



**FINAL REPORT**

# Foundation Investigation & Design Report

*Replacement of Structural Culvert 29X-0229/C0*

*Highway 41, Grattan, Ontario*

*MTO GWP 4123-17-00; Agreement Number 4021-E-0021-04*

Submitted to:

**Ministry of Transportation Ontario**

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**PART A**

# **Foundation Investigation Report**

Replacement of Structural Culvert 29X-0229/C0

Highway 41, Grattan, Ontario

MTO GWP 4123-17-00; Agreement Number 4021-E-0021-04

## 1.0 INTRODUCTION

WSP Canada Inc. (WSP, formerly Golder Associates Ltd., amalgamated with WSP in 2023), has been retained by the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation associated with the detailed design for the replacement of Structural Culvert No. 29X-0229/C0. The foundation investigation services for this project have been delivered under MTO Agreement No. 4021-E-0021-04 as part of GWP 4123-17-00.

## 2.0 SITE DESCRIPTION AND GEOLOGY

### 2.1 Site Description

The orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and may differ from magnetic north shown on the foundations drawing. For the purpose of this report, Highway 41 is oriented in a north-south direction with the culvert positioned approximately perpendicular to the highway in an east-west orientation.

Culvert 29X-0229/C0 is located at about Station 14+878 on Highway 41 approximately 1.4 km north of Opeongo Road, in Renfrew County. The site location is shown on the key plan in Drawing 1.

Based on the information provided in Ainley Group Consulting Engineers and Planners Ltd. (Ainley) Structural Design Report (SDR) dated April 2024, the existing culvert consists of a Structural Plate Corrugated Steel Pipe Arch (SPCSPA) with a span of 3.1 m and a rise of 2.1 m. The culvert extends below Highway 41 westbound lanes and eastbound lanes over a total length of approximately 25.6 m. The watercourse flows from west to east at this site. According to the drainage report prepared for this project, the culvert inlet and outlet were designed at Elevations 195.0 m and 194.7 m, respectively.

At the culvert location, Highway 41 is an undivided two-lane rural collector highway with gravel shoulders. The highway grade is at approximately Elevation 199 m, and there is approximately 0.7 m to 1.0 m thickness of fill above the top of the existing culvert. There is approximately 1.0 m of cover over the existing culvert and the embankments are about 2.5 m high with side slope inclined at about 2 horizontals to 1 vertical (2H:1V). Meadow marsh wetlands are present both upstream and downstream of the culvert, west and east of the highway, respectively.

Based on our site observations at the time of the field investigation and a review of the available site photographs/satellite images, the existing embankments north and south of the culvert area appear to be performing satisfactorily. Ainley's SDR reports indicates that there is some erosion and undermining noted at the inlet and outlet. There was no visual evidence of instability (i.e., soil movement) on the embankment side slopes, nor tension cracks near the embankment crest that would be indicative of instability.

Site photographs showing the general conditions of the site at the time of the 2023 investigation are presented in Appendix F.

## 2.2 Regional Geology

The overall study area is generally located within the Physiographic Region known as the Algonquin Highlands as delineated in The Physiography of Southern Ontario<sup>1</sup> (Chapman and Putnam, 1984). The overburden within the physiographic region is shallow in nature, generally stony, sandy, with outwash sand and gravel within the valleys. There are frequent swamps, bogs, and outcrops of bare rock.

Available mapping indicates that the bedrock in this region is carbonate meta-sedimentary rocks of the Grenville Supergroup and Flinton Group.

## 3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out in two mobilizations that included advancing a total five boreholes (i.e., Boreholes 23-01 to 23-05). Boreholes 23-03 to 23-05 were advanced from the top of the roadway embankment between August 10 and 14, 2023. Due to in-water work restrictions, the inlet and outlet Boreholes 23-01 and 23-02 were advanced on October 25 and 27, 2023 at the embankment toes. The borehole locations are shown on Drawing 1.

Boreholes 23-03 to 23-05 were advanced with a CME75 truck-mounted drilling rig. Borehole 23-02 was advanced adjacent the culvert inlet from a floating platform using portable drill equipment. Borehole 23-01 was advanced on land adjacent the culvert outlet using portable drilling equipment. The drilling equipment was supplied and operated by OGS Drilling of Althea, Ontario.

Soil samples were obtained using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)<sup>2</sup>. Soil samples were obtained at vertical sampling intervals of about 0.76 m at Boreholes 23-03 to 23-05 and near continuous sampling at Boreholes 23-01 and 23-02 that were advanced with the portable drilling equipment.

NQ-sized bedrock core samples were obtained using rotary diamond drilling techniques and a triple-tube core-barrel at Boreholes 23-03 to 23-05. Bedrock rock core samples were obtained from Boreholes 23-01 and 23-02 using BW-casing and a 75 mm outside diameter thin-walled core-barrel.

A monitoring well was installed at Borehole 23-05, to observe the stabilized groundwater level at the site. The monitoring well consists of 52 mm outside diameter PVC tubing with a 1.5 m long slotted screen. The borehole containing the monitoring well was backfilled with bentonite mixed with cuttings to the underside of the well screen depth, followed by a sand pack to 0.6 m above the top of the well screen, followed by a minimum 1.5 m thick layer of bentonite to form a “cap” over the well screen, followed by a layer of bentonite mixed with cuttings to ground surface. The groundwater level was measured in the monitoring well on August 14, 2023, and again on October 24, 2023. The monitoring well was also decommissioned on October 24, 2023, by qualified personnel in accordance with Ontario Regulation 903 (amended) after taking the final reading. The site conditions were restored following completion of the fieldwork.

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

<sup>2</sup> ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

The boreholes without monitoring wells were backfilled with bentonite within the bedrock, and bentonite mixed with soil cuttings within the overburden. The boreholes were backfilled in general accordance with the intent of Ontario Regulation (O.Reg.) 903, as amended.

The fieldwork was supervised on a full-time basis by WSP's technical staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labeled containers, and transported to WSP's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses, and organic content determinations were carried out on selected soil samples and uniaxial compressive strength (UCS) testing was carried out on selected samples of the bedrock. The laboratory tests were carried out to MTO LS and/or ASTM Standards, as applicable at WSP's Ottawa laboratory.

Two soil samples were sent to Eurofins Environmental Testing Canada Inc. (Eurofins) for basic chemical analysis related to potential corrosion of buried steel elements and sulfate attack on buried concrete elements (corrosion and sulphate attack).

The borehole locations and elevations were surveyed by WSP using a Trimble R10 GPS unit referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 9 geodetic datum. The Trimble R10 GPS data has a vertical accuracy of approximately 0.1 m and a horizontal accuracy of approximately 0.5 m in accordance with the requirements of MTO's Guideline for Foundation Engineering Services (Version 3.0). The borehole locations, including northing and easting coordinates, ground surface elevations, and drilled depths are summarized in Table 1.

**Table 1: Summary of Borehole Locations**

Borehole	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Drilled Depths (m)	Comments
	Northing (m), (Latitude)	Easting (m), (Longitude)			
23-01	5027965.7 (45.390460°)	264131.3 (-77.019388°)	197.2	7.1	Bedrock Cored
23-02	5027966.5 (45.390465°)	264105.7 (-77.019530°)	197.0	5.3	Bedrock Cored
23-03	5027973.0 (45.390520°)	264119.9 (-77.019530°)	198.8	8.7	Bedrock Cored
23-04	5027989.0 (45.390660°)	264118.2 (-77.019550°)	198.8	8.8	Bedrock Cored
23-05	5027959.4 (45.390390°)	264117.0 (-77.019570°)	199.1	10.2	Bedrock Cored

### 3.1 Species at Risk and Fisheries Act Desktop Screening

During the initial site visit carried out by WSP prior to commencing field work at the site, several environmental issues were noted. After discussions and approval from MTO, WSP carried out a Species at Risk (SAR) desktop assessment and Mitigation Assessment Under the Fisheries Act for the proposed field investigation at the culvert site. The results of the assessment are presented in the Technical Memorandums in Appendix E. In summary the findings indicate that the field investigation works as outlined above would have no impacts to SARs both on-land

or in-water or to the habitat, and as such, there is not a need for any approvals or permits under the *Endangered Species Act, 2007* (ESA; Ontario 2007) and the *Species at Risk Act* (SARA; Canada 2002). It is noted that this screening was carried out based on the proposed field investigation only and may not cover the proposed construction activities or timelines. As such further screening may be required prior to conducting the construction works at the site.

## 3.2 2021 Investigation

A field investigation was carried out at the Culvert 29X-0229/C0 site in 2021 by Ainley. The subsurface information and results of the original investigation are contained in the following report:

- Draft Foundation Investigation Report, Structural Culvert 29x-0229/C0, Agreement 4017-E-0053 Assignment 23" dated November 2021, prepared by Ainley Group Consulting Engineers and Planners Ltd. AG File No. 18804-23.

A copy of the borehole locations and Record of Boreholes relevant to the current investigation are provided for reference in Appendix C and the Soil Strata have been incorporated into Drawings 1 and 2. The results of the 2021 investigation have also been incorporated into the following description of the subsurface conditions.

## 4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

### 4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the current investigation are shown on the Records of Borehole, and Drillhole sheets presented in Appendix A. The results of the laboratory testing carried out during the investigation are presented on the Record of Borehole sheets as well as in Figures B1 to B4 in Appendix B. The borehole locations and the interpreted stratigraphic profiles projected along the existing culvert alignment, and parallel to the centerline of Highway 41, are provided in Drawings 1 to 2, respectively.

Photographs of the core samples recovered from the underlying bedrock are shown in Figures A1 to A10, provided in Appendix A. The results of the chemical testing/analysis completed on select soil samples are provided in Appendix D.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic sections in Drawings 1 and 2, are inferred from observations of the drilling progress and noncontinuous sampling and therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

### 4.2 Site Stratigraphy Overview

At the borehole locations, the subsurface conditions generally consist of the existing pavement structure (asphalt and pavement granular material) overlying embankment fill in boreholes advanced on the highway, or topsoil/peat in boreholes advanced at the culvert ends, underlain by a deposit of generally compact silty sand to sand with varying amounts of gravel over a silty sand to sandy silty gravel (glacial) till, underlain by bedrock. A deposit of peat was encountered below the embankment fill at Boreholes 23-04, and 23-05 from the current investigation, and at BH1 from the 2021 investigation.

A more detailed description of the overburdened soil deposits encountered during the field investigation is provided in the following sections.



#### **4.2.1 Pavement Structure and Embankment Fill**

Asphalt with a thickness of approximately 100 mm was encountered at the surface of Boreholes 23-03 to 23-05.

Fill layers comprised of sandy gravel (base/sub-base layers of pavement structure) and sand with varying amounts of gravel and silt (embankment fill) were encountered below the asphalt at Boreholes 23-02 to 23-05 and at the ground surface of Boreholes BH1 and BH2. The top of this layer was encountered at elevations ranging from 198.4 m to 199.0 m. The total thickness of this layer ranges from about 2.3 m to 3.6 m. The SPT N-values recorded in the fill layers ranges from 5 to 51 blows per 0.3 m of penetration but more typically 7 to 19 blows per 0.3 m indicating a loose to compact state of compactness. The measured water content of 13 samples tested range from 1% to 15%. The results of grain size analysis testing carried out on three samples of fill materials are provided in Figure B1 in Appendix B.

#### **4.2.2 Organic Silty Sand to Silty Sand with Organics**

A deposit of organic silty sand to silty sand with organics, some gravel was encountered below the embankment fill at Boreholes 23-04, 23-05, and BH1 and at the ground surface of Borehole 23-01. The top of this deposit was encountered at elevations ranging from 195.9 m and 197.2 m. The thickness of the deposit ranged from 0.2 m to 0.6 m. The measured water content of two samples of this deposit is 40% and 134%. The results of organic content testing carried out on two samples on this deposit are 4% and 19%.

#### **4.2.3 Silty Sand to Sand**

A silty sand to sand deposit with varying amounts of gravel was encountered below the peat deposit at Boreholes 23-01, 23-04 and BH1 and below the fill layer at Borehole BH2. The top of this deposit was encountered at elevations ranging from 195.7 m to 196.6 m. The total thickness of this deposit ranges from about 0.8 m to 2.0 m. The SPT N-values recorded in the silty sand to sand deposit range from 1 to 22 blows per 0.3 m of penetration but more typically 7 to 21 blows per 0.3 m indicating a loose to compact state of compactness.

The measured water content of six samples tested range from 10% to 40%. The results of grain size analysis testing carried out on two samples of this material are provided in Figure B2 in Appendix B.

#### **4.2.4 Gravelly Silty Sand to Sandy Silty Gravel (Till)**

A till deposit generally consisting of a soil matrix of gravelly silty sand to sandy silty gravel, containing cobbles and boulders, was encountered below the fill layers at Boreholes 23-02 and 23-03, below the peat deposit at Borehole 23-05 and below the silty sand deposit at Boreholes 23-01, 23-04, BH1, and BH2. Cobbles and boulders were encountered within the till, and coring techniques were required to advance the boreholes through this deposit. The top of this layer was encountered at elevations ranging from 193.9 m to 196.5 m. The thickness of the deposit ranges from about 0.3 m to 4.2 m at the boreholes. The SPT N-values recorded in the till range from 7 to 63 blows per 0.3 m of penetration but more typically 13 to 30 blows per 0.3 m of penetration indicating a compact to dense state of compactness. The higher SPT N-values within this deposit (e.g., 90/0.2 m of penetration at Borehole 23-03) suggests a very dense compactness; however, these blow counts have likely been influenced by the presence of cobbles, boulders, or the proximity to the bedrock surface rather than the actual compactness of the soil matrix.

The measured water content of seventeen samples of the till deposit ranges from 3% to 12%. The results of grain size analysis testing carried out on seven samples of this material are provided in Figure B3 in Appendix B.

### 4.3 Bedrock

The overburden materials are underlain by granitic gneiss bedrock.

Table 2 summarizes the depths and the elevations of the bedrock surface as encountered at the borehole locations.

**Table 2: Summary of Bedrock Surface Depths and Elevations**

Borehole	Existing Ground Surface Elevation (m)	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
23-01	197.2	4.5	192.7
23-02	196.1 (top of creek bed)	4.1	192.0
23-03	198.8	5.4	193.5
23-04	198.8	5.2	193.6
23-05	199.1	6.8	192.3
BH1	198.4	5.7 <sup>1</sup>	193.1
BH2	198.8	6.1 <sup>1</sup>	192.3

Notes: 1. Borehole records noted end of borehole on 'inferred bedrock'.

Rock Quality Designation (RQD) values measured on the recovered granitic gneiss bedrock core samples range from about 30% to 100%, but are typically 48% to 93%, indicating a poor to excellent rock quality. The UCS testing carried out on four bedrock core samples measured a uniaxial compressive strength ranging from 89 MPa to 214 MPa, indicating a strong to very strong bedrock. The results of UCS testing are provided on Figure B4 in Appendix B.

### 4.4 Groundwater Conditions

A monitoring well was installed in Borehole 23-05 to measure the groundwater level at the site. A piezometer was installed in Borehole BH2 during the 2021 investigation.

The groundwater levels measured in the monitoring wells are presented in Table 3.

The creek water level was measured at Elevation 197.2 m on October 27, 2023.

It is expected that the groundwater levels will be subject to fluctuations both seasonally and as a result of precipitation events.

**Table 3: Summary of Groundwater Conditions**

Borehole	Screened Interval	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date
Current Investigation					
23-05	Glacial Till	199.1	2.5	196.6	August 14, 2023
23-05	Glacial Till	199.1	2.1	197.0	October 24, 2023
Previous Investigation					
BH2	Sand/Till	198.4	3.0	195.4	May 17, 2021
			1.4	197.0	July 10, 2021

## 4.5 Analytical Laboratory Testing Results

Two soil samples were submitted to Eurofins for chemical testing/analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D and are summarized in Table 4.

**Table 4: Steel Corrosion and Sulphate Attack, Chemical Analysis**

Borehole	Sample Depth (m)	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
23-03	0.8-1.4	0.039	<0.01	0.83	9.41	1,205
23-05	1.5-2.1	0.016	<0.01	0.42	8.44	2,381

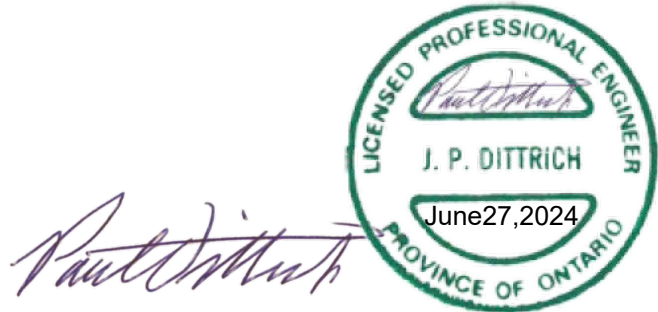
## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Ben Waechter, EIT and reviewed by Kenton Power, P.Eng., a Senior Geotechnical Engineer with WSP. Paul Dittrich, P.Eng., a Geotechnical Engineering Fellow and MTO Principal Foundations Contact for WSP conducted an independent technical and quality review of this report.

