the coefficients should be adjusted in accordance with CHBDC Clause C6.12.1, Figures C6.28 (active earth pressure) and C6.29 (passive earth pressure) and Clause C6.12.2.2 (at-rest earth pressure).
2. The total passive resistance may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement, in accordance with Figure C6.27 of the CHBDC (2019), to account for the fact that a large strain would be required for mobilization of the full passive resistance.

6.5 Cover and Backfill

Culvert construction, backfill and cover for a box culvert extension or open footing culvert extension should be completed in accordance with OPSS 803.010 (Backfill and Cover for Concrete Culverts with Spans Less than or Equal to 3.0 m). Backfill to the culvert walls and cover should consist of granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates), Granular 'A' or Granular 'B' Type II.

The backfill and cover should be placed and compacted in accordance with OPSS.PROV 501 (Compacting) as amended by Special Provision 105S22. The cover and backfill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 400 mm in accordance with OPSS.PROV 422. 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. Excavation, bedding and backfilling operations should be inspected in accordance with OPSS 902 (Excavating and Backfilling Structures).

Excavated material that meets the specifications for earth borrow as per OPSS.PROV 212 (Earth Borrow) may be used to backfill above the culvert cover material. Excavated fill material should be placed and compacted in accordance with OPSS.PROV 501 (Compacting) as amended by Special Provision 105S22.

6.6 Scour and Erosion Protection

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

As per "MTO Concrete Culvert Design and Detailing Manual" and MTO SS114-2, it is understood that a concrete cut-off wall (i.e., apron wall) will be required and should extend from the top of the bottom culvert slab to a depth

of 1.2 m, for the full width of the culvert. The apron wall should be founded on a 100 mm thick granular pad comprised of compacted OPSS 1010 Granular "A".

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

The requirements for and design of erosion protection measures for the culvert 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 OPSS 810.010 (Rip-Rap Layout for Sewer and Culvert Outlets), with the rip-rap placed up to the toe of slope level.

6.7 Global Stability

Fill placement along the embankment widening should be carried out as per OPSS 208.010 (Benching of Earth Slopes) to integrate the existing and new embankment fill, as appropriate. The existing embankment is inclined at about 2H:1V and appears to be in good condition with no evidence of instability. Considering the embankment will be flattened to about 3H:1V, and the embankment height is less than 4 m at the culvert location, global stability mitigation measures are not required.

6.8 Construction Considerations

6.8.1 Temporary Open-Cut Excavations

Excavations for construction of the culvert extension are anticipated to extend through compact gravelly sand fill, stiff silty clay fill, and potentially into the underlying compact sandy silt to silty sand till. All excavations must be carried out in accordance with Ontario Regulation 213 (Ontario Occupation Health and Safety Act for Construction Projects), as amended.

The overburden soils within the anticipated depths of excavation may be classified as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. As per Ontario Regulation 213, the soil type with the highest number governs temporary excavations and as such, the excavation side slopes should be formed no steeper than 3H:1V (Type 4 soil). However, the Contractor is responsible for the design of the temporary works, including an assessment of the excavation wall stability and any potential impacts associated with equipment, stockpiled soils, and/or construction materials placed within the vicinity of the excavations.

Excavated material must be stockpiled at a distance away from the excavation equal to or greater than the depth of the open cut excavation. Where inadequate space is available for stockpiling of the excavated material, off-site storage of the excavated material intended for reuse is required.

6.8.2 Control of Groundwater and Surface Water

The groundwater level measured at the site was about Elevation 238.1 m (measured September 2025). As such, excavations for box culvert or open footing culvert construction will extend below the groundwater level and some form of dewatering will be required to facilitate construction in dry conditions. Further, depending on the time of year of construction, surface water diversion / temporary flow passage systems may be required to facilitate construction in dry conditions. It is noted that at the time of the current investigation (September 2025), the culvert was dry.

Dewatering systems and temporary flow passage systems must be in accordance with OPSS.PROV 517 (*Dewatering*) and MTO's Special Provision 517F01 (*Dewatering System*). A sample Special Provision is provided in Appendix E. The fill-in in Table A of Special Provision 517F01 should indicate that a preconstruction survey is required at a distance equal to the approximate groundwater drawdown zone of influence (i.e. approximately 5 m distance) and that the groundwater drawdown should be taken to 1 m below the base of the excavation. 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 of Special Provision 517F01 should indicate “Yes” for the “Design Engineer Requirements”.

Provided adequate water flow diversion / flow passage is provided during construction, based on the soil conditions at this site and the anticipated culvert extension invert elevation, it is anticipated that an Environmental Activity Section Registry (EASR) will be required as per the Environmental Protection Act by the Ontario Ministry of Environment, Conservation and Parks (MECP) to facilitate dewatering / unwatering within the excavation.

Surface water shall be directed away from the excavation areas to prevent ponding of water that could impede foundation construction.

6.8.3 Obstructions

The contractor should be alerted to the potential presence of cobble and boulder obstructions within the till deposits, which could affect excavation, as well as the installation of dewatering systems. It is recommended that a Notice to Contractor be included in the Contract Documents to alert the Contractor of these obstructions. A sample Notice to Contractor regarding the subsurface conditions (i.e., cobble/boulder obstructions) is provided in Appendix E for inclusion in the Contract Documents. Note that the extent and depth of the cobble and boulder obstructions may vary beyond and between the borehole locations.

6.8.4 Corrosion Assessment and Protection

The results of analytical tests carried out on one soil sample are presented in Section 4.4 and on the Certificate of Analysis in Appendix D. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel elements.

For potential sulphate attack on concrete, the results of the soil analysis were compared to Table 3 in CAN/CSA-A23.1-19. The sulphate concentration was 0.012% in the sample analyzed, which is below the exposure class S-3 “Moderate”; and may be considered negligible according to Table 7.2 of the MTO Gravity Pipe Design Guidelines (2014).

The resistivity result indicates that the soil corrosiveness is severe ($R < 2,000$), as per Table 3.2 of the MTO Gravity Pipe Design Guidelines (2014).

The measured pH was 7.4. According to the MTO Gravity Pipe Design Guidelines (2014), pH levels between 5.5 and 8.5 are not considered detrimental to steel durability.

These recommendations are provided as guidance only; the structural designer should take the results of the laboratory testing and the potential for corrosion into consideration as part of the materials selection and to determine the appropriate exposure class and to ensure that all aspects of CAN/CSA-A23.1-19 Section 4.1.1 (Durability Requirements) are satisfied.

6.8.5 Temporary Protection Systems

It is understood that temporary protection systems are not likely required to facilitate construction of the proposed culvert extension. However, the soil parameters provided in Section 6.5.1 above may be used for temporary protection systems. The detailed design of the temporary protection systems is the responsibility of the Contractor.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Maor Levy, an Engineer-In-Training with WSP, and was reviewed by Ms. Anastasia Poliacik, P.Eng., a Senior Geotechnical Engineer with WSP and an MTO Principal Foundations Contact. Mr. David Staseff, P.Eng., a Senior Principal and MTO Principal Foundations Contact with WSP conducted a technical review of this report. Mr. Kevin Bentley, P.Eng. and MTO Principal Foundations Contact with WSP performed an independent quality review of this report.