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BW/KCP/JPD/yj

[https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared documents/06. deliverables/2-final/gwp 4123-17-00 final fidr rev0 culvert 29x-0229 2024-06-07 \(ca0009744.5044\).docx](https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared%20documents/06.%20deliverables/2-final/gwp%204123-17-00%20final%20fidr%20rev0%20culvert%2029x-0229%202024-06-07%20(ca0009744.5044).docx)

**PART B**

# **Foundation Design Report**

Replacement of Structural Culvert 29X-0229/C0

Highway 41, Grattan, Ontario

MTO GWP 4123-17-00; Agreement Number 4021-E-0021-04

## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides foundation recommendations for the detailed design of the replacement of Culvert 29X-0229/C0. The guidance provided herein is based on an interpretation of the factual data obtained from the 2023 investigation completed by WSP supplemented with data from the 2021 investigation at the site completed by Ainley and a review of the design information in the Preliminary General Arrangement (GA) drawing prepared by Ainley Group Consulting Engineers and Planners Ltd. (Ainley). A copy of the GA drawing is provided in the Drawings Appendix.

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

### 6.2 Project Understanding

The preliminary GA drawing dated January 2022 indicates that the replacement culvert is to be approximately 25 m long and installed along the existing culvert alignment and that the existing highway platform grade will be maintained (i.e., no grade raise). To prevent erosion and undermining, concrete wing-walls and cut-off-walls are proposed at the inlet and outlets of the new culvert. It is anticipated that the culvert will be replaced via open-cut excavations in multiple stages, with the use of temporary protection systems along Highway 41. It is understood that to accommodate the proposed staging, Highway 41 will be reduced to one lane during construction and traffic will be controlled with temporary signalling.

Depending on the creek flow, surface water flow conditions and the groundwater levels at the time of construction, water flow could be bypassed through either the existing culvert or through newly installed diversion pipe(s) by diverting the flow toward or pumping from behind a temporary water diversion system. However, it is noted that culvert construction staging, timing for decommissioning of the existing culvert, and maintenance of flow will need to be confirmed as part of the design.

### 6.3 Culvert Replacement and Foundation Options

From a geotechnical/foundation perspective, a Structural Plate Corrugated Steel Pipe Arch (SPCSPA) culvert, or a closed-bottom pre-cast concrete box culvert, or an open-footing cast-in-place culvert are considered feasible alternatives for culvert replacement at this site. The culvert types are briefly summarized below, and a comparison of advantages, disadvantages and risks is provided in Table 9 following the text of this report.

- Replacing the existing culvert with another SPCSPA culvert is considered feasible however standard erosion protection for the new SPCSPA culvert would consist of installing rip-rap or gabion baskets, and these baskets would require regular maintenance. Further, corrugated steel pipe culverts typically have a shorter design life compared to concrete structures.



- A closed-bottom, segmental pre-cast concrete box culvert can be placed more expeditiously compared to a cast-in-place option, offering schedule advantages with respect to construction/traffic staging dewatering and in-water restrictions. Concrete box culverts can typically be founded at a shallower depth compared to open footing culverts, reducing excavation and dewatering requirements. Soil materials can be incorporated above the base slab to create a more natural substrate for fisheries.
- A cast-in-place concrete open-footing culvert typically requires deeper foundation excavations as compared to a box culvert and would likely extend the construction schedule and increase the excavation, dewatering, and shoring requirements compared to a pre-cast concrete box culvert. There can also be a slightly higher risk of erosion/scour and undermining of foundations along the length of an open footing culvert, compared to a box culvert in which erosion and scour protection is required only at the inlet and outlet.

Based on the above considerations, a closed-bottom segmental, pre-cast concrete box culvert is preferred from a geotechnical/foundation perspective. However, other culvert types may be preferred due to construction staging or other considerations, such as fisheries requirements related to natural channel substrate or alignment.

As per our meeting with Ainley and MTO Foundations on April 24, 2023, it is understood that a pre-cast reinforced concrete box culvert has been selected as the preferred structure replacement type at this site. The culvert will have an internal span and height of 3.0 m and 2.1 m, respectively. Based on hydraulic requirements, the underside of the concrete base will vary from approximately Elevation 195.2 m at the north (inlet) end to Elevation 195.1 m at the south (outlet) end. Natural substrate and new streambed materials will be provided at the stream bed level within the culvert.

## 6.4 General Foundation Design Context

### 6.4.1 Consequence and Site Understanding Classification

As the proposed replacement culvert crosses Highway 41, which carries medium traffic volumes with the potential to impact alternative transportation corridors, a “typical consequence level” is considered appropriate for this project, as outlined in Section 6.5 of the Canadian Highway Bridge Design Code (CHBDC (2019) and its Commentary. Further, given the level of foundation investigation and laboratory testing completed to date as presented in Sections 3.0 and 4.0, a “typical degree of site and prediction model understanding” has been utilized. Accordingly, the appropriate corresponding ULS and SLS consequence factor,  $\Psi$ , and geotechnical resistance factors,  $\phi_{gu}$  and  $\Phi_{gs}$ , from Tables 6.1 and 6.2 of the CHBDC have been used for design.

For seismic design, the consequence factor,  $\psi$ , and resistance factor,  $\phi_{gu}$ , should be taken as unity, and the geotechnical resistance factor shall be as specified in Table 6.3. as per Section 6.14.4 of CHBDC (2019).

### 6.4.2 Seismic Design

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

### 6.4.2.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation. Based on the energy-corrected average standard penetration resistance,  $\bar{N}_{60}$ , below the founding level, the site may be classified as Site Class C in accordance with Clause 4.4.3.2 and Table 4.1 of CHBDC (2019), in the absence of site-specific geophysical testing. Geophysics testing such as Multi-Channel Analysis of Surface Waves (MASW) or vertical seismic profiling would provide a more accurate average shear wave velocity that might result in a more favourable site class.

### 6.4.2.2 Spectral Response Values

In accordance with Section 4.4.3.1 of the CHBDC and based on the location of the proposed structure, the Class C peak seismic hazard values based on data obtained from Earthquakes Canada ([www.earthquakescanada.nrcan.gc.ca](http://www.earthquakescanada.nrcan.gc.ca)) are provided in Table 5.

**Table 5: Class C Peak Seismic Hazard Values**

Parameter	2% Probability of Exceedance in 50 Years (2,475-year return period) (g)
PGA	0.226
Sa (0.2)	0.45
Sa (0.5)	0.283
Sa (1.0)	0.156
Sa (2.0)	0.0744
Sa (5.0)	0.0203
Sa (10.0)	0.00688
PGV [m/s]	0.192

### 6.4.3 Soil Liquefaction

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

In general, the fill materials and native soils at this culvert site consist of compact to dense silty sand overlying shallow granitic bedrock. Based on the compactness of the till deposits, the proximity of the bedrock, and the site-specific PGA, the founding soils below the proposed underside of the culvert at this site are considered to have a low potential for liquefaction during a seismic event.

#### 6.4.4 Frost Protection

The frost penetration depth in this area is approximately 1.8 m as interpreted from Ontario Provincial Standard Drawing (OPSD) 3090.101. Footings constructed at this site would require a minimum embedment depth of 1.8 m below the final finished grade for frost protection purposes. However, if a box culvert is constructed it is not necessary to ensure that the full length of the replacement culvert is founded below the frost depth, as box culverts are tolerant of small magnitudes of movement related to freeze-thaw cycles.

### 6.5 Culvert Foundation Design Recommendations

#### 6.5.1 General

The factored geotechnical resistances provided Sections 6.5.3 and 6.5.4 for both the box culvert and wing/retaining wall foundations are based on a “typical” consequence level,  $\Psi = 1.0$ , and a “typical” degree of site understanding with corresponding geotechnical resistance factors for “Shallow Foundations” of  $\phi_{gu} = 0.50$  for “Bearing” and  $\phi_{gs} = 0.80$  for “Settlement” as per Table 6.2 of CHBDC (2019).

The factored geotechnical resistances provided are also based on the loading applied perpendicular to the base of the culvert and wing/retaining walls; where applicable, the inclination of the load should be taken into account in accordance with Section 6.10.2 and Section C6.10.5 of CHBDC (2019) and its Commentary. The factored geotechnical resistances should be reviewed if the founding elevation and/or the foundation width differ from those indicated below.

#### 6.5.2 Box Culvert Bedding and Levelling Layer Requirements

The bedding and levelling pad requirements for a pre-cast box culvert should be in accordance with OPSS.PROV 422.

Provided adequate dewatering is in place, a minimum 150 mm thick layer of OPSS.PROV 1010 (Aggregates) Granular A material is recommended for bedding purposes. The bedding should be placed in accordance with OPSS.PROV 501 (Compacting) and compacted to at least 98% of the material’s Standard Proctor maximum dry density (SPMDD).

In addition, a 75 mm thick uncompacted levelling pad consisting of OPSS.PROV 1010 (Aggregates) Granular ‘A’ or fine concrete aggregate meeting the grading requirements specified in OPSS.PROV 1002 (Aggregates – Concrete) should be provided with a geometry similar to that provided on OPSD 803.010 (Backfill and Cover for Concrete Culverts).

#### 6.5.3 Box Culvert Founding Level and Factored Axial Geotechnical Resistances

Based on the underside of concrete elevation noted on the Preliminary GA drawing (ranges from Elevations 195.2 m to 195.1 m) and the bedding and leveling layer thicknesses recommended above, the founding subgrade level for the replacement box culvert will be at approximately Elevation 194.9 m at the west (inlet) end and Elevation 194.8 m at the east (outlet) end. For the proposed pre-cast concrete box culvert with an overall footprint width of 3.5 m (exterior dimension) founded on the properly prepared granular bedding/leveling course overlying the native soils at the above-noted elevations, the following factored geotechnical resistances may be used for design:

- Factored axial geotechnical resistance at ULS: 500 kPa
- Factored axial geotechnical resistance at SLS (for 25 mm of settlement): 300 kPa

### 6.5.4 Wingwall Founding Level and Factored Axial Geotechnical Resistances

Wingwalls are required on both sides of the replacement culvert at the upstream and downstream ends to retain the Highway 41 embankment fills within the MTO right-of-way and separate the fills from the watercourse channel. It is understood that each of the walls will be approximately 3.5 m long, with a maximum height on the order of 2 m relative to the ground surface in front of the wall. Based on the Preliminary GA drawing, the footings for the wingwalls are to be 2.0 m wide.

Based on a 600 mm thick footing and the bedding and levelling layer thicknesses recommended in Section 6.5.2, the founding subgrade level for the wingwall footings will be at approximately Elevation 194.4 m at the west (inlet) end and Elevation 194.3 m at the east (outlet) end. The following factored geotechnical resistances may be used for design:

- Factored axial geotechnical resistance at ULS: 400 kPa
- Factored axial geotechnical resistance at SLS (for 25 mm of settlement): 400 kPa

### 6.5.5 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance should be calculated in accordance with Section 6.10.4 of CHBDC (2019), applying the appropriate consequence and degree of site understanding factors, as noted above in Section 6.2. The following interface friction angle(s) and interface shear strengths in Table 6 maybe utilized to assess the critical conditions for sliding resistance:

**Table 6: Interface Friction Angles and Shear Strengths**

Interface	Interface Strength
Between pre-cast concrete and underlying granular bedding/levelling layer	$\delta'_i = 20^\circ$ , $c'_i = 0$ kPa
Between the granular bedding layer and underlying Glacial Till	$\phi' = 34^\circ$ , $c' = 0$ kPa
Between cast-in-place retaining wall footings and underlying Glacial Till	$\delta'_i = 26^\circ$ , $c'_i = 0$ kPa

### 6.5.6 Culvert Subgrade Preparation

Based on the elevation of the bedrock surface as encountered in the boreholes, bedrock is not anticipated to be encountered during excavation to subgrade level along the proposed culvert alignment. However, cobbles and boulders could be encountered within the till above the bedrock and at the subgrade level. A Notice to the Contractor should be included in the Contract Documents to alert the Contractor of the potential for the presence of obstructions (cobbles and boulders) in the overburden. Example text for this Notice to Contractors has been provided in Appendix G.

Prior to placing the bedding/levelling course for pre-cast concrete box culvert sections, it is recommended that any organic material (i.e., topsoil, peat and/or mixed organic soils), existing fill, and any disturbed materials encountered below the foundation footprint be sub-excavated and replaced with Ontario Provincial Standard Specification, Provincial Oriented (OPSS.PROV) 1010 Granular A or Granular B Type II fill; Granular B Type II fill is recommended for placement in wet conditions.

### 6.5.7 Culvert Backfill

Backfill above/behind the culvert walls, headwalls, wingwalls and/or retaining walls should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular A or Granular B II. The backfill should be placed and compacted to not less than 98% of the material's SPMDD in accordance with OPSS.PROV 501 (Compacting). The fill should also be placed concurrently on both sides of the culvert, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm as per OPSS.PROV 422. Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS.PROV 206.

### 6.5.8 Culvert Erosion and Scour 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 which could lead to the formation of sinkholes), consideration should be given to the use of a concrete cut-off wall and/or clay seal. Based on the preliminary GA drawing, it is understood that concrete cut-off walls are to be constructed at both the inlet and outlet ends of the replacement culvert.

If a clay seal is included in the design in addition to the cut-off walls, the clay material should meet the requirements of OPSS.PROV 1205 (Clay Seal), and the seal should be a minimum of 1 m thick, whether constructed of natural clay or soil-bentonite mix. Alternatively, a geosynthetic clay liner (GCL) may be incorporated, and this is generally considered the preferred alternative as it is much thinner (only a few millimeters thick) than the standard natural clay or soil-bentonite layer, thus requiring a shallower excavation into the slope, and is much easier to install. The clay seal or GCL should extend a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and from a depth of 1 m below the scour level up to a minimum vertical height on the embankment side slopes equivalent to the high-water level. If a GCL is utilized, the GCL should be constructed within the embankment slope to allow for a minimum 0.3 m thick granular cover layer to be placed over the GCL to provide protection from the requisite overlying erosion protection material. Rip-rap/rock fill slope protection material should be placed on the granular cover layer and not directly on the GCL.

As a minimum, rip-rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (Rip-Rap Treatment). Erosion protection for the inlet of the culvert could also follow the standard presented in OPSD 810.010 (Rip-rap Treatment) similar to the outlet but with the rip-rap placed up to the toe of the slope level, in combination with the cut-off measures noted above.

The requirements for and design of erosion protection measures for the culvert and re-constructed embankment side slopes should be assessed by the Drainage and Hydrology engineers. If additional erosion protection is required, consideration could be given to the use of rip-rap, rock protection, or granular sheeting meeting the requirements of OPSS.PROV 1004 (Aggregates – Miscellaneous), placed and constructed in accordance with OPSS.PROV 511 (Rip-Rap, Rock Protection, and Granular Sheeting).

### 6.5.9 Lateral Earth Pressures

The lateral earth pressures acting on the headwalls, retaining/wing walls, and side walls of the culvert will depend on the type and method of placement of backfill materials, the nature of the soils/embankment fill 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 replacement culvert and associated headwalls and retaining walls:

- Select, free draining, non-frost susceptible granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II should be used as backfill behind the culvert walls and associated headwalls and retaining walls, as well as on top of the culvert for a minimum thickness of 300 mm in a similar configuration to that shown in OPSD 803.010 (Backfill and Cover for Concrete Culverts).
- 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, the granular fill should be placed in a zone with a width equal to at least 1.8 m behind the back of the wall (see Figure C6.31(a) of the Commentary to CHBDC). For unrestrained walls, the fill should be placed within the wedge-shaped zone defined by a line drawn flatter than 1 horizontal to 1 vertical (1H:<1V) extending up and back from the rear face of the footing (see Figure C6.31(b) of the Commentary to CHBDC). However, where side slopes inclined at 3H:1V or flatter are required for open-cut excavations extending below the groundwater level, in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act (OHSA) for Construction Projects (as amended), consideration could be given to backfilling the full open-cut excavation area with OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II in order to satisfy both the backfilling requirements outlined in the Commentary to the CHBDC and the open-cut excavation requirements outlined in the OHSA.

The lateral earth pressure coefficients provided in Table 7 have been developed for flat (i.e., non-sloping) ground above/behind the culvert walls, as well as for a 2H:1V slope condition for unrestrained walls as applicable for the retaining walls at the ends of the replacement culvert. If the inclination of the slope above the wall differs, revised lateral earth pressure parameters will need to be calculated 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).

If the wall does not allow lateral yielding (i.e., a restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.