WSP Canada Inc.



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Engineer-in-Training



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ML/AMP/DS/KJB/al

[https://wsponline.sharepoint.com/sites/ca-14m-00321-01/technical/07_early works - contract 3 - bovaird dr/04-foudations/7_deliverables/culvert extension fidr/5_final/14m-00321-01-hwy 413 bovaird culvert ext-fidr-rev0-08may2026.docx](https://wsponline.sharepoint.com/sites/ca-14m-00321-01/technical/07_early%20works%20-%20contract%203%20-%20bovaird%20dr/04-foudations/7_deliverables/culvert%20extension%20fidr/5_final/14m-00321-01-hwy%20413%20bovaird%20culvert%20ext-fidr-rev0-08may2026.docx)

REFERENCES

Canadian Standard Association (CSA) Group. *Canadian Highway Bridge Design Code (CHBDC (2019)) and Commentary on CAN/CSA-S6-19.*

Ministry of Transportation, Ontario. 2004. *Gravity Pipe Design Guidelines.*

SNC-Lavalin Inc., January 26, 2021. Geotechnical Investigation and Pavement Design for Bovaird Drive W Widening Project”, Reference No. 672432.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ontario Regulation 903 Wells (as amended)

Ontario Provincial Standard Specifications (OPSS):

OPSS.PROV 212 Construction Specification for Earth Borrow

OPSS.PROV 422 Construction Specification for Box Culverts and Box Sewers in Open Cut

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 517 Construction Specification for Dewatering

OPSS.PROV 803 Construction Specification for Vegetative Cover

OPSS.PROV 902 Construction Specification for Excavating and Backfilling – Structures

OPSS.PROV 1002 Construction Specification for Aggregates – Concrete

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

OPSS.PROV 1205 Construction Specification for Clay Seal

Special Provision 105S22 Amendment to OPSS PROV 501

Special Provision 517F01 Amendment to OPSS PROV 517

Special Provision 109S61 Amendment to OPSS.PROV 902

Special Provision 109F57 Amendment to OPSS.PROV 903

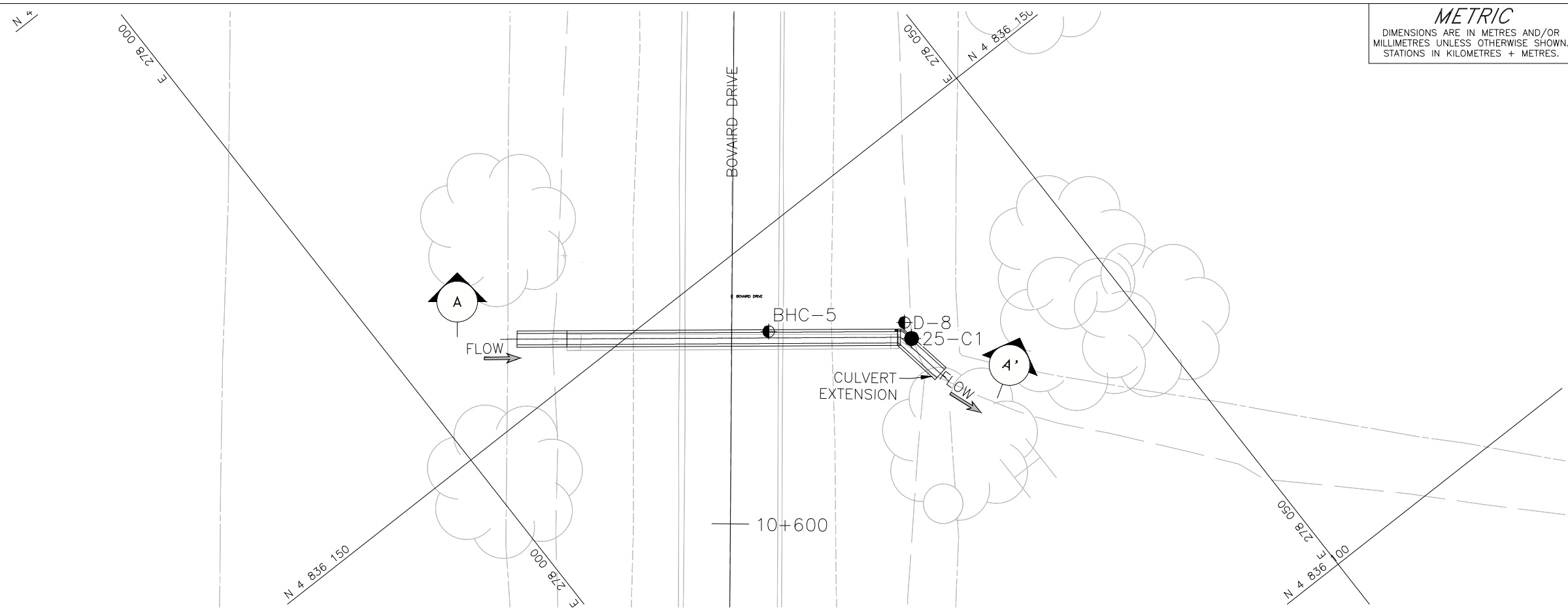
Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010 Benching of Earth Slopes

OPSD 803.010 Backfill and Cover for Concrete Culverts With Spans Less Than or Equal To 3.0 m

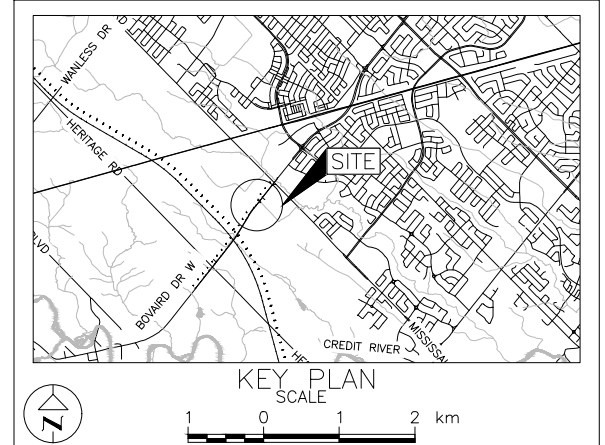
OPSD 810.010 General Rip-Rap Layout for Sewer and Culvert Outlets

OPSD 3090.101 Foundation, Frost Penetration Depths for Southern Ontario



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

CONT No. GWP No. 2034-24-00		SHEET
HIGHWAY 413 PROJECT CULVERT EXTENSION BOREHOLE LOCATIONS PLAN AND SOIL STRATA		

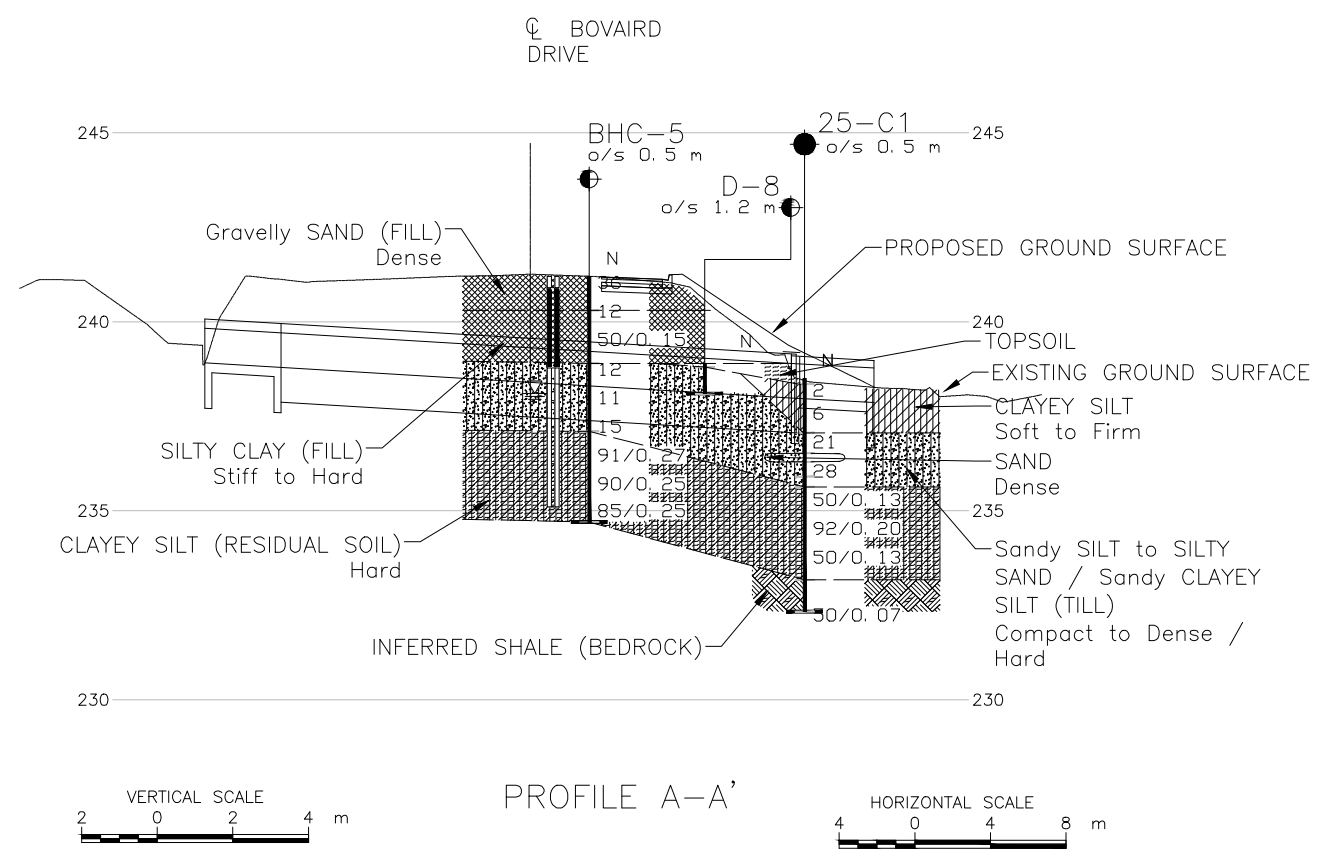


LEGEND

- Borehole - Current Investigation
- ⊙ Borehole - Previous Investigation
- ⊥ Seal
- ▭ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ▽ WL upon completion of drilling
- ▽ WL in piezometer, measured on September 29, 2025

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
25-C1	238.5	4836135.7	278034.1
BHC-5	241.2	4836143.3	278025.4
D-8	239.0	4836137.1	278034.5



NOTES

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

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

REFERENCE

Base plan provided in digital format by WSP, drawing file No. X-Base_West.dwg, received April 27, 2022.
Link to GA file No. GA (10+615.0.29).dwg Projectwise, received April 29, 2026.
Alignment provided by WSP, file No. H14M-00321-01-XA01.dwg.



NO.	DATE	BY	REVISION

Geocres No. 30M12-556

HWY. 413	PROJECT NO. CA-WSP-14M-00321-01	DIST. CENTRAL
SUBM'D.	CHKD. ML	DATE: 05/08/2026
DRAWN: SA	CHKD. AMP	APPD. KB
		DWG. 1

APPENDIX A

**2020 Investigation -
Borehole Records**

NOTES TO RECORD OF BOREHOLES

DRILLING DATA

Method:	-	
SolSt Auguring	-	Solid Stem Auguring
HolSt Auguring	-	Hollow Stem Auguring
WB	-	Washed Boring

LABORATORY DATA

W _P	-	Plastic Limit
W	-	Water Content (%)
W _L	-	Liquid Limit
γ	-	Natural Unit Weight (kN/m ³)
UNDR STRNG or c _u	-	Undrained Shear Strength (kPa)
		Field Vane: St-sensitivity
pp	-	Pocket Penetrometer
UC	-	Unconfined Compression
UU	-	Unconsolidated Undrained at Overburden Pressure
CU	-	Consolidated Undrained
CD	-	Consolidated Drained
TOV	-	Total Organic Vapors

SAMPLES TYPE

SS	-	Split Spoon
AS	-	Auger Sample
TW	-	Thin wall Open
TP	-	Thin wall Piston
WS	-	Washed Sample
BS	-	Block Sample
RC	-	Rock Core
PH	-	Sample Advanced Hydraulically
PM	-	Sample Advanced Manually

Standard Penetration Test: The Standard Penetration Test (SPT) 'N'-values are the number of blows required to cause a standard 51 millimeters o.d. split barrel sampler to penetrate 0.3 meter into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kilograms falling freely a distance of a 0.76 meter. For penetrations of less than 0.3 meter, N-values are indicated as the number of blows for the penetration achieved (e.g. 50/25: 50 blows for 25 centimeters penetration).