If the wall allows lateral yielding (i.e., unrestrained structure), active earth pressures should be used in the geotechnical design of the structure. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.12 of the Commentary to CHBDC (2019).



**Table 7: Lateral Earth Pressure Coefficients**

Wall Movement Condition	Restrained Wall	Unrestrained Wall			
Fill Material	Existing Embankment Fill Behind Granular $\phi'=32^\circ$	Granular A and B Type II $\phi'=35^\circ$		Granular B Type I $\phi'=32^\circ$	
Unit Weight (kN/m <sup>3</sup> )	19	22	22	21	21
Ground Surface Above Top of Wall	Horizontal	Horizontal	2H:1V	Horizontal	2H:1V
Active Earth Pressure ( $K_a$ )	0.31	0.27	0.39	0.31	0.47
At-Rest Earth Pressure ( $K_o$ )	0.47	0.42	0.62	0.47	0.68
Passive Earth Pressure ( $K_p$ ) <sup>1</sup>	3.25	3.69	10.78	3.25	8.58

**Notes:**

- 1 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.

## 6.6 Embankment Design and Reinstatement

The existing embankments at this culvert site are up to approximately 2.5 m in height relative to the surrounding ground surface with slopes that are at approximately 2 horizontals to 1 vertical (2H:1V). Based on the Preliminary GA drawing, it is understood that the existing embankment heights at the culvert location will generally be maintained (i.e., no grade raise).

Embankment reinstatement, after culvert replacement, should be carried out in accordance with OPSS.PROV 206 and should match the adjacent slope geometry. The new embankment material should consist of imported Granular B Type II material. Excavated (existing) granular fill may also be reused as embankment fill provided there is no organic material in the excavated fill and there is sufficient space to stockpile on site and control the water content within acceptable limits for compaction. Excavated granular fill must not be used as culvert bedding or backfill.

Granular fill should be placed and compacted in accordance with OPSS.PROV 501. Where new embankment fill is placed against existing embankment slopes the existing earth or fill slope must be benched in accordance with OPSD 208.010.

For these low embankment heights with side slopes flatter than 2H:1V, the factor of safety for global stability will be greater than 1.5, which satisfies CHBDC (2019) requirements for global stability.

## 6.7 Corrosion Assessment and Protection

The analytical results for the soil samples submitted for testing are summarized in Section 4.5 of this report and the analytical laboratory test reports are included in Appendix D. The potential for sulphate attack and corrosion are discussed in the following sub-sections; however, it is ultimately up to the designer to determine the appropriate construction materials, including the exposure class, and ensure that all aspects of CSA A23.1:19 Section 4.1.1 "Durability Requirements" are followed when designing concrete elements, as applicable.

### 6.7.1 Potential for Sulphate Attack

The sulphate test results are summarized in Table 4 of this report were compared with Table 3 of the CSA Standard A23.1-19 and Table 7.2 of MTO's Gravity Pipe Design Guidelines (2014), and generally indicate a low degree of sulphate attack potential on concrete structures at this site. Accordingly, GU cement in accordance with Table 6 of the CSA Standard A23.1-19 could be specified for concrete in below-grade applications.

### 6.7.2 Potential for Corrosion

The soil has a pH of 9.4 and according to the MTO Gravity Pipe Design Guidelines (2014), pH levels above 8.5 are considered detrimental to culvert durability. The measured resistivity, R, of 1,205 and 2,381 ohm-cm indicates that the soil corrosiveness is high ( $R < 2,000$ ), as per Table 3.2 of the MTO Gravity Pipe Design Guidelines (2014). Given that the culvert location will be exposed to de-icing salts, it is recommended that a C-1 (reinforced concrete) or C-2 (non-structurally reinforced concrete) class exposure concrete be considered, as appropriate as defined by CSA A23.1 Table 1.

## 6.8 Construction Considerations

### 6.8.1 Construction Staging and Temporary Roadway Protection

The temporary excavations for the culvert replacement will extend through the existing granular embankment fill and into the native subgrade soils. The granular fill and native soils at this site are considered Type 3 soil above the groundwater table and Type 4 soil below the groundwater table. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are excavated no steeper than 1H:1V. In Type 4 soils, the side slopes should be excavated no steeper than 3H:1V. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended).

Based on the preliminary construction staging plan, it is understood that one lane of traffic will be maintained during construction with the traffic being controlled by temporary signalling. A temporary protection system (i.e., temporary shoring) is expected to be required along Highway 41 between the stages.

The selection of the type and method of installation of a temporary protection system must consider the granular nature of the fill soils, the presence of cobbles and boulders in the till soils, the irregularly sloping and relatively shallow depth to bedrock, and the high groundwater table at the site. Given these challenging conditions, the use of soldier pile and lagging may not be a practical option because the H-piles would have to be placed in drilled holes advanced using rotary percussion drilling with a down-the-hole hammer and socketed into bedrock (not driven) and extensive dewatering and possibly grouting would be required given the lack of watertightness of the lagging. In addition, the granular nature of the fills would be prone to sloughing during excavation and could make installation of the lagging difficult. A secant pile wall could be used for shoring because the overlap of the adjacent piles (i.e., caissons/drilled shafts) sealed into bedrock would provide sufficient watertightness to minimize the requirements for dewatering and could be installed through the cobbles and boulders and socketed into bedrock using rotary percussion drilling with a down-the-hole hammer; however, the installation costs for this type of shoring wall would be high. A steel sheet pile wall could also be used for shoring and the interlocking nature of the adjacent sheet piles would reduce the dewatering requirements; however, since the sheet piles would not be able to penetrate the bedrock surface, groundwater could seep through the gaps between the tips of the sheet piles and the irregular bedrock surface. In addition, pre-drilling would be required along the alignment of the sheet pile walls to break-up the cobbles and boulders prior to installation of the sheet piles and toe-pins drilled into bedrock may be required to provide additional lateral fixity at the base of the wall. These additional measures would increase the costs of a conventional sheet pile shoring system at this site. Additional lateral support to the shoring

system could be in the form of struts, wales, rakers, or anchors and the amount of lateral support required will depend on the type, stiffness, and toe fixity of the selected shoring wall.

The design of the shoring will be entirely the responsibility of the Contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539. The lateral movement of the temporary protection systems should meet Performance Level 2 as specified in OPSS.PROV 539. Traffic loading should be included as a surcharge. Traffic loading does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm the load requirements. The design of the temporary support system should include an evaluation of base stability and hydraulic uplift stability, as defined in the Canadian Foundation Engineering Manual 6<sup>th</sup> Edition (CFEM 2023).

Although the contractor is responsible for the selection and detailed design of the temporary protection/dewatering systems, the parameters in Table 8 are provided to enable the detail designers, to develop a conceptual design and assess the approximate construction costs for protection systems.

**Table 8: Geotechnical Parameters for Temporary Protection Systems**

Soil Type	Bulk Unit Weight, $\gamma$ (kN/m <sup>3</sup> )	Internal Angle of Friction $\phi'$ (°)	Lateral Earth Pressure Coefficients <sup>1</sup>		
			Active, $K_a$	At Rest, $K_o$	Passive $K_p$ <sup>(2)</sup>
New Granular A or B Type I or II	22	35	0.27	0.42	3.69
Existing Embankment Fill (compact to very dense)	21	32	0.31	0.47	3.25
Silty Sand to Gravelly Silty Sand Very loose to compact	21	32	0.31	0.47	3.25
Glacial Till	22	34	0.28	0.44	3.53

**Notes:**

1. The lateral earth pressure coefficients presented above are based on a horizontal surface behind the excavation. If sloped surfaces are present, the coefficients should be corrected accordingly.
2. The total passive resistance below the base of the excavation adjacent to the temporary protection system 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.

## 6.8.2 Temporary Water Diversion Systems

Excavations to install the proposed culvert will extend below the groundwater and creek water levels. Given the permeable nature of the granular overburden soils and the high creek level and groundwater table at this site, an active dewatering system is expected to be required during construction, likely in conjunction with a cofferdam/cut-off system surrounding the replacement culvert excavation, to maintain a dry and stable subgrade.

Depending on the creek flow, surface water flow conditions and the groundwater levels at the time of construction, water flow could be bypassed through newly installed diversion pipe(s) by diverting the flow toward or pumping from behind a temporary water diversion system. A cut-off/cofferdam could consist of construction of a steel sheet pile wall driven to refusal in the silty sand till, or a sandbag or inflatable water diversion system installed to a suitable depth below the creek bed to control the surface water inflow from the creek.

An Environmental Activity Section Registry (EASR) (for pumping volumes greater than 50 m<sup>3</sup>/day) or PTTW (for pumping volumes greater than 400 m<sup>3</sup>/day) will be required, depending on the groundwater conditions at the time of construction and estimated pumping volumes. The Contractor should evaluate the estimated seepage and groundwater removal quantity, based on their proposed construction methods/procedures and the groundwater conditions at the time of construction, to confirm their dewatering estimate and discharge plan.

Unwatering, cofferdam construction and groundwater seepage control/management for the culvert foundations should be carried out in accordance with OPSS.PROV 517 as amended by SP No. 517F01, a copy of which is included in Appendix G. Given the cohesionless subgrade conditions encountered at this site, as well as the absence of any settlement-sensitive infrastructure in the vicinity of the culvert, the risk of settlement impacts is considered low from a foundation perspective provided the pumping is carried out from properly filtered sumps/well points. As such, the geotechnical/foundation fill-in SP 517F01 should indicate that a preconstruction survey is not applicable. Any temporary flow bypass requirements should be assessed and confirmed by drainage engineers during the future detail design for inclusion in SP 517F01.

### **6.8.3 Subgrade Preparation**

Prior to placing the levelling pad/bedding layer material and precast culvert, all existing fill, organic materials (including topsoil, peat, and/or mixed organic soil), and any disturbed/loosened native soils should be sub-excavated from below the plan limits of the proposed works to expose the undisturbed native subgrade soil. The subgrade should be inspected to ensure that all organics and other unsuitable materials have been removed, in accordance with OPSS.PROV 422 (Precast Reinforced Concrete Box Culverts) and/or OPSS.PROV 902 (Excavating and Backfilling – Structures).

Following inspection, the sub-excavated area should be backfilled with granular material meeting the requirements of an OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II that is placed and compacted in accordance with OPSS.PROV 501 (Compacting), as amended by SSP 105S22. The use of Granular 'B' Type II fill (and not clear stone) is recommended in wet conditions or below water.

### **6.8.4 Obstructions**

The contractor should be alerted to the potential presence of cobble and boulder obstructions within the fill material, and within the glacially derived native soils at the site. A sample Notice to the Contractor is included in Appendix G.

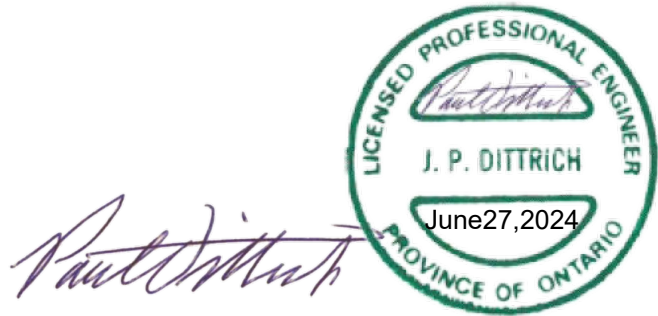
## 7.0 CLOSURE

This Foundation Design Report was prepared by Kenton Power, P.Eng., a Senior Geotechnical Engineer with WSP. Paul Dittrich, P.Eng., a Geotechnical Engineering Fellow and MTO Principal Foundations Contact for WSP conducted an independent technical and quality review of this report.

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[https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared documents/06. deliverables/2-final/gwp 4123-17-00 final fidr rev0 culvert 29x-0229 2024-06-07 \(ca0009744.5044\).docx](https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared%20documents/06.%20deliverables/2-final/gwp%204123-17-00%20final%20fidr%20rev0%20culvert%2029x-0229%202024-06-07%20(ca0009744.5044).docx)

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- Gravity Pipe Design Guidelines, Circular Culverts and Storm Sewers, April 2014.
- MTO Foundations Guideline, Embankment Settlement Criteria for Design, July 2010.
- Provincial Engineering Memorandum #20201, Material Engineering and Research Office (MERO), March 23, 2020.
- Guideline for MTO Foundation Engineering Services, Version 3, dated April 2022.

### Ontario Provisional Standard Drawing:

- |               |   |
|---------------|---|
| 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                       |

### Ontario Provincial Standard Specifications and Special Provisions:

- |               |  |
|---------------|--|
| OPSS.PROV 206 | Construction Specification for Grading |
|---------------|--|



---

OPSS.PROV 422	Construction Specification for Installation of Precast Reinforced Concrete Box Culverts with Span 3m or Less in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 517	Dewatering
SP 517F01	Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 803	Construction Specification for Vegetative Cover
OPSS.PROV 804	Construction Specification for Temporary Erosion Control
OPSS.PROV 902	Construction Specification for Excavating and Backfilling - Structures
OPSS.PROV 1002	Material Specification for Aggregates – Concrete
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS.PROV 1860	Material Specification for Geotextiles

#### **Ontario Provincial Regulations**

Ontario Regulation 213	Construction Projects (as amended)
Ontario Regulation 903	Wells (as amended)

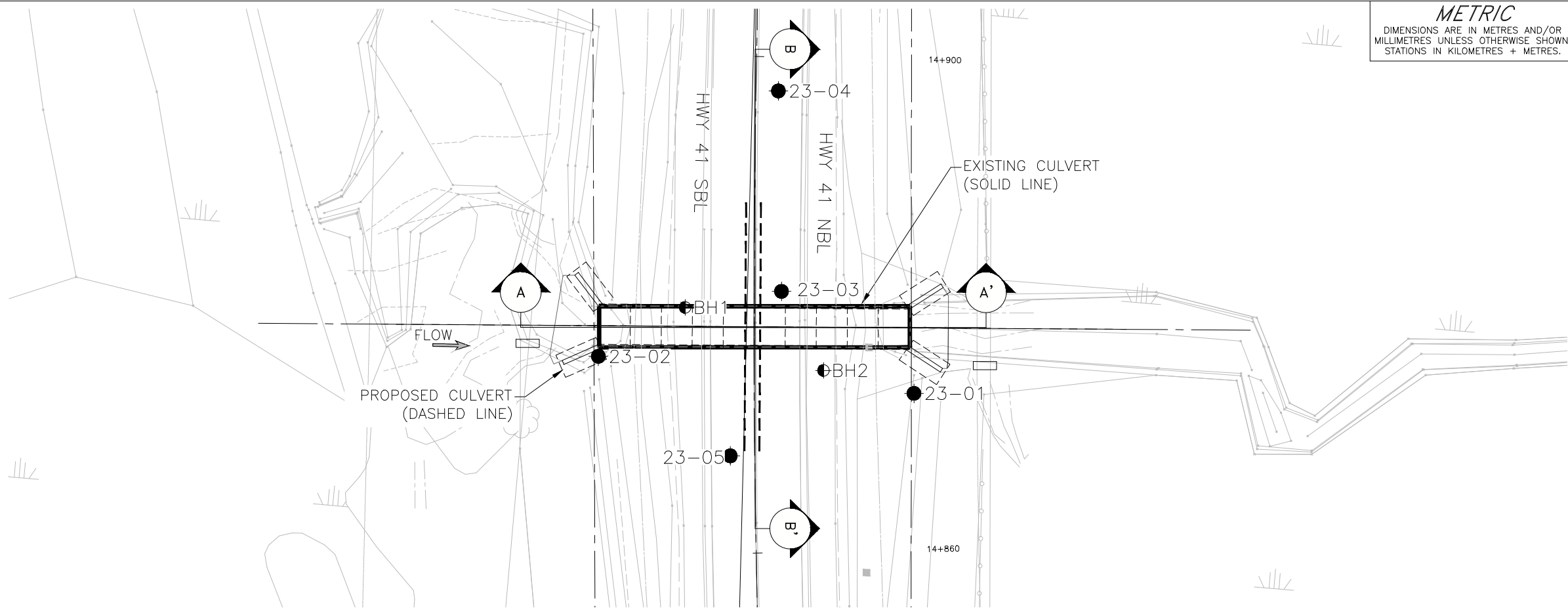
**Table 9: Comparison of Alternative Culvert Types**