Dynamic Cone Penetration Test: Continuous penetration of a conical steel point (51 millimeters o.d. 60° cone angle) driven by 475 J impact energy on a size drill rods. The resistance to cone penetration is measured as the number of blows for each 0.3 meter advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency or relative density

CONSISTENCY: Cohesive soils are described on the basis of their undrained shear strength (c_u) or 'N'-values as follows:

c _u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	<i>VERY SOFT</i>	<i>SOFT</i>	<i>FIRM</i>	<i>STIFF</i>	<i>VERY STIFF</i>	<i>HARD</i>
N (blows/0.3 meter)	0 - 2	2 - 4	4 - 8	8 - 15	15 - 30	>30

COMPACTNESS CONDITION: Cohesionless soils are described on the basis of compactness condition as indicated by 'N'-values as follows:

N (blows/0.3 meters)	0 - 4	4 - 10	10 - 30	30 - 50	>50
	<i>VERY LOOSE</i>	<i>LOOSE</i>	<i>COMPACT</i>	<i>DENSE</i>	<i>VERY DENSE</i>

Rocks are described by their composition and structural features and/or strength

RECOVERY: Sum of all recovered rock core pieces from a coring run expressed as a percent of the total length of the coring run.

ROCK QUALITY DESIGNATION (RQD): Sum of those intact core pieces, 100 millimeters in length expressed as a percent of the length of the coring run. Classification of a rock based on the RQD value as follows:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	<i>VERY POOR</i>	<i>POOR</i>	<i>FAIR</i>	<i>GOOD</i>	<i>EXCELLENT</i>

JOINTING AND BEDDING:

SPACING	50 mm	50 - 300 mm	0.3 - 1.0 m	1.0 - 3.0 m	>3.0 m
JOINTING	<i>VERY CLOSE</i>	<i>CLOSE</i>	<i>MOD. CLOSE</i>	<i>WIDE</i>	<i>VERY WIDE</i>
BEDDING	<i>VERY THIN</i>	<i>THIN</i>	<i>MEDIUM</i>	<i>THICK</i>	<i>VERY THICK</i>

RECORD OF BOREHOLE No. **BHC-5**

Project Number: **672432** Drilling Location: **Westbound Shoulder** Logged by: **MA**
 Client: **Region of Peel** Drilling Method: **100 mm Solid Stem Augering** Compiled by: **MA**
 Project Name: **Bovaird Drive W - Geotechnical Investigation and Pavement Analysis** Drilling Machine: **Truck Mounted Drill D25** Reviewed by: **AK**
 Location: **Bovaird Dr W, Brampton** Date Started: **Sep 22, 2020** Date Completed: **Sep 22, 2020** Revision No.: **0**

Lithology Profile	SOIL SAMPLING				DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	EASTING: 594170 NORTHING: 4835301.52
	DESCRIPTION	Sample Type	Sample Number	Recovery (%)						
	Local Ground Surface Elevation: 241.15 m									
LITHOLOGY PROFILE PAVEMENT GRANULAR Grey, dense to compact, gravelly SAND, some silt, moist 240.2 Brownish grey, stiff, silty CLAY, some sand, trace gravel, some asphalt particles, moist becomes hard 238.9 NATIVE TILL Brown, compact, sandy SILT, trace to some clay, trace to some gravel, moist becomes wet 237.0 Reddish brown, very stiff, silty CLAY, some sand to sandy, trace weathered shale fragments, moist GR: 10%; SA: 10%; FA: 80% becomes hard GR: 14%; SA: 47%; SI: 29%; CL: 10% 234.6 End of Borehole.	SS	01	75	36		241				
						240				
		SS	02	100	12		240			
							239			
		SS	03	100	50 / 150 mm		239			
							238			
		SS	04	75	12		238			
							237			
		SS	05	38	11		237			
						236				
	SS	06	100	15		237				
						236				
	SS	07	91	91 / 275 mm		236				
						235				
	SS	08	100	90 / 250 mm		235				
						235				
	SS	09	100	85 / 250 mm		235				
						235				
						235				

SNC-LAVALIN
 401 Hanlan Rd
 Vaughan, Ontario L4L 3T1
 Tel: 905-851-0090

Groundwater depth on completion of drilling: **4.1 m** Cave in depth recorded on completion of drilling: **4.6 m.**
 Groundwater depth observed on **07/10/2020** at a depth of: **dry m.**

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Notes to Record of Boreholes'.

Scale: 1 : 38
 Page: 1 of 1

RECORD OF BOREHOLE No. D-8

Project Number: **672432** Drilling Location: **Eastbound Ditch** Logged by: **FS**
 Client: **Region of Peel** Drilling Method: **75 mm Hand Augering** Compiled by: **MA**
 Project Name: **Bovaird Drive W - Geotechnical Investigation and Pavement Analysis** Drilling Machine: **Hand Auger** Reviewed by: **AK**
 Location: **Bovaird Dr W, Brampton** Date Started: **Sep 24, 2020** Date Completed: **Sep 24, 2020** Revision No.: **0**

LITHOLOGY PROFILE		SOIL SAMPLING				FIELD TESTING		LAB TESTING				INSTRUMENTATION INSTALLATION	EASTING: 594179.2 NORTHING: 4835295.47				
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing ○ SPT ● DCPT MTO Vane* Nilcon Vane* △ Intact ◇ Intact ▲ Remould ◆ Remould * Undrained Shear Strength (kPa) 20 40 60 80					★ Rinse pH Values 2 4 6 8 10 12 △ Soil Vapour Reading parts per million (ppm) 100 200 300 400 ▲ Lower Explosive Limit (LEL) * Passing 75 um (%) ○ Moisture Content (%) Atterberg Limits W _p W _L				COMMENTS
	Local Ground Surface Elevation: 237.98 m																
	Topsoil ~ 100 mm 237.9																
	NATIVE TILL Brown to dark grey, silty CLAY, some sand, trace gravel, moist 0.1	AS	01														
	End of Borehole 237.2 0.8																
	Notes: 1. GA, SA, SI and CL denote Gravel, Sand, Silt and Clay																

DRAFT

APPENDIX B

**Current Investigation -
Borehole Records**

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

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY COMPONENTS^{1,2}

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (<i>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)

- Only applicable to components not described by Primary Group Name.
- 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)
Y	unit weight

- 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

- 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.
- 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

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- 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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_{\alpha(e)}$	secondary compression index
C_{α}	rate of secondary compression
$C_{\alpha(e)}$	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 = σ'_p / σ'_{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

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

Notes: 1
2

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING CLASSIFICATION

Fresh (W1): no visible sign of rock material weathering.

Slightly Weathered (W2): discoloration indicates weathering of rock mass material on discontinuity surfaces. **Less than 5%** of rock mass is altered or weathered.

Moderately Weathered (W3): less than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Highly Weathered (W4): more than 50% of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

Completely Weathered (W5): 100% of the rock mass is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.

Residual Soil (W6): all rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

AXJ Axial Joint	KV Karstic Void
BD Bedding	K Slickensided
BC Broken Core	LC Lost Core
CC Continuous Core	MB Mechanical Break
CL Closed	PL Planar
CO Contact	PO Polished
CU Curved	RO Rough
CT Coated	SA Slightly Altered
FLT Fault	SH Shear
FOL Foliation	SM Smooth
FR Fracture	SR Slightly Rough
GO Gouge	SY Stylolite
IN Infilled	UN Undulating
IR Irregular	VN Vein
JN Joint	VR Very Rough

ISRM Intact Rock Material Strength Classification

Grade	Description	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	0.25 – 1.0
R1	Very weak rock	1.0 – 5.0
R2	Weak rock	5.0 – 25
R3	Medium strong rock	25 – 50
R4	Strong rock	50 -100
R5	Very strong rock	100 -250
R6	Extremely strong rock	>250



PROJECT 14M-00321-00 **RECORD OF BOREHOLE No 25-C1** SHEET 1 OF 1 **METRIC**

G.W.P. 2034-24-00 LOCATION N 4836135.7; E 278034.1 MTM NAD 83 ZONE 10 (LAT. 43.664693; LONG. -79.831887) ORIGINATED BY ML

DIST Central HWY 413 BOREHOLE TYPE 98 mm O.D. Tri-cone with Manual Half-weight Hammer COMPILED BY _____

DATUM CGVD28:78 DATE September 10, 2025 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 (%)						
						20	40	60	80	100	20	40	60	80	100	10	20	30	GR	SA	SI	CL	
238.5	GROUND SURFACE																						
238.0	TOPSOIL (150 mm)																						
0.2	Sandy CLAYEY SILT (CL), trace gravel Soft to firm Brown Moist - Rootlets at a depth of 0.2 m to 0.7 m - Mottling in sample 2 at a depth of 0.7 m to 1.5 m		1	SS	2																		
			2	SS	6																		5 23 53 19
237.1	Sandy SILT (ML), trace gravel, trace clay (TILL) Compact Brown Moist		3A	SS	21																		9 40 48 3
236.5	SAND (SP), trace fines, trace gravel		3B																				
236.3	SANDY CLAYEY SILT (CL), trace gravel (TILL)		4A																				
235.9	Very stiff Brown Moist		4B	SS	28																		
235.6	SILTY SAND (SM), trace gravel (TILL) Very dense Reddish brown Moist		4C																				
235.2	CLAYEY SILT (CL), trace sand, contains shale fragments (INFERRED RESIDUAL SOIL) Hard Red Moist - Hard drilling from a depth of 2.9 m to 5.3 m		5	SS	50/0.13																		
234.8			6	SS	92/0.20																		
234.2			7	SS	50/0.13																		
233.2	Inferred red SHALE (BEDROCK) - Grinding at a depth of about 5.3 m																						
232.3	NOTES: 1. The presented SPT "N-Values" have been halved due to use of halfweight hammer. 2. Borehole open upon completion of drilling. 3. Water level could not be measured due to introduction of water via mud rotary method. *Water level not representative due to introduction of water via mud rotary method.		8	SS	50/0.07																		

GTA-MTO 001 S:\CLIENTS\MTOWHWY_413002_DATA\GINT\HWY_413.GPJ GAL-GTA.GDT 10/22/25

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

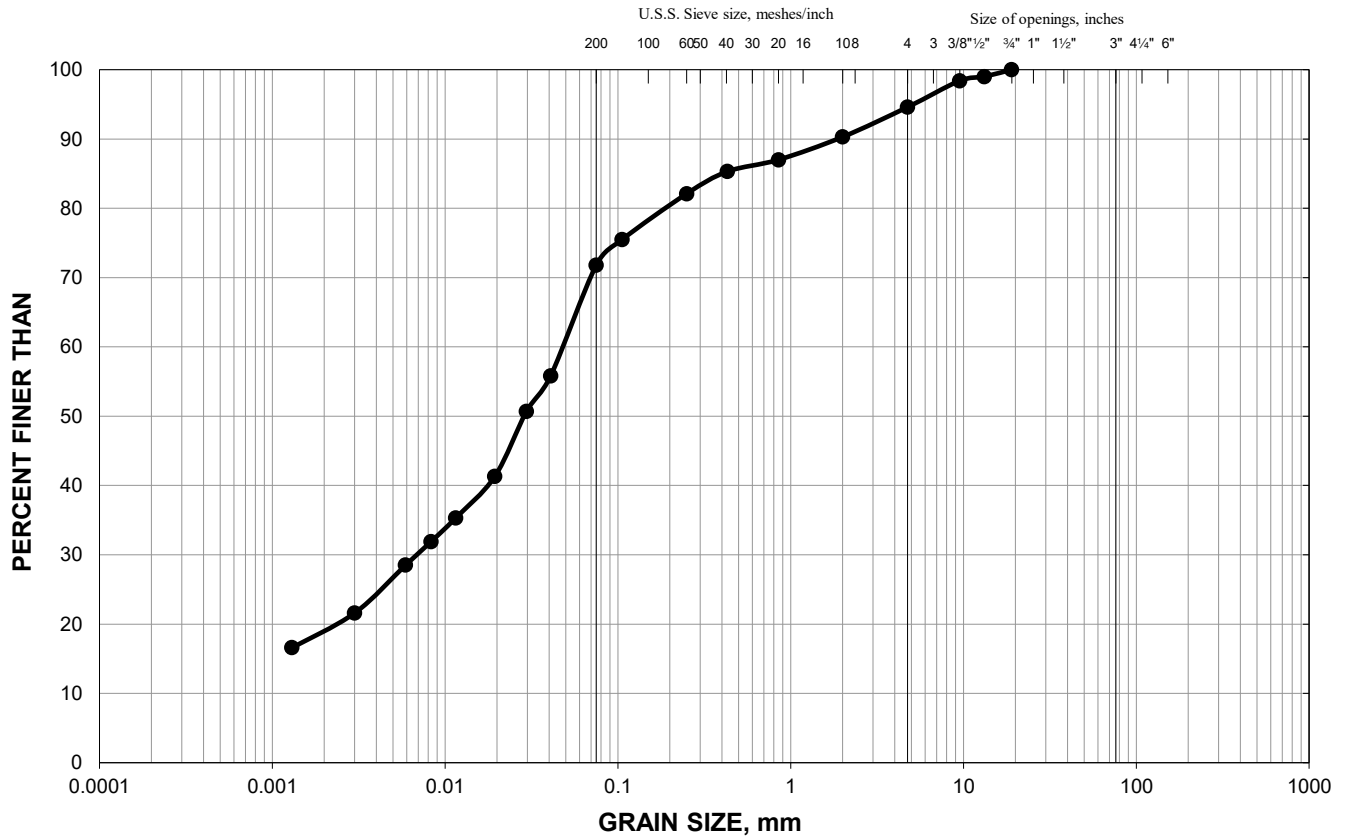
APPENDIX C

**Geotechnical Laboratory
Test Results**

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT (CL)