Option	Feasibility	Advantages	Disadvantages	Risks/Consequences
Precast Concrete, Box Culvert	<ul style="list-style-type: none"> <li>Feasible – preferred option from a foundation perspective.</li> </ul>	<ul style="list-style-type: none"> <li>Minimizes depth of excavation, extent of protection systems, and dewatering requirements compared to cast-in-place, open-footing culvert option.</li> <li>Allows faster construction resulting in shorter duration for dewatering and surface water diversion pumping.</li> <li>More tolerant of total and differential settlements.</li> <li>A portion of the backfill/bedding under the culvert could be placed in-the-wet (i.e., using Granular 'B' Type II) potentially reducing unwatering requirements.</li> <li>Allows for greater flow volume than circular/arch SPCSP culvert.</li> </ul>	<ul style="list-style-type: none"> <li>May not satisfy fisheries requirements related to natural channel substrate, if applicable.</li> <li>Cut-off wall (or clay seal) likely required at inlet to mitigate potential scour under the culvert.</li> <li>Transportation to site, and on-site lifting of large precast sections will be required.</li> </ul>	<ul style="list-style-type: none"> <li>Lower risk of disturbance of the native subgrade soils during construction; can be mitigated with the use of a granular working pad/bedding layer or concrete working slab.</li> <li>Low risk related to settlement performance as precast, box segments can accommodate some total and differential settlements.</li> </ul>
Cast-in-Place Concrete, Open Footing Culvert	<ul style="list-style-type: none"> <li>Feasible from a foundation perspective.</li> </ul>	<ul style="list-style-type: none"> <li>May be feasible to construct the culvert on precast footing sections to accelerate construction schedule and reduce time for dewatering/unwatering (pumping).</li> <li>Would likely satisfy fisheries requirements related to natural channel substrate, if applicable.</li> <li>Allows for greater flow volume than circular/arch SPCSP.</li> </ul>	<ul style="list-style-type: none"> <li>Excavation depths are greater than for a pre-cast box culvert option, resulting in increased excavation support, cofferdam and dewatering requirements, and additional spoil material to be disposed off-site.</li> <li>Constructing footings in the dry will take longer, due to requirements for installation of a groundwater and surface water control system, dewatering and surface water pumping, and excavation in a confined space.</li> <li>Less tolerant of total and differential settlements, especially if the highway embankment is raised or widened at the culvert site.</li> </ul>	<ul style="list-style-type: none"> <li>Higher risk of disturbance of the native subgrade soils during construction; can be mitigated with use of a granular working pad/bedding layer or concrete working slab.</li> <li>May require greater depth of dewatering for footing construction.</li> <li>Culvert joints may be required to accommodate the anticipated total and differential settlement.</li> </ul>

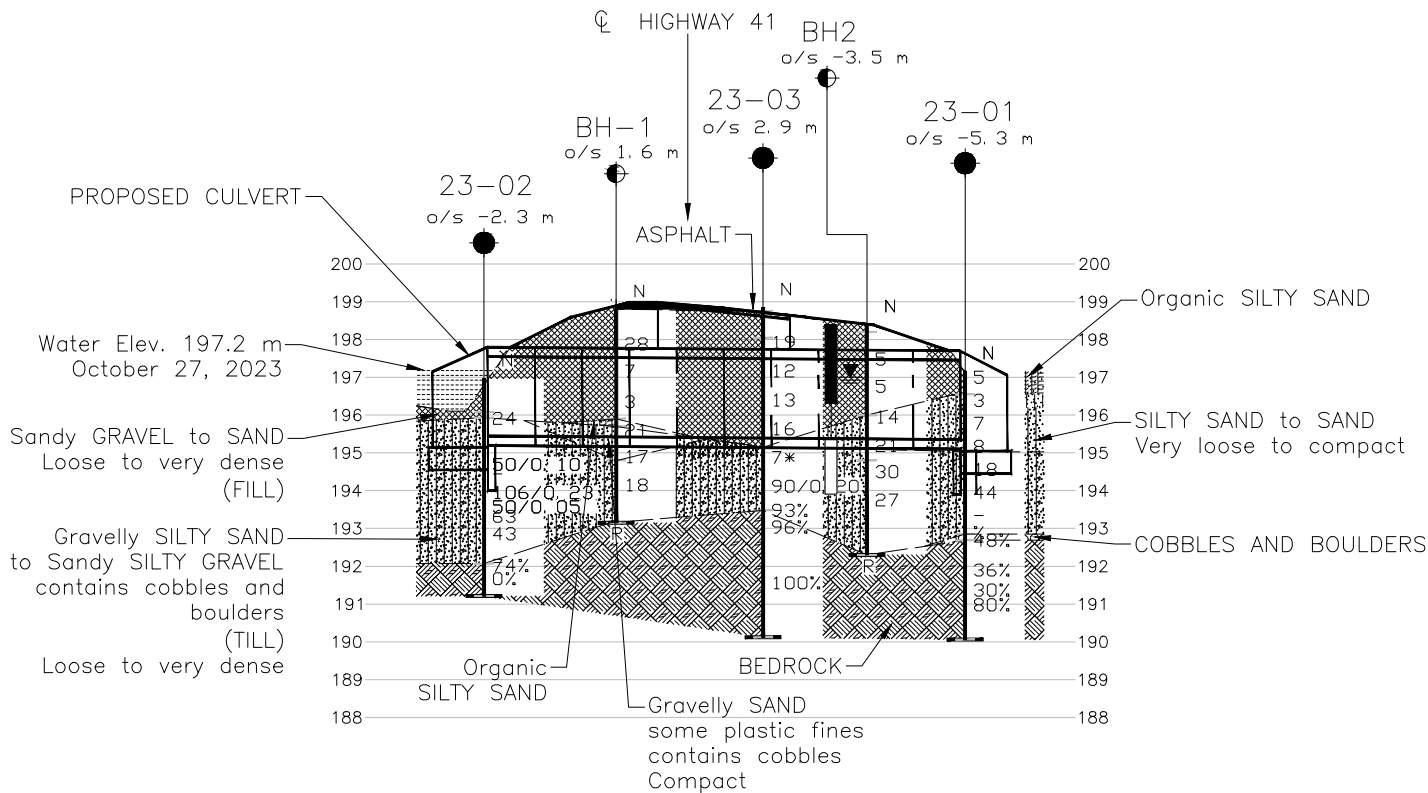
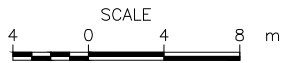
Option	Feasibility	Advantages	Disadvantages	Risks/Consequences
SPCSP Pipe Culvert(s)	<ul style="list-style-type: none"> <li>Feasible from a foundation's perspective.</li> </ul>	<ul style="list-style-type: none"> <li>Allows for faster construction resulting in shorter duration for unwatering and surface water diversion pumping compared to open-footing and box culverts.</li> <li>More tolerant of total and differential settlement.</li> </ul>	<ul style="list-style-type: none"> <li>Reduced flow-through capacity compared to box culvert and open-footing culvert options with a similar span – additional flow through capacity may have to be provided by multiple pipes.</li> <li>Cut-off wall or clay seal may be required at inlet to mitigate potential scour under the culvert(s).</li> <li>Difficult to compact backfill materials to level of culvert springline if not done in the dry.</li> <li>SPCSP culvert does not have as long of a design life compared to concrete options.</li> </ul>	<ul style="list-style-type: none"> <li>Lower risk of disturbance of the native subgrade soils during construction; can be mitigated with the use of a granular working pad/bedding layer or concrete working slab.</li> <li>Lower risk related to anticipated total and differential settlement compared to box culvert or open-footing culvert options.</li> </ul>

**DRAWINGS**

**Drawings 1 and 2 Borehole Locations and Soil Strata  
Preliminary General Arrangement Drawing; dated  
January 2022**



PLAN



CROSS-SECTION A-A'



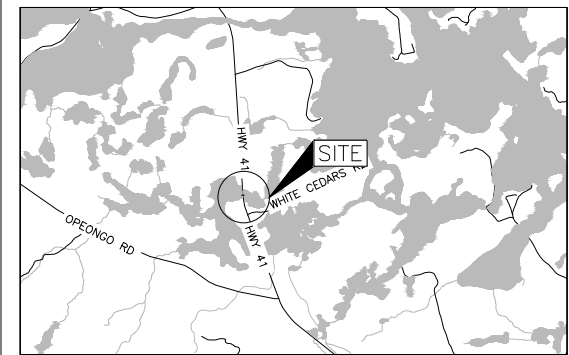
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 4123-17-00

HIGHWAY 41  
REPLACEMENT OF CULVERT 29X-0229/C0  
BOREHOLE LOCATIONS AND SOIL  
STRATA



SHEET



KEY PLAN  
SCALE



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 in piezometer, measured on May, 2021
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD83 MTM			ZONE 9
No.	ELEVATION	NORTHING	EASTING
23-01	197.2	5027965.7	264131.3
23-02	197.0	5027966.5	264105.7
23-03	198.8	5027973.0	264119.9
23-04	198.8	5027989.0	264118.2
23-05	199.1	5027959.4	264117.0
BH1	198.8	5027971.0	264112.3
BH2	198.4	5027966.9	264123.9

Structure location: LAT. 45.390460 LONG. -77.019388

#### NOTES

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

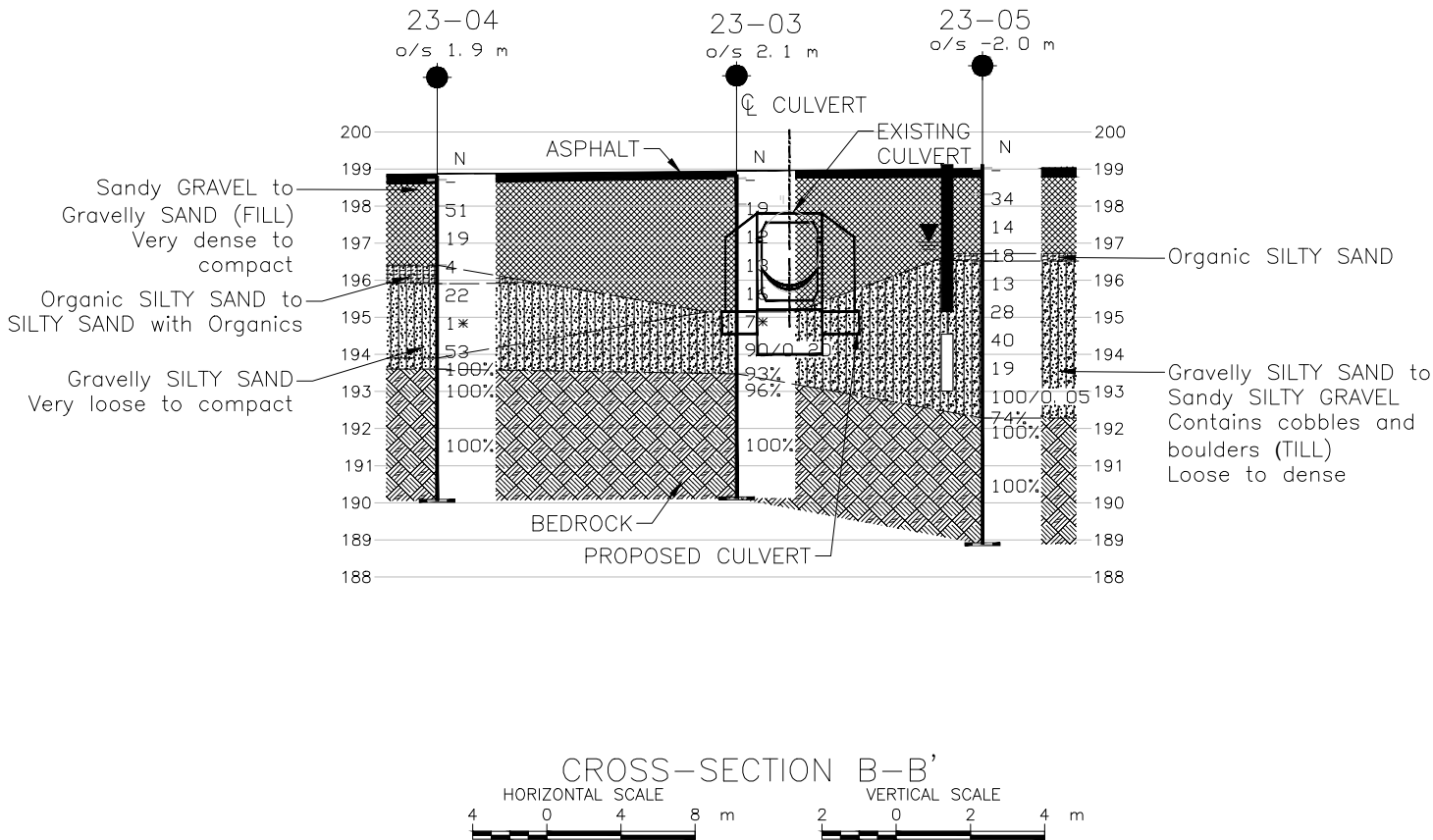
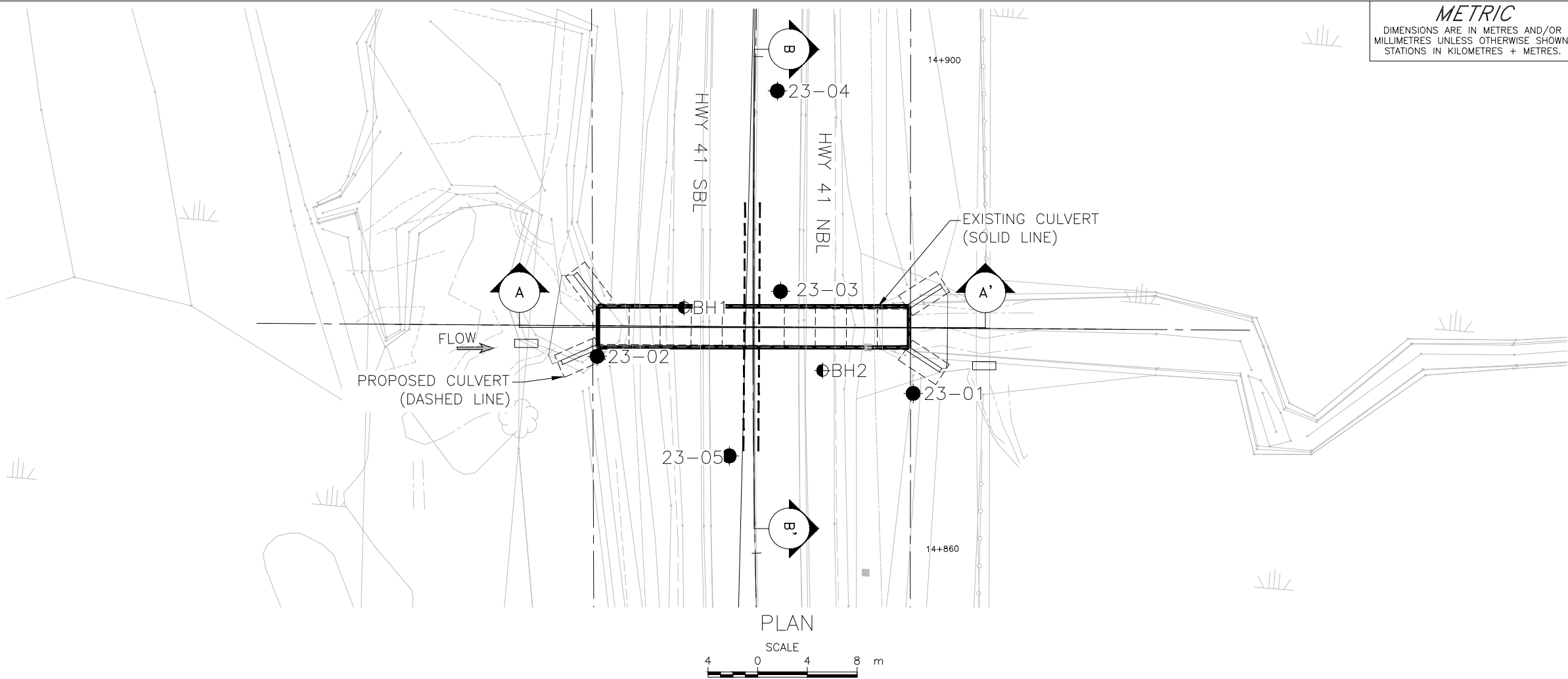
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

#### REFERENCE

Base plans provided in digital format by MTO, drawing file no. B041GRA.dwg, received October 31, 2023.  
General arrangement provided by MTO, drawing file no. 29X-0229C0 - Preliminary General Arrangement - for MTO.dwg, received April 12, 2024.