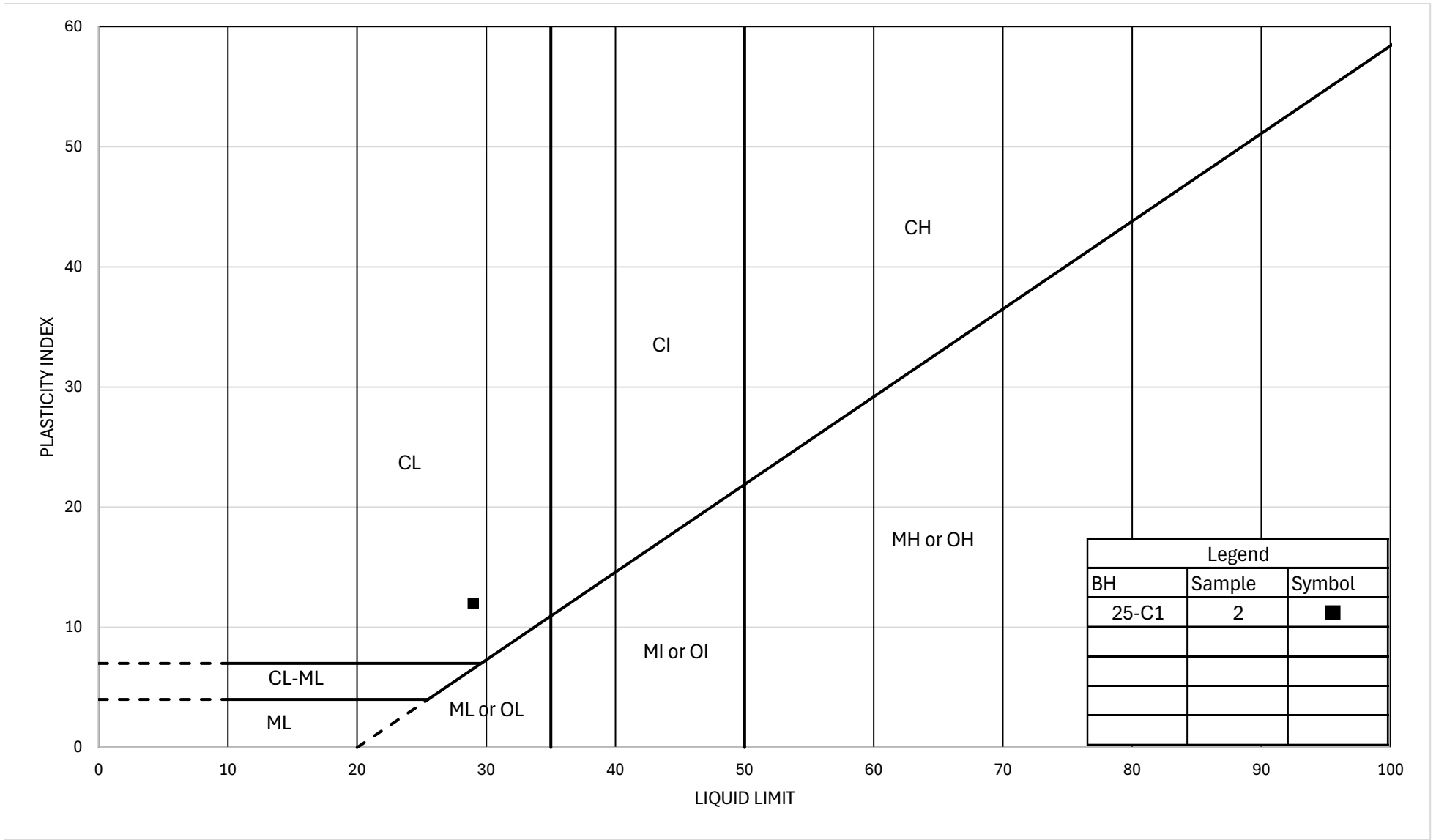
FIGURE C-1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	Elevation (m)
—●—	25-C1	2	237.4



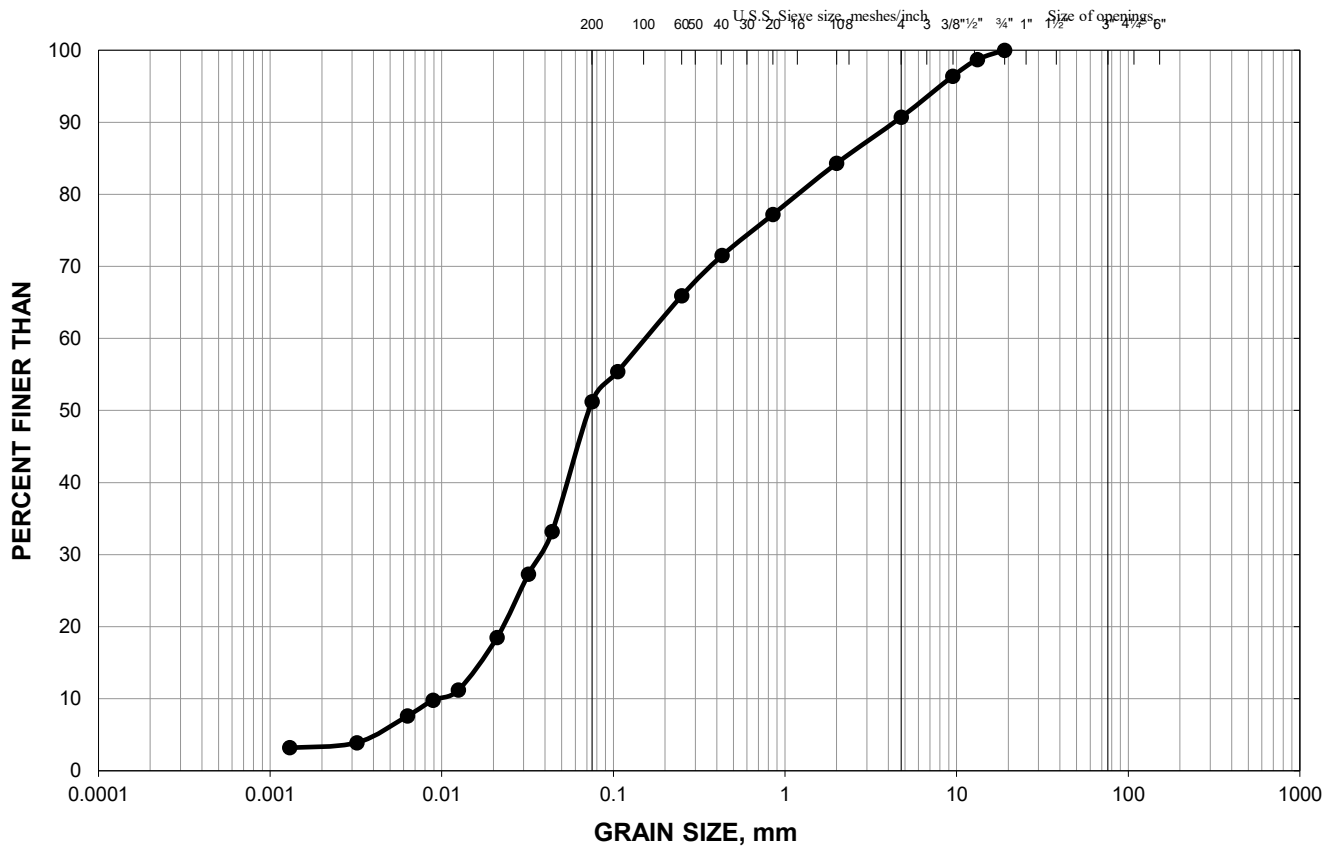
PLASTICITY CHART
Sandy CLAYEY SILT (CL)

Figure No.:	C-2
Project No.:	14M-00321-01
Produced by:	ML
Checked by:	AMP

GRAIN SIZE DISTRIBUTION

Glacial Till

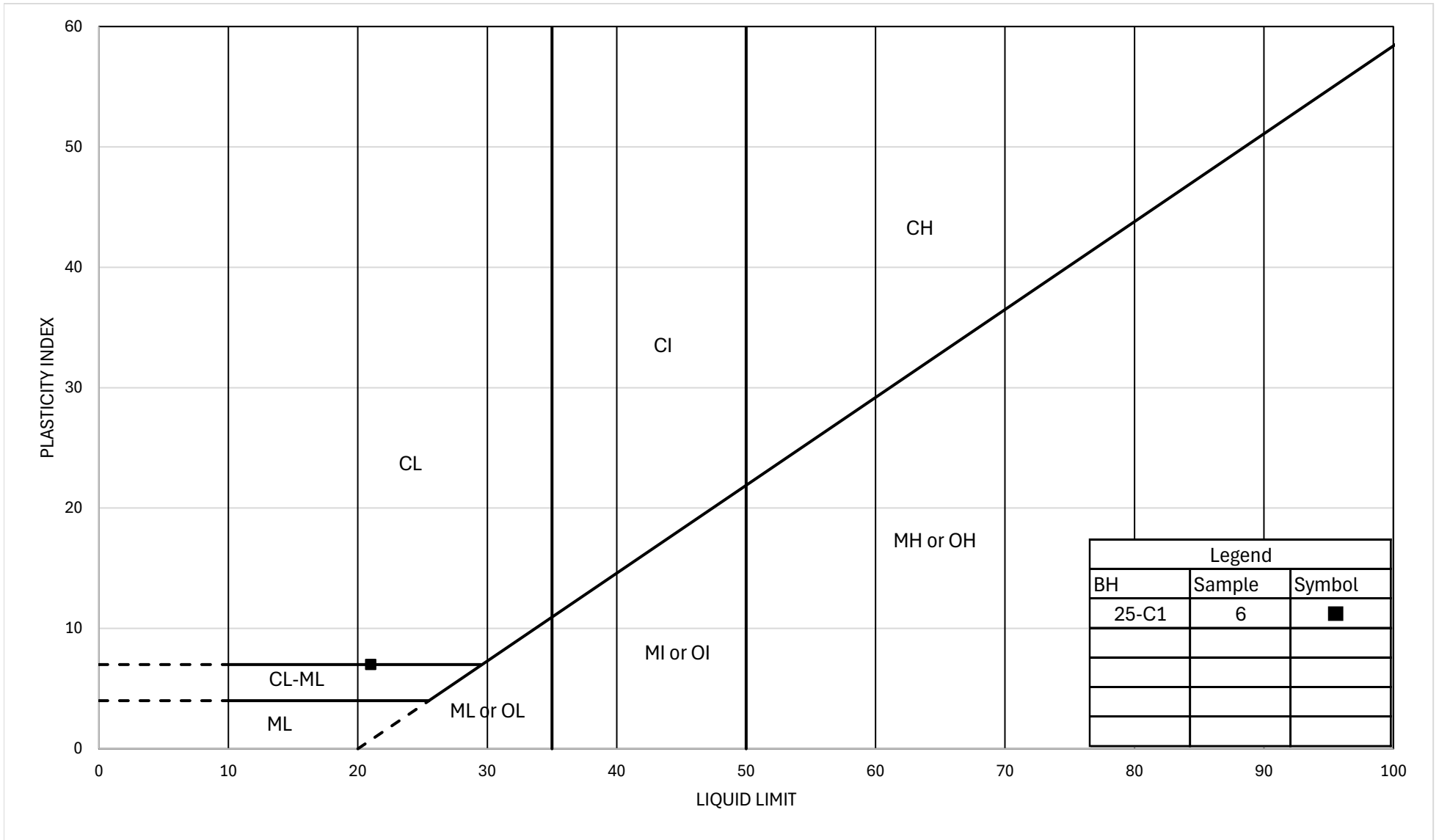
FIGURE C-3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	Elevation (m)
—●—	25-C1	3A	236.8



PLASTICITY CHART
Residual Soil

APPENDIX D

Analytical Laboratory Test Results



Your P.O. #: 14M-00321-01 TASK 1003.904
 Your Project #: 14M-00321-01 TASK 1003.904
 Site Location: BRAMPTON, ONTARIO
 Your C.O.C. #: MB-041

Attention: Maor Levy

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

Report Date: 2025/10/15
 Report #: R8631318
 Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C5C2461

Received: 2025/09/30, 17:28

Sample Matrix: Soil
 # Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2025/10/06	2025/10/06	CAM SOP-00463	MOE E3013 m
Conductivity	1	2025/10/06	2025/10/06	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2025/10/06	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2025/10/06	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2025/10/04	2025/10/04	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	1	2025/10/06	2025/10/07	CAM SOP-00421	SM 24 2580 B
Resistivity of Soil	1	2025/09/30	2025/10/06	CAM SOP-00414	SM 24 2510 m
Sulphate (20:1 Extract)	1	2025/10/06	2025/10/06	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, EPA, APHA or the Quebec Ministry of Environment.

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 P.O. #: 14M-00321-01 TASK 1003.904
Your Project #: 14M-00321-01 TASK 1003.904
Site Location: BRAMPTON, ONTARIO
Your C.O.C. #: MB-041

Attention: Maor Levy

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

Report Date: 2025/10/15
Report #: R8631318
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C5C2461

Received: 2025/09/30, 17:28

(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:

Keshani Vijh, Sr. Project Manager
Email: keshani.vijh@bureauveritas.com
Phone# (905) 817-5700

=====

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BUREAU
VERITAS

Bureau Veritas Job #: C5C2461
Report Date: 2025/10/15

WSP Canada Inc.
Client Project #: 14M-00321-01 TASK 1003.904
Site Location: BRAMPTON, ONTARIO
Your P.O. #: 14M-00321-01 TASK 1003.904
Sampler Initials: ML

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		AVSJ92		
Sampling Date		2025/09/30		
COC Number		MB-041		
	UNITS	25-C1 SS1	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	1900		A021785
CONVENTIONALS				
Redox Potential	mV	190	N/A	A025765
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	120	20	A025864
Conductivity	umho/cm	533	2	A025795
Available (CaCl2) pH	pH	7.42		A025544
Soluble (20:1) Sulphate (SO4)	ug/g	120	20	A025878
Sulphide	mg/kg	1.16 (1)	0.50	A027191
RDL = Reportable Detection Limit QC Batch = Quality Control Batch N/A = Not Applicable (1) Sample contained greater than 10% headspace at time of extraction.				