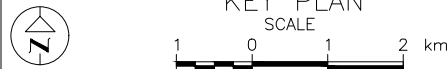
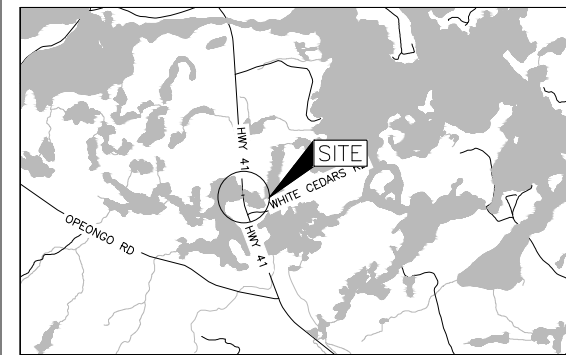
NO.	DATE	BY	REVISION
Geocres No. 31F06-001			
HWY. 41		PROJECT NO. CA0009744.5044	
SUBM'D. BW		CHKD. BW	DATE: 6/27/2024
DRAWN: SA		CHKD. KCP	APPD. JPD
		DIST. EASTERN	
		SITE: 29X-0229/C0	
		DWG. 1	



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

CONT No.  
GWP No. 4123-17-00

HIGHWAY 41  
REPLACEMENT OF CULVERT 29X-0229/C0  
BOREHOLE LOCATIONS 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 in piezometer, measured on October 2023

BOREHOLE CO-ORDINATES NAD83 MTM		ZONE 9	
No.	ELEVATION	NORTHING	EASTING
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23-04	198.8	5027989.0	264118.2
23-05	199.1	5027959.4	264117.0
BH1	198.8	5027971.0	264112.3
BH2	198.4	5027966.9	264123.9

Structure location: LAT. 45.390460 LONG. -77.019388

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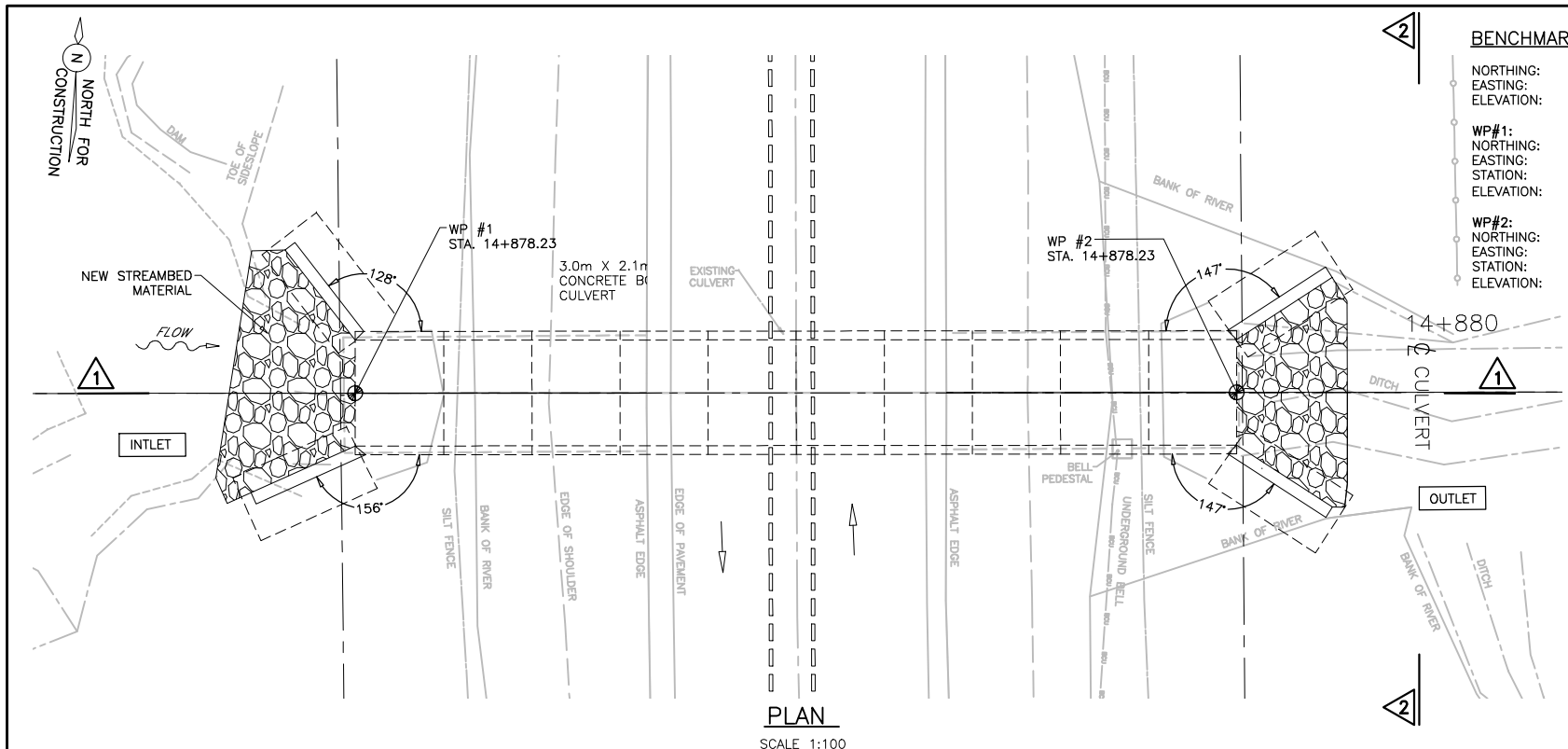
#### REFERENCE

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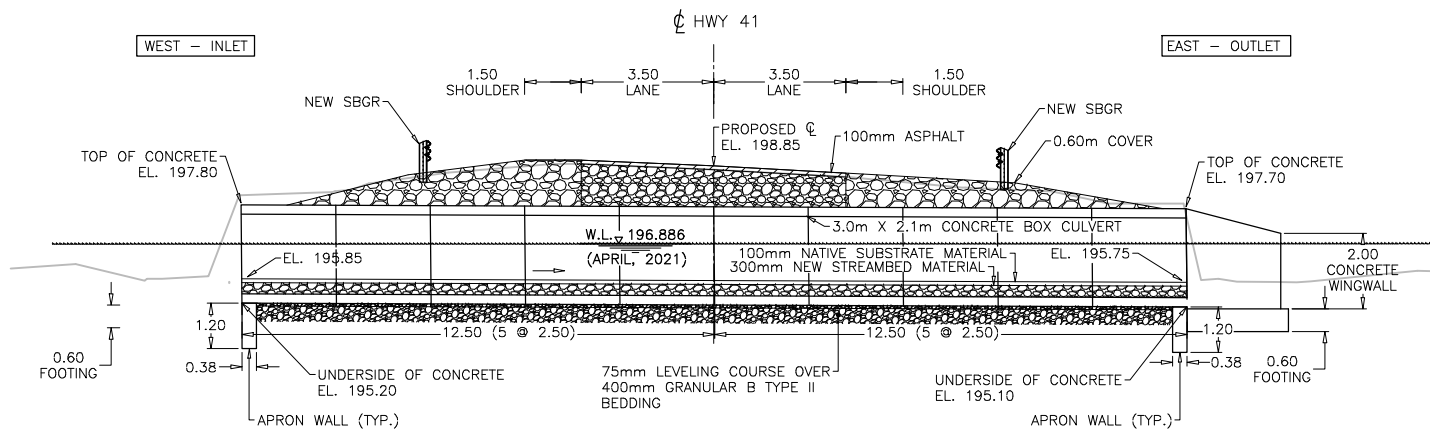


NO.	DATE	BY	REVISION
Geocres No. 31F06-001			
HWY. 41	PROJECT NO. CA0009744.5044		DIST. EASTERN
SUBM'D. BW	CHKD. BW	DATE: 6/27/2024	SITE: 29X-0229/C0
DRAWN: SA	CHKD. KCP	APPD. JPD	DWG. 2

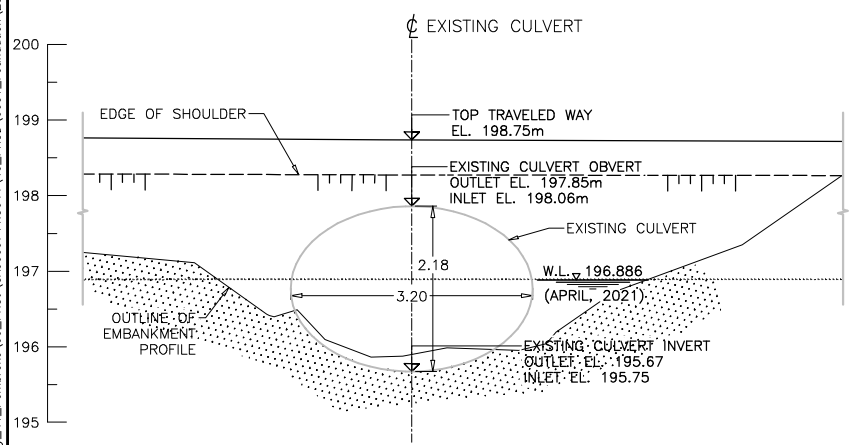
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FILE NAME: S:\Clients\WTD\Hwy\_41\_Pembroke\99\_PROJ\CA0009744\_5044\_V0\_PROD\0001\_Foundation\_29X-0229C0 - Preliminary General Arrangement - for MTD.dwg



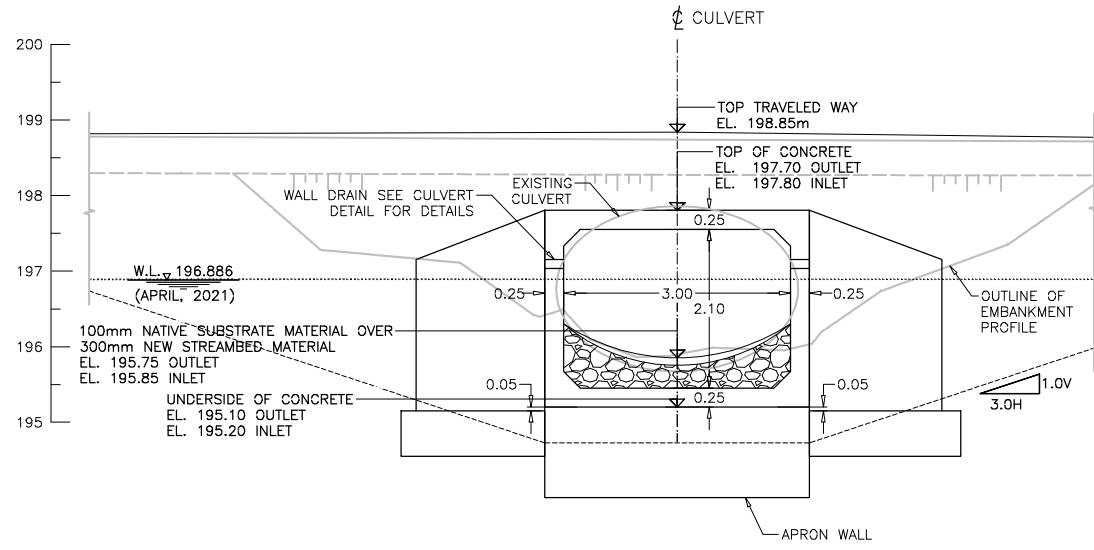
PLAN  
SCALE 1:100



LONGITUDINAL SECTION  
SCALE 1:100



EAST ELEVATION - EXISTING  
SCALE 1:50  
(WEST ELEVATION SIMILAR)



EAST ELEVATION  
SCALE 1:50  
(WEST ELEVATION SIMILAR)

BENCHMARK NOTES:	
NORTHING:	4925397.795
EASTING:	398257.926
ELEVATION:	100.590 m
WP #1:	
NORTHING:	5027968.9375
EASTING:	264105.5071
STATION:	14+878.23
ELEVATION:	197.80m(NEW)
WP #2:	
NORTHING:	5027970.9637
EASTING:	264130.4435
STATION:	14+878.23
ELEVATION:	197.70m(NEW)

LEGEND:	
	GRANULAR MATERIAL
	EXISTING STREAMBED
	SEDIMENTARY MATERIAL
	STREAMBED MATERIAL

### SCOPE OF WORK:

THE FOLLOWING SCOPE OF WORK IS NOT INTENDED TO BE AN EXHAUSTIVE LIST OF ALL ITEMS REQUIRED TO COMPLETE THE REHABILITATION WORK, NOR IS IT INTENDED TO PROVIDE A SEQUENCE OF CONSTRUCTION ACTIVITIES.

### STAGE 1:

1. ERECT SIGNAGE AND TEMPORARY TRAFFIC SIGNALS.
2. WIDEN THE HIGHWAY EMBANKMENT ON THE WEST SIDE OF THE ROAD AS SHOWN ON THE STAGING DRAWINGS.
3. INSTALL TEMPORARY CONCRETE BARRIER (TCB) AND DETOUR TRAFFIC ON THE WEST SIDE OF THE HIGHWAY.
4. INSTALL THE ENVIRONMENTAL PROTECTION MEASURES.
5. INSTALL TEMPORARY FLOW PASSAGE SYSTEM (TFPS) AND COFFERDAMS. DEWATER THE EXISTING CULVERT.
6. INSTALL TEMPORARY ROADWAY PROTECTION.
7. REMOVE ASPHALT PAVEMENT AND EXCAVATE TO THE LIMITS SHOWN IN DRAWINGS. REMOVE THE HALF OF THE EXISTING CULVERT.
8. INSTALL BEDDING MATERIAL. INSTALL THE PRECAST BOX UNITS AND APRON WALL. CONSTRUCT THE RETAINING WALLS. INSTALL WATERPROOFING AND PROTECTION BOARD ON THE CULVERT. BACKFILL THE CULVERT AND BEHIND THE RETAINING WALLS. INSTALL RIP RAP.
9. WIDEN THE HIGHWAY EMBANKMENT ON THE EAST SIDE OF THE ROAD AS SHOWN ON THE STAGING DRAWINGS.
10. PAVE THE ROADWAY.

### STAGE 2:

1. RELOCATE TCB AND DETOUR TRAFFIC ON THE REHABILITATED EAST SIDE OF THE HIGHWAY.
2. REPEAT STEPS 4, 6, 7, 8 AND 10 OF STAGE 1.
3. INSTALL SUBSTRATE ON THE BOTTOM OF THE CULVERT.
4. REMOVE TFPS AND COFFERDAMS. REMOVE THE TEMPORARY ROADWAY WIDENINGS. PERFORM FINAL CLEAN UP. REMOVE ENVIRONMENTAL PROTECTION SYSTEM AND TRAFFIC CONTROL MEASURES.
5. OPEN ROADWAY TO NORMAL TRAFFIC OPERATION.

## METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

GWP No. XXXX-XX-XX  
CONTRACT No. XXXX-XXXX

HIGHWAY 41  
CULVERT REPLACEMENT  
SITE No. 29X-0229/C0

GENERAL ARRANGEMENT



SHEET  
1

### GENERAL NOTES:

#### 1. CLASS OF CONCRETE:

CLASS OF CONCRETE SHALL BE 30MPa

#### 2. CLEAR COVER TO REINFORCING STEEL:

PRECAST CONCRETE	50 ±10
REMAINDER	70 ±20

#### 3. REINFORCING STEEL:

REINFORCING STEEL SHALL BE GRADE 400W, UNLESS OTHERWISE SPECIFIED.  
UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.

BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE A MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12-1 AND SS12-2, UNLESS INDICATED OTHERWISE.

#### 4. CONSTRUCTION NOTES:

THE PROPONENT SHALL VERIFY ALL DIMENSIONS AND ELEVATIONS OF THE EXISTING STRUCTURE AND ALL DETAILS ON SITE BEFORE PROCEEDING WITH THE DESIGN.

THE PROPONENT IS RESPONSIBLE FOR THE DESIGN AND INSTALLATION OF ALL TEMPORARY STRUCTURES AND CONSTRUCTION PLATFORMS, DEBRIS CONTAINMENT SYSTEMS ETD.

THE CONTRACTOR SHALL DESIGN AND CONSTRUCT THE ROADWAY PROTECTION SYSTEMS COFFERDAMS AND TEMPORARY FLOW PASSAGE SYSTEM TO PERMIT EXCAVATION, REMOVALS AND INSTALLATION OF THE NEW CULVERT AND ALL PERTAINING OPERATIONS. ROADWAY PROTECTION SYSTEM TO BE PERFORMANCE LEVEL 2.

THE PEAK FLOW RATE OF THE CREEK RUN 2XR RETURN PERIOD IS 0.48 M<sup>3</sup>/S

ALL ELEVATIONS ARE TO GEODETIC DATUM.

BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF THE CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 300mm.

A PREFORMED GASKET SHALL BE USED TO SEAL THE JOINT BETWEEN BOXES.

FOR EXISTING ROADWAY DIMENSIONS SEE ROADWAY DRAWINGS.

#### 5. DESIGN NOTES:

TRANSVERSE JOINTS BETWEEN PRECAST UNITS MUST BE WATER PROOFED, PER MANUFACTURERS RECOMMENDATION.

LONGITUDINAL JOINTS IN THE PRECAST BOX SHALL NOT BE PERMITTED.

THE CULVERT SHALL BE DESIGNED TO THE MINIMUM CRITERIA:

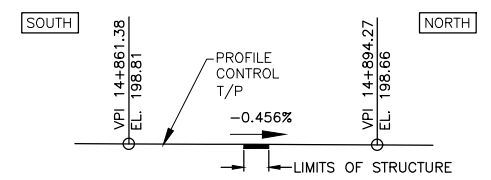
- 0.6m-1.2m FILL HEIGHT
- 3.0m CLEAR SPAN
- 2.1m AVERAGE CLEAR HEIGHT
- 197.80m STREAMBED ELEVATION UPSTREAM (WEST)
- 197.70m STREAMBED ELEVATION DOWNSTREAM (EAST)

### APPLICABLE STANDARD DRAWINGS

OPSD 3370.101 DECK WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS.

OPSD 912.240 GUIDE RAIL SYSTEM, STEEL BEAM TREATMENT OF CULVERT MINIMAL COVER INSTALLATION

MTOD 3541.210 FIGURED IN CONCRETE, SITE NUMBER AND DATE LAYOUT



PROFILE OF HIGHWAY  
N.T.S.

DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING

REVISIONS									
	JAN 19, 2022	AS			ISSUED FOR SDR				
	NOV 26, 2021	AS			PRELIMINARY DESIGN - OPTION 1 & 2				
	DATE	BY			DESCRIPTION				
DESIGN	BM	CHK	AS	CODE	CSA-S6-14	LOAD	CL6250NT	DATE	NOV 2021
DRAWN	MH	CHK	BM	SITE	No. 29X-0229/C0			DWG	1

**APPENDIX A**

# Borehole Records - Current Investigation



# ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

## MINISTRY OF TRANSPORTATION, ONTARIO

### PARTICLE SIZES OF CONSTITUENTS

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

### MODIFIERS FOR SECONDARY COMPONENTS<sup>1,2</sup>

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

1. Only applicable to components not described by Primary Group Name.

2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

### PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

#### Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	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

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

### COARSE-GRAINED SOILS

#### Compactness<sup>1</sup>

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

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

2. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

### FINE-GRAINED SOILS

#### Consistency

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

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

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

### Field Moisture Condition

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

# LIST OF SYMBOLS

## MINISTRY OF TRANSPORTATION, ONTARIO

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

### I. GENERAL

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta\sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)

$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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
$C_{a(e)}$	secondary compression index
$C_a$	rate of secondary compression
$C_{a(e)}$	modified secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$c'$	effective cohesion
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	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  $\rho$ . Unit weight symbol is  $\gamma$ .  
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 CA0009744.5044

RECORD OF BOREHOLE No 23-01

SHEET 1 OF 1

METRIC

G.W.P. 4123-17-00

LOCATION N 5027965.7; E 264131.3 MTM NAD 83 ZONE 9 (LAT. 45.390460; LONG. -77.019388)

ORIGINATED BY RI

DIST Eastern HWY 41

BOREHOLE TYPE Portable Rotary Drill-Washbore (BW Casing)/ NQ coring

COMPILED BY BW

DATUM Geodetic

DATE October 27 to 30, 2023

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
								20	40	60	80	100					
197.2	GROUND SURFACE																
0.0	Organic SILTY SAND (SM), some gravel Wet		1	SS	5												
196.6	SILTY SAND (SM), trace gravel, trace organics Very loose to loose Black Wet		2	SS	3												
			3	SS	7												
195.1	SILTY SAND (SM), some gravel, trace organics, contains cobbles and boulders (TILL) Loose to dense Grey Wet		4	SS	8												
2.1			5	SS	18												
			6	SS	44												
	- Cobbles and boulders from 3.7 m to 4.5 m		7	RC	-												
192.9	Cobbles and boulders	1	RC	-													
4.5	GNEISS (BEDROCK)																
	Bedrock cored from 4.5 m to 7.1 m	2	RC	REC 85%												RQD = 48%	
	For rock coring details see Record of Drillhole 23-01	3	RC	REC 100%												RQD = 36%	
		4	RC	REC 100%												RQD = 30%	
		5	RC	REC 100%												RQD = 80%	
190.1	END OF BOREHOLE																
7.1																	

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+ 3, X 3: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR:

[illegible]

DEPTH SCALE

1 : 50



LOGGED: BW

CHECKED: KCP



PROJECT CA0009744.5044

RECORD OF BOREHOLE No 23-02

SHEET 1 OF 1

METRIC

G.W.P. 4123-17-00

LOCATION N 5027966.5; E 264105.7 MTM NAD 83 ZONE 9 (LAT. 45.390465; LONG. -77.019715)

ORIGINATED BY RI

DIST Eastern HWY 41

BOREHOLE TYPE Portable Rotary Drill-Washbore (BW & AW Casing)/ 57 mm O.D. thin wall barrel

COMPILED BY BW

DATUM Geodetic

DATE October 23 to 25, 2023

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
								20	40	60	80	100					
197.0	GROUND SURFACE																
0.0	WATER																
196.1																	
1.0	Organic SILTY SAND (SM) Wet Gravelly SILTY SAND (SM), contains cobbles and boulders (TILL) Compact to very dense Grey brown to grey Wet - Cobbles and boulders from 1.6 m to 5.0 m		1	SS	24												
			2	SS	50/0.10												
			3	RC	-												
			4	SS	106/0.23											34 42 20 4	
			5	SS	50/0.05												
			6	RC	63												
			7	SS	43											27 49 20 4	
			8	RC	-												
192.0	GNEISS (BEDROCK)		9	RC	74%												
191.7			10	RC	0%												
5.3	Bedrock cored from 5.0 m to 5.3 m END OF BOREHOLE  NOTE:  1. Bedrock core was not recovered from RC 10.																

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PROJECT		RECORD OF BOREHOLE No 23-03										SHEET 1 OF 2			METRIC			
G.W.P. 4123-17-00		LOCATION N 5027973.0; E 264119.9 MTM NAD 83 ZONE 9 (LAT. 45.390520; LONG. -77.019530)										ORIGINATED BY BW						
DIST Eastern HWY 41		BOREHOLE TYPE Power Auger 200 mm Dia. (Hollow Stem), NQ3 Coring										COMPILED BY NV						
DATUM Geodetic		DATE August 10, 2023										CHECKED BY KCP						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	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						
198.8 0.0	GROUND SURFACE ASPHALT (100 mm)		1	GS	-													
198.0 0.8	Sandy GRAVEL (GP) (FILL) Grey-brown Moist		2	SS	19													
			3	SS	12													
			4	SS	13													
			5	SS	16													
195.1 3.7	SILTY SAND (SM), some gravel, contains cobbles and boulders (TILL) Loose Grey-brown Wet - Cobbles and boulders from 4.5 m to 5.3 m		6	SS	7*													
			7	SS	90/0.20													
193.5 5.3	GNEISS (BEDROCK)		1	RC	REC 100%													
	Bedrock cored from 5.3 m to 8.7 m For bedrock coring details see Record of Drillhole 23-03		2	RC	REC 100%													
			3	RC	REC 100%													
190.1 8.7	END OF BOREHOLE  NOTE:  1 * SPT N values impacted by sample disturbance due to groundwater conditions and heave within hollow-stem augers.																	

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PROJECT: CA0009744.5044

**RECORD OF DRILLHOLE: 23-03**

SHEET 2 OF 2

LOCATION: N 5027972.98 ;E 264119.92

DRILLING DATE: August 10, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: -

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				DEPTH (m)	FLUSH RETURN		RECOVERY		R.Q.D. %	FRACT INDEX PER	DISCONTINUITY DATA					WEATH- ERING INDEX					Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
							TOTAL CORE %	SOLID CORE %			DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon	W1	W2	W3	W4	W5		W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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UCS=171 MPa

DEPTH SCALE

1 : 50



LOGGED: BW

CHECKED: KCP





PROJECT		RECORD OF BOREHOLE No 23-04				SHEET 1 OF 2		METRIC							
G.W.P. 4123-17-00		LOCATION N 5027989.0; E 264118.2 MTM NAD 83 ZONE 9 (LAT. 45.390660; LONG. -77.019550)				ORIGINATED BY BW									
DIST Eastern HWY 41		BOREHOLE TYPE Power Auger 200 mm Dia. (Hollow Stem), NQ3 Coring				COMPILED BY NV									
DATUM Geodetic		DATE August 14, 2023				CHECKED BY KCP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED							
							20 40 60 80 100	20 40 60 80 100			25 50 75				
198.8	GROUND SURFACE														
0.0	ASPHALT (100 mm)														
0.1	Sandy GRAVEL (GP) (FILL)		1	GS	-										
	Grey-brown Moist														
198.0	Gravelly SAND (SP-SM), trace non-plastic fines (FILL)		2	SS	51		198						33 57 (10)		
0.8	Very dense to compact Grey-brown Moist to wet														
			3	SS	19		197								
196.4			4A												
2.4	Organic SILTY SAND (SM) to SILTY SAND (SM) with organics		4B	SS	4		196					OC=4.1%			
195.9	Black Wet														
2.9	Gravelly SILTY SAND (SM)		5	SS	22		195						30 55 (15)		
	Compact to very loose Brown Wet														
			6	SS	1*										
193.9			7A	SS	53		194						52 31 (17)		
193.6	Sandy SILTY GRAVEL (GM), contains cobbles and boulders (TILL)		7B												
5.2	Brown Moist		1	RC	-		193						RQD = 100%		
	GNEISS (BEDROCK)														
	Bedrock cored from 5.2 m to 8.8 m		2	RC	REC 100%		192						RQD = 100%		
	For bedrock coring details see Record of Drillhole 23-04														
			3	RC	REC 100%		191						RQD = 100%		
190.1	END OF BOREHOLE														
8.8	NOTE:  1 * SPT N values impacted by sample disturbance due to groundwater conditions and heave within hollow-stem augers.														

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PROJECT: CA0009744.5044

**RECORD OF DRILLHOLE: 23-04**

SHEET 2 OF 2

LOCATION: N 5027989.05 ;E 264118.25

DRILLING DATE: August 14, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: -

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP W/L CORE AXIS	DISCONTINUITY DATA			WEATH- ERING INDEX	Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja			Jzon																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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DEPTH SCALE

1 : 50



LOGGED: BW

CHECKED: KCP

GTA-RCK 046 S:\CLIENTS\MT\HWY 41 PEMBROKE\02 DATA\GINT\HWY 41 PEMBROKE.GPJ GAL-MISS.GDT 6/27/24



PROJECT		RECORD OF BOREHOLE		No 23-05		SHEET 1 OF 2		METRIC													
G.W.P. 4123-17-00		LOCATION		N 5027959.4; E 264117.0 MTM NAD 83 ZONE 9 (LAT. 45.390390; LONG. -77.019570)		ORIGINATED BY		BW													
DIST Eastern HWY 41		BOREHOLE TYPE		Power Auger 200 mm Dia. (Hollow Stem), NQ3 Coring		COMPILED BY		NV													
DATUM Geodetic		DATE		August 14, 2023		CHECKED BY		KCP													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)												
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20	40	60	80	100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	GR	SA	SI	CL
199.1	0.0	GROUND SURFACE																			
198.3	0.8	ASPHALT (100 mm)		1	GS	-		199													
		Sandy GRAVEL (GP) to Gravelly SAND (SP) (FILL)		2	SS	34		198										27	65		(8)
		Grey-brown Moist		3	SS	14		197													
		Gravelly SAND (SP-SM), trace non-plastic fines (FILL)		4A	SS	18		196													
		Dense to compact Grey-brown Moist to wet		4B	SS	18		195													
		Organic SILTY SAND (SM) Black Wet		4C	SS	18		194													
		Gravelly SILTY SAND (SM), contains cobbles and boulders (TILL)		5	SS	13		193													
		Compact to dense Brown Moist to Wet		6	SS	28		192													
		- Cobbles and boulders from 6.1 m to 6.8 m		7	SS	40		191													
				8	SS	19		190													
				9	SS	100/0.0		189													
192.3	6.8	GNEISS (BEDROCK)		1	RC	REC 100%		192													
		Bedrock cored from 6.8 m to 10.2 m		2	RC	REC 100%		191													
		For bedrock coring details see Record of Drillhole 23-05		3	RC	REC 100%		190													
188.9	10.2	END OF BOREHOLE						189													
		NOTE:																			
		1. Water level in screen measured as follow:																			
		Date Depth (m) Elev. (m)																			
		14-Aug-23 2.5 196.6																			
		24-Oct-23 2.1 197.0																			





Cobbles and  
boulders

**BH 23-1 (Dry)**  
**Core Box 1 & 2 of 2**

Top of Bedrock Elevation 192.7 m

Elevation 190.1 m End of Drillhole



**Replacement of Structural Culvert 29X-0229/C0**  
**Highway 41, Grattan, Ontario**  
**MTO GWP 4123-17-00;**  
**Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	BW
Date:	2024-01-03
Checked:	KCP
Review:	JPD

**Figure A1**



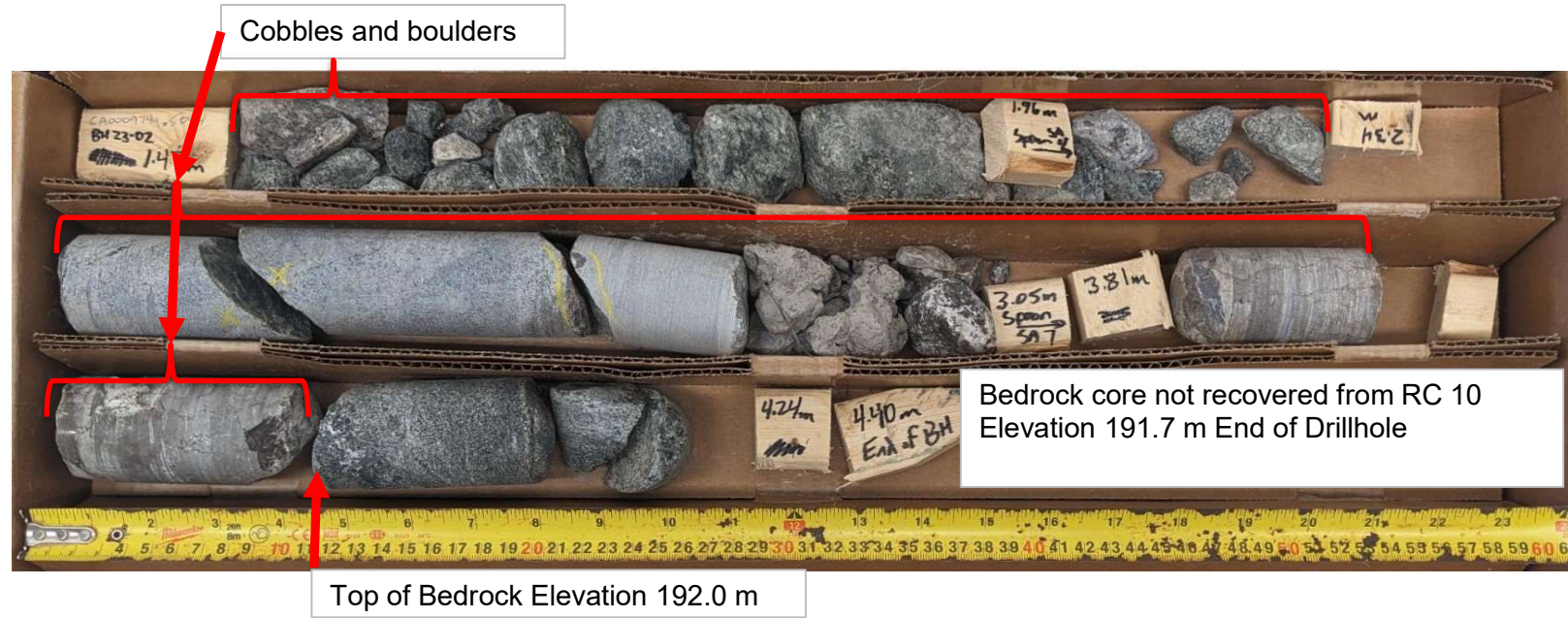


**Replacement of Structural Culvert 29X-0229/C0**  
**Highway 41, Grattan, Ontario**  
**MTO GWP 4123-17-00;**  
**Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	BW
Date:	2024-01-03
Checked:	KCP
Review:	JPD