**BUREAU
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Sampler Initials: ML

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		AVSJ92		
Sampling Date		2025/09/30		
COC Number		MB-041		
	UNITS	25-C1 SS1	RDL	QC Batch
Physical Testing				
Moisture-Subcontracted	%	16	0.30	A027192
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				



**BUREAU
VERITAS**

Bureau Veritas Job #: C5C2461
Report Date: 2025/10/15

WSP Canada Inc.
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Site Location: BRAMPTON, ONTARIO
Your P.O. #: 14M-00321-01 TASK 1003.904
Sampler Initials: ML

TEST SUMMARY

Bureau Veritas ID: AVSJ92
Sample ID: 25-C1 SS1
Matrix: Soil

Collected: 2025/09/30
Shipped:
Received: 2025/09/30

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	A025864	2025/10/06	2025/10/06	Massarat Jan
Conductivity	AT	A025795	2025/10/06	2025/10/06	Gurparteek KAUR
Moisture (Subcontracted)	BAL	A027192	N/A	2025/10/06	Amsaveni Murugesan
Sulphide in Soil	SPEC	A027191	N/A	2025/10/06	Naitik Jigneshbhai Desai
pH CaCl2 EXTRACT	AT	A025544	2025/10/04	2025/10/04	Sreena Thekkoot
Redox Potential	COND	A025765	2025/10/06	2025/10/07	Gurparteek KAUR
Resistivity of Soil		A021785	2025/10/06	2025/10/06	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	A025878	2025/10/06	2025/10/06	Massarat Jan



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GENERAL COMMENTS

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

Package 1	7.3°C
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Results relate only to the items tested.



BUREAU
VERITAS

Bureau Veritas Job #: C5C2461

Report Date: 2025/10/15

QUALITY ASSURANCE REPORT

WSP Canada Inc.

Client Project #: 14M-00321-01 TASK 1003.904

Site Location: BRAMPTON, ONTARIO

Your P.O. #: 14M-00321-01 TASK 1003.904

Sampler Initials: ML

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
A025544	Available (CaCl ₂) pH	2025/10/04			99	97 - 103			1.5	N/A
A025765	Redox Potential	2025/10/07			100	95 - 105			12	35
A025795	Conductivity	2025/10/06			101	90 - 110	<2	umho/cm	0.33	10
A025864	Soluble (20:1) Chloride (Cl ⁻)	2025/10/06	NC	70 - 130	99	70 - 130	<20	ug/g	1.3	35
A025878	Soluble (20:1) Sulphate (SO ₄)	2025/10/06	NC	70 - 130	100	70 - 130	<20	ug/g	12	35
A027191	Sulphide	2025/10/06	151 (1)	75 - 125	118	75 - 125	<0.50	mg/kg	NC	30
A027192	Moisture-Subcontracted	2025/10/06					<0.30	%		

N/A = Not Applicable

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

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

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

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

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

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

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.



BUREAU
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Site Location: BRAMPTON, ONTARIO
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VALIDATION SIGNATURE PAGE

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

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

Louise Harding, Scientific Specialist

Suwan (Sze Yeung) Fock, B.Sc., Scientific Specialist

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6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/6

WORK ORDER

CHAIN OF CUSTODY RECORD

Invoice Information		Report Information (if differs from invoice)				Project Information (where applicable)				Turnaround Time (TAT) Required					
Company Name: WSP Canada Inc		Company Name: WSP Canada Inc				Quotation #: _____				<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses					
Contact Name: Canada Accounts Payable		Contact Name: Maor Levy				P.O. #/ AFE#: 14M-00321-01 task 1003.904				PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS					
Address: 6925 Century Ave. Suite 100 Mississauga, ON		Address: 6925 Century Ave. Suite 100 Mississauga, ON L5N 7K2				Project #: _____				Rush TAT (Surcharges will be applied)					
Phone: 905-567-4444 Fax: 905-567-6561		Phone: 289-838-4608 Fax: 905-567-6561				Site Location: Brampton, Ontario				<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days					
Email: CAPayablesInvoice@wsp.com		Email: maor.levy@wsp.com				Site Location Province: _____ Ontario				Date Required: _____					
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS DRINKING WATER CHAIN OF CUSTODY															
Regulation 153 <input checked="" type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Utner <input type="checkbox"/> Table _____ FOR RSC (PLEASE CIRCLE) Y / N			Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer bylaw <input type="checkbox"/> PWQU <input type="checkbox"/> region _____ <input type="checkbox"/> Other (Specify) _____ <input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED) <input type="checkbox"/> REG 406 Table _____			Analysis Requested # OF CONTAINERS SUBMITTED FIELD FILTERED (CIRCLE) Metals / Hg / CrVI BTEX/ PHC F1 PHC F2 - F4 VOCs REG 153 METALS & INORGANICS REG 153 ICPMS METALS REG 153 METALS (Hg, Cr, VI, ICPMS Metals, HWS - B) Corrosivity Package (+ Sulphide)						LABORATORY USE ONLY CUSTODY SEAL Y / N Present Intact COOLER TEMPERATURES COOLING MEDIA PRESENT: <input checked="" type="checkbox"/> Y / N			
SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS															
SAMPLE IDENTIFICATION		DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHC F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr, VI, ICPMS Metals, HWS - B)	Corrosivity Package (+ Sulphide)	HOLD - DO NOT ANALYZE	COMMENTS
1 25-C1 SS1		2025-09-30	PM	SOIL	2								X		2 Jars
2															
3															
4															
5															
6															
7															
8															
9															
10															
RELINQUISHED BY: (Signature/Print)		DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)		DATE: (YYYY/MM/DD)	TIME: (HH:MM)								
<i>Maor Levy</i> / Maor Levy		2025/09/30	17:25	<i>Trevor Rodrigues</i> TREVOR RODRIGUES		2025/09/30	17:28								



NONT-2025-09-6564

APPENDIX E

Non-Standard Special Provisions

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		
Bovaird Underpass						Yes	
Culvert Extension						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)		
Bovaird Underpass	35 m	1 m			Yes		
Culvert Extension	5 m	1 m			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://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.							

OBSTRUCTIONS – Item No.

Notice to Contractor

The Contractor shall also be alerted to the potential presence of cobbles and boulders within the glacial till deposits at this site. Consideration of the presence of these obstructions shall be made in the selection of appropriate equipment and procedures for excavations and installation of dewatering systems and any temporary protection systems.