**Figure A2**

**BH 23-2 (Dry)  
Core Box 1 of 1**



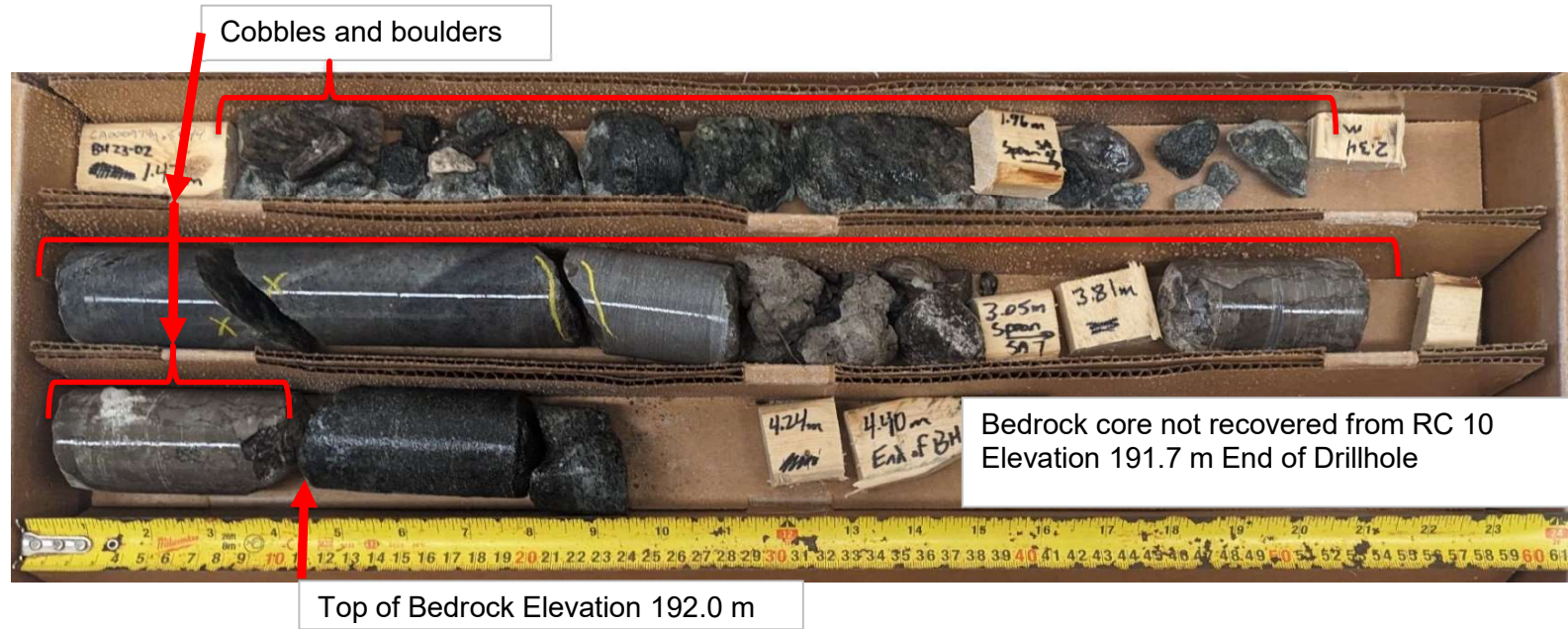
**Replacement of Structural Culvert 29X-0229/C0  
Highway 41, Grattan, Ontario  
MTO GWP 4123-17-00;  
Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	BW
Date:	2024-03-21
Checked:	KCP
Review:	JPD

**Figure A3**



BH 23-2 (Wet)  
Core Box 1 of 1



Replacement of Structural Culvert 29X-0229/C0  
Highway 41, Grattan, Ontario  
MTO GWP 4123-17-00;  
Agreement Number 4021-E-0021-04

Project No.	CA0009744.5044
Drawn:	BW
Date:	2024-03-21
Checked:	KCP
Review:	JPD

Figure A4



**BH 23-3 (Dry)  
Core Box 1 of 1**

Cobbles and  
boulders

Top of Bedrock Elevation 193.4 m



Elevation 190.1 m  
End of Drillhole



**Replacement of Structural Culvert 29X-0229/C0  
Highway 41, Grattan, Ontario  
MTO GWP 4123-17-00;  
Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	PAK/ KG/BW
Date:	2023-08-16
Checked:	KCP
Review:	JPD

**Figure A5**

**BH 23-3 (Wet)  
Core Box 1 of 1**

Cobbles and  
boulders

Top of Bedrock Elevation 193.4 m



Elevation 190.1 m



**Replacement of Structural Culvert 29X-0229/C0  
Highway 41, Grattan, Ontario  
MTO GWP 4123-17-00;  
Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	PAK/ KG/BW
Date:	2023-08-16
Checked:	KCP
Review:	JPD

**Figure A6**

**BH 23-4 (Dry)  
Core Box 1 of 1**

Cobbles and  
boulders

Top of Bedrock Elevation 193.6 m



Elevation 190.1 m  
End of Drillhole



**Replacement of Structural Culvert 29X-0229/C0  
Highway 41, Grattan, Ontario  
MTO GWP 4123-17-00;  
Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	PAK/ KG/BW
Date:	2023-08-16
Checked:	KCP
Review:	JPD

**Figure A7**



**BH 23-4 (Wet)**  
**Core Box 1 of 1**

Cobbles and  
boulders

Top of Bedrock Elevation 193.6 m



Elevation 190.1m  
End of Drillhole



**Replacement of Structural Culvert 29X-0229/C0**  
**Highway 41, Grattan, Ontario**  
**MTO GWP 4123-17-00;**  
**Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	PAK/ KG/BW
Date:	2023-08-16
Checked:	KCP
Review:	JPD

**Figure A8**

**BH 23-5 (Dry)**  
**Core Box 1 of 1**

Top of Bedrock Elevation 192.3 m



Elevation 188.9 m  
 End of Drillhole



**Replacement of Structural Culvert 29X-0229/C0**  
**Highway 41, Grattan, Ontario**  
**MTO GWP 4123-17-00;**  
**Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	PAK/ KG/BW
Date:	2023-08-16
Checked:	KCP
Review:	JPD

**Figure A9**

**BH 23-5 (Wet)**  
**Core Box 1 of 1**

Top of Bedrock Elevation 192.3 m



Elevation 188.9 m  
 End of Drillhole



**Replacement of Structural Culvert 29X-0229/C0**  
**Highway 41, Grattan, Ontario**  
**MTO GWP 4123-17-00;**  
**Agreement Number 4021-E-0021-04**

Project No.	CA0009744.5044
Drawn:	PAK/ KG/BW
Date:	2023-08-16
Checked:	KCP
Review:	JPD

**Figure A10**

**APPENDIX B**

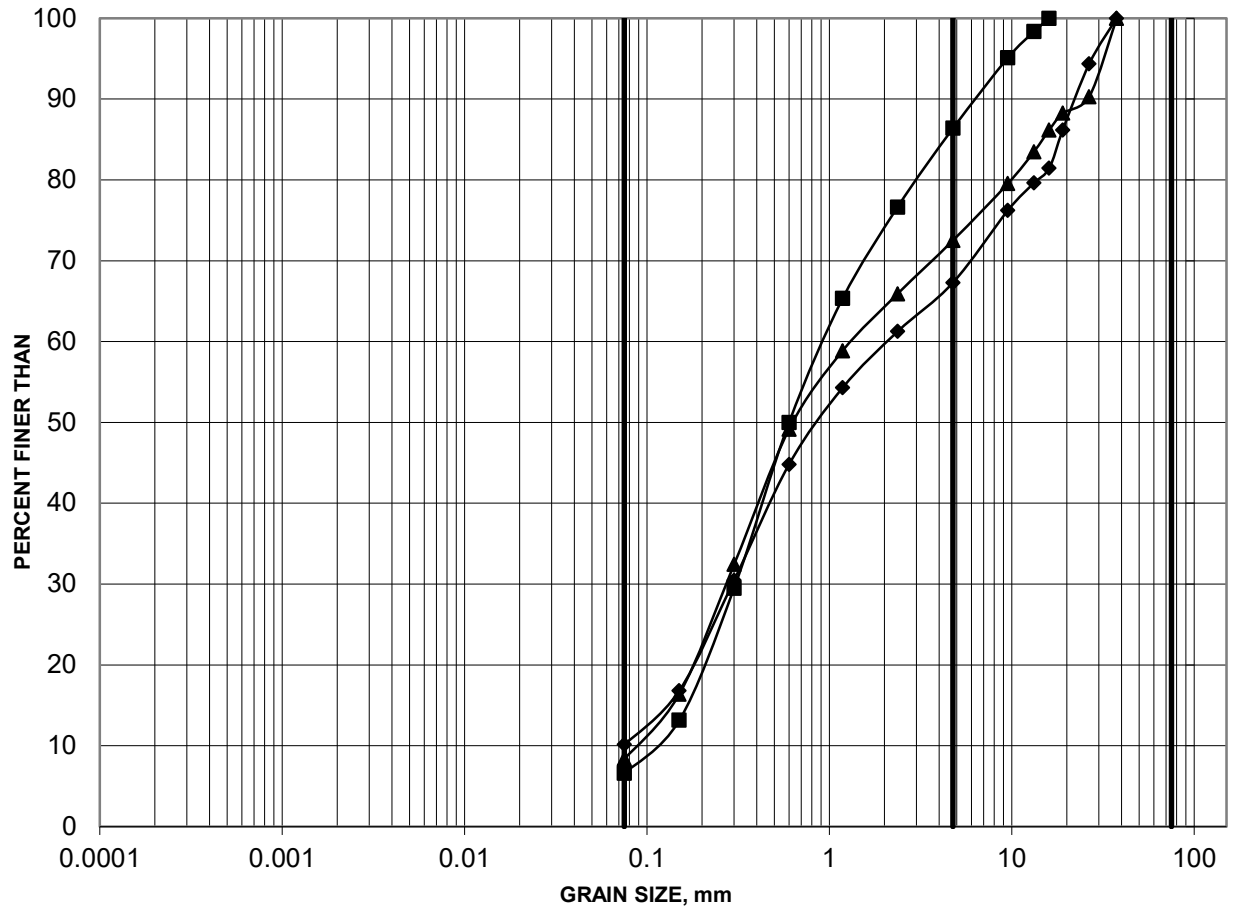
# Geotechnical Laboratory Test Results



# GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND, to SAND, some gravel (FILL) (SP-SM)



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

Borehole	Sample	Depth (m)	Constituents (%)			
			Gravel	Sand	Silt	Clay
■ 23-03	4	2.30-2.90	14	79	7	
◆ 23-04	2	0.80-1.40	33	57	10	
▲ 23-05	2	0.80-1.40	27	65	8	

Project: CA0009744.5044

<https://wsponlinecan.sharepoint.com/sites/CA-CA00097445044/Shared Documents/05. Technical/Lab/Lab Figures/>



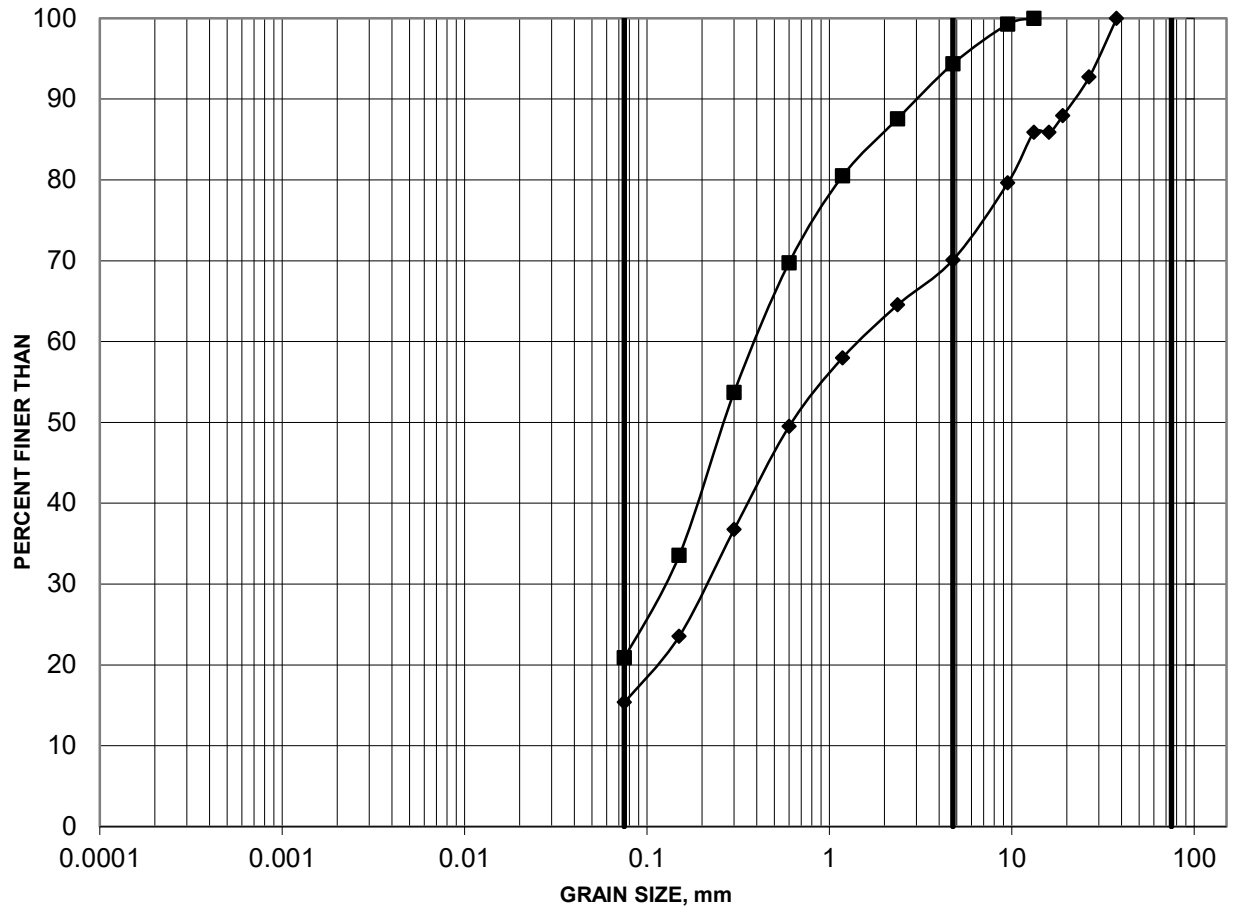
Created by: BW  
Checked by: MI



# GRAIN SIZE DISTRIBUTION

FIGURE B2

## Gravelly SILTY SAND to SILTY SAND (SM)



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

	Borehole	Sample	Depth (m)	Constituents (%)			
				Gravel	Sand	Silt	Clay
■	23-01	3	1.22-1.83	6	73	21	
◆	23-04	5	3.00-3.70	30	55	15	



Project: CA0009744.5044

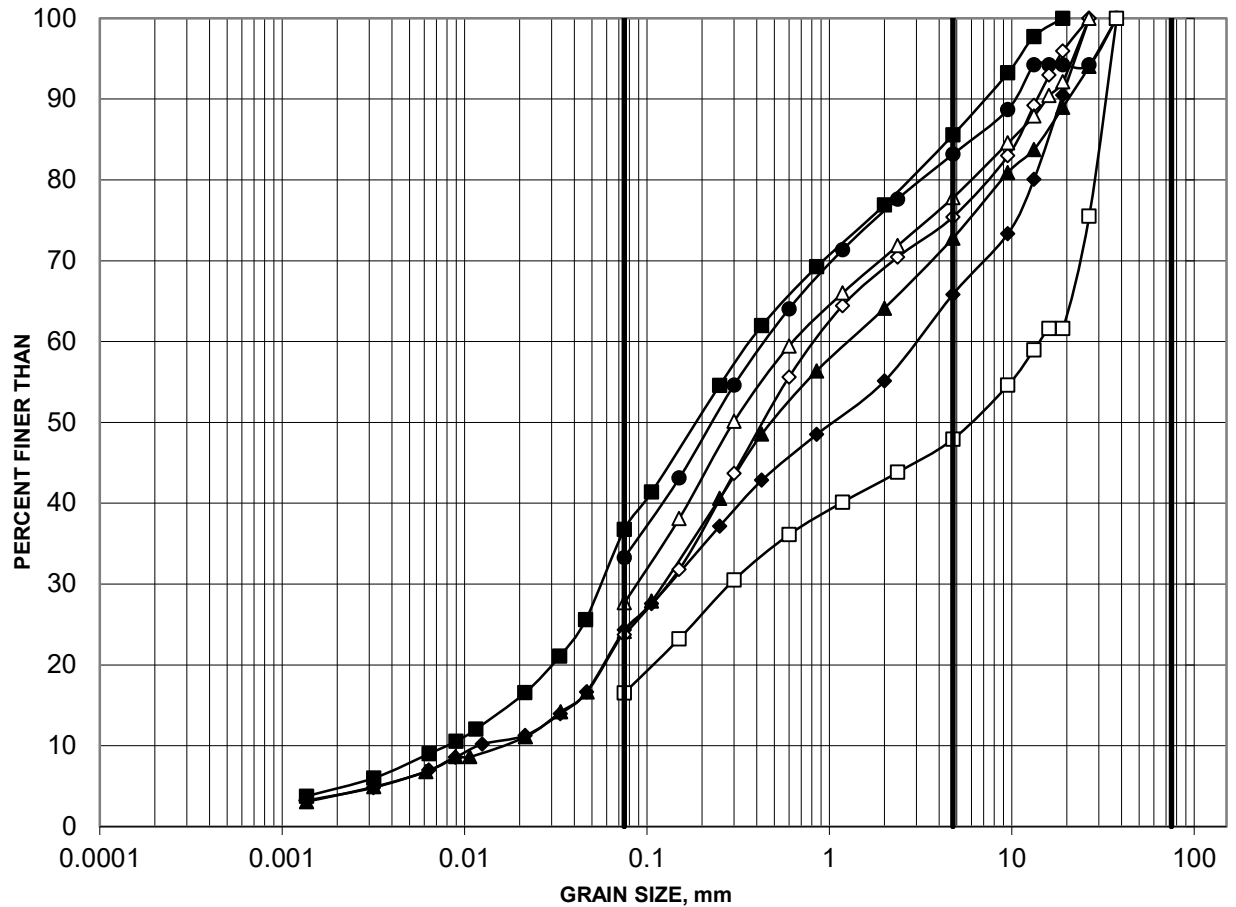
<https://wsponlinecan.sharepoint.com/sites/CA-CA00097445044/Shared Documents/05. Technical/Lab/Lab Figures/>

Created by: BW  
Checked by: MI

# GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY SAND, some gravel to Sandy SILTY GRAVEL (TILL) (SM to GM)



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

	Borehole	Sample	Depth (m)	Constituents (%)			
				Gravel	Sand	Silt	Clay
■	23-01	5	2.44-3.05	14	49	32	5
◆	23-02	4	2.01-2.34	34	42	20	4
▲	23-02	7	3.05-3.66	27	49	20	4
●	23-03	6	3.80-4.40	17	50		33
□	23-04	7B	4.90-5.10	52	31		17
◇	23-05	5	3.00-3.70	25	51		24
△	23-05	8	5.30-5.90	22	50		28

wsp

Project: CA0009744.5044

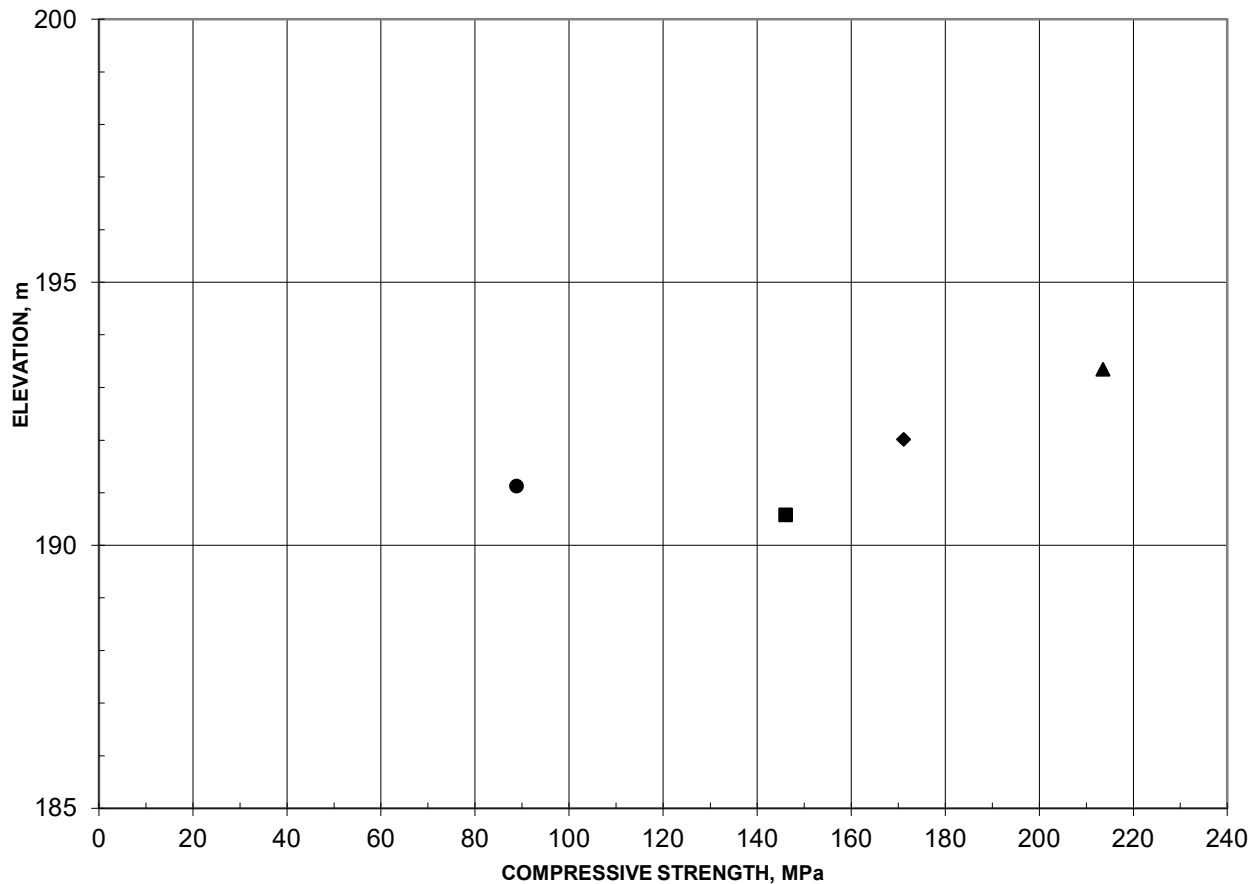
<https://wsponlinecan.sharepoint.com/sites/CA-CA00097445044/Shared Documents/05. Technical/Lab/Lab Figures/>

Created by: BW

Checked by: MI

**ASTM D7012 - Method C**  
**UNCONFINED UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE**  
**SUMMARY OF LABORATORY TEST RESULTS**

**FIGURE B4**



	Borehole	Depth (m)	L/D	Bulk Density (kg/m <sup>3</sup> )	Lithology	UCS (MPa)	Failure Type
■	23-01 RC1	6.6	3	2649	Granitic Gneiss	146	1
◆	23-03 RC1	6.8	2.2	2817	Granitic Gneiss	171	1
▲	23-04 RC1	5.5	2.5	2568	Granitic Gneiss	214	1
●	23-05 RC1	8.0	2.3	2590	Granitic Gneiss	89	1

**Notes:**

**Failure Types**

1. Well formed cones on both ends
2. Well formed cones on one end, vertical cracks through cap
3. Columnar vertical cracking through both ends
4. Diagonal fracture with no cracking through ends
5. Side fractures at top or bottom
6. Side fractures at both sides of top or bottom

**Remarks**

- Cores tested in vertical direction.
- Cores tested in air-dry condition.
- Time to failure > 2 and < 15 minutes.

**wsp**

Project: CA0009744.5044

Created by: BW

Checked by: MI

**APPENDIX C**

# 2021 Investigation Results

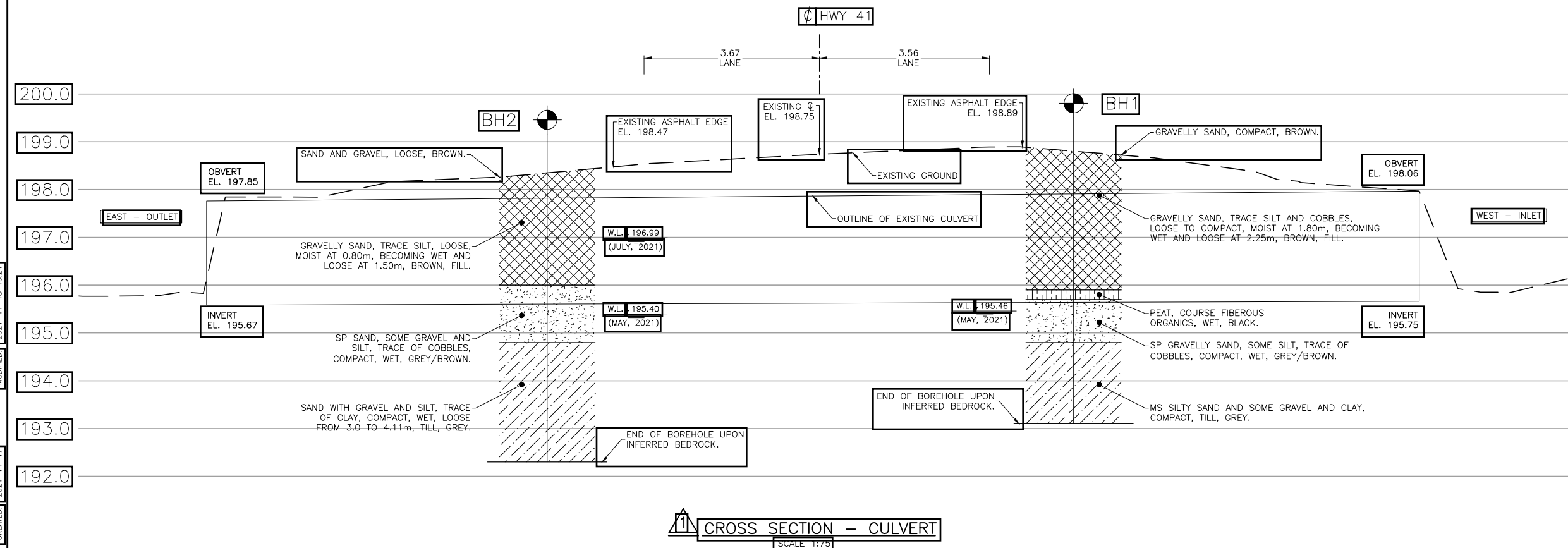
FIGURE 1



## LEGEND



- DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING



FILE NAME: 18804-23 - Borehole Location Plan.dwg  
CREATED: 2021-11-17  
MODIFIED: 2021-11-18 16:24

# RECORD OF BOREHOLE No BH1

1 OF 1

**METRIC**

W.P. 18804-23 LOCATION Structural Culvert 29X-0229/C0 South Bound Shoulder ORIGINATED BY JRC  
 DIST HWY 41 BOREHOLE TYPE Truck Mounted CME 55 COMPILED BY ETD  
 DATUM GEODETIC DATE 2021.05.17 - 2021.05.17 LATITUDE 45.390506 LONGITUDE -77.019631 CHECKED BY LAH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								WATER CONTENT (%)				GR
198.8	Fill							20	40	60	80	100								
0.0	Gravelly sand, compact, brown.		7	GRAB																33 56 (11)
198.6																				
0.2	Gravelly sand, trace silt and cobbles, loose to compact, moist at 1.80 m, becoming wet and loose at 2.25 m, brown, fill.																			
			8	SS	28															
			9	SS	7															
			10	SS	3															
195.9	Peat, coarse fibrous organics, wet, black.																			
2.9																				
195.7																				
3.1	SP Gravelly sand, some silt, trace of cobbles, compact, wet, grey/brown.		11	SS	21															36 44 (20)
194.8	MS Silty sand some gravel and clay, compact, till, grey.		12	SS	17															
4.0																				
			12	SS	16															18 44 25 13
193.1	End of Borehole at 5.65 m below existing site grades upon inferred bedrock. Groundwater infiltration was encountered at 2.1 m below existing site grades.																			
5.7																				

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH2/MW

1 OF 1

METRIC

W.P. 18804-23 LOCATION Structural Culvert 29X-0229/C0 North Bound Shoulder ORIGINATED BY JRC  
 DIST HWY 41 BOREHOLE TYPE Truck Mounted CME 55 COMPILED BY ETD  
 DATUM GEODETIC DATE 2021.05.17 - 2021.05.17 LATITUDE 45.39047 LONGITUDE -77.019483 CHECKED BY LAH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
198.4	Fill							20	40	60	80	100					
0.0	Sand and gravel, loose, brown.		1	GRAB													45 47 (8)
198.2	Gravelly sand, trace of silt, loose, moist at 0.80 m, becoming wet at 1.50 m, brown, fill.																
0.2																	
			2	SS	5												
			3	SS	5												35 61 (4)
196.0	SP Sand some gravel and silt, trace of cobbles, compact, wet, grey and brown.																
2.4			4	SS	14												20 64 (16)
			5	SS	21												
194.8	Sand, with gravel and silt, trace of clay, compact, wet, loose from 3.80 to 4.11 m, grey, till.																
3.6			5	SS	30												20 47 21 12
			6	SS	27												25 45 21 9
192.3	End of Borehole at 6.10 m below existing site grades upon inferred bedrock. Depth to groundwater was measured to be 2.98 m below existing site grades on May 17, 2021 and 1.39 m below existing site grades on July 10, 2021.		6	SS	R												
6.1																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**APPENDIX D**

# Analytical Laboratory Test Results

**Certificate of Analysis**

Client: Golder Associates Ltd (Ottawa)  
1931 Robertson Road,  
Ottawa, Ontario

Attention: Mr. Kenton Power  
PO#:  
Invoice to: WSP Canada Inc.

Report Number: 3000876  
Date Submitted: 2023-08-30  
Date Reported: 2023-09-07  
Project: CA0009744.5044  
COC #: 910339

Page 1 of 3

---

**Dear Kenton Power:**

**Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).**

Report Comments:

APPROVAL:

\_\_\_\_\_  
Raheleh Zafari, Environmental Chemist

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: <https://directory.cala.ca/>.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

## Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)  
1931 Robertson Road,  
Ottawa, Ontario

Attention: Mr. Kenton Power

PO#:

Invoice to: WSP Canada Inc.

Report Number: 3000876  
Date Submitted: 2023-08-30  
Date Reported: 2023-09-07  
Project: CA0009744.5044  
COC #: 910339

					Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	
Group	Analyte	MRL	Units	Guideline	1701270 Soil  2023-08-10 23-03 Sa2/0.8-1.4m	1701271 Soil  2023-08-14 23-05 Sa3/1.5-2.1m
Anions	Cl	0.002	%		0.039	0.016
	SO4	0.01	%		<0.01	<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.83	0.42
	pH	2.00			9.41	8.44
	Resistivity	1	ohm-cm		1205	2381

Guideline =

\* = Guideline Exceedence

Results relate only to the parameters tested on the samples submitted.  
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

# Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)  
1931 Robertson Road,  
Ottawa, Ontario

Attention: Mr. Kenton Power

PO#:

Invoice to: WSP Canada Inc.

Report Number: 3000876  
Date Submitted: 2023-08-30  
Date Reported: 2023-09-07  
Project: CA0009744.5044  
COC #: 910339

## QC Summary

Analyte	Blank	QC % Rec	QC Limits
<b>Run No</b> 448353 <b>Analysis/Extraction Date</b> 2023-09-06 <b>Analyst</b> IP <b>Method</b> Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	99	90-110
pH	6.66	99	90-110
Resistivity			
<b>Run No</b> 448357 <b>Analysis/Extraction Date</b> 2023-09-06 <b>Analyst</b> IP <b>Method</b> AG SOIL			
SO4	<0.01 %	95	70-130
<b>Run No</b> 448454 <b>Analysis/Extraction Date</b> 2023-09-07 <b>Analyst</b> AsA <b>Method</b> C CSA A23.2-4B			
Chloride	<0.002 %	100	90-110

**Guideline =**      **\* = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.  
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

**APPENDIX E**

# Ecology Technical Memorandums





## TECHNICAL MEMORANDUM

**DATE** November 6, 2023

**Project No.** CA009744.5044

**TO** Ministry of Transportation Ontario

**FROM** Leslie Keith and Tamara Darwish, WSP

**EMAIL** tamara.darwish@wsp.com

### BOREHOLE DRILLING MITIGATION ASSESSMENT UNDER THE FISHERIES ACT

## 1.0 INTRODUCTION

The Ontario Ministry of Transportation (MTO) – East Region Office has retained WSP Canada Inc. (WSP) to undertake a geotechnical field investigation for the replacement of Culvert 29X-0229/C0 located on Highway 41 approximately 1.0 kilometre (km) north of Opeongo Road, in Grattan, Ontario (the Site; Attachment 1 – Figure 1). The Project includes advancing two in-water boreholes to assess cofferdam design requirements upstream and downstream of the culvert. As part of the Project requirements, WSP has completed a review of potential impacts of the Project on fish and fish habitat at the Site, to determine the need for a project review by Fisheries and Oceans Canada (DFO) under the *Fisheries Act*. WSP has also provided a list of mitigation measures to follow during in and near water work. For the purposes of this memorandum, the Site includes the entire expected area of disturbance from the proposed works, and the Study Area refers to the area within 120 metres (m) of the Site.

## 2.0 METHODS

A desktop review of existing background data sources was completed following the methods outlined below.

### 2.1 Review of Existing Data

The information available for the Site and Study Area served to identify fall spawning fish species and fish species at risk (SAR) known to be present, or having the potential to be present. Information sources consulted included:

- Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Make-a-Map Explorer (MNRF 2023b) for information on known occurrences of Species at Risk (SAR)
- Species at Risk Public Registry (ECCC 2021)
- Species at Risk in Ontario (SARO) List (MECP 2023)
- MNRF Land Information Ontario (LIO) mapping (LIO 2023)
- Fisheries and Oceans Canada (DFO) Aquatic SAR Mapping (DFO 2023a)
- Canadian Freshwater Mussel Guide (Toronto Zoo and DFO 2023)
- MNRF Fish ONLine (MNRF 2023a)
- DFO Habitat Ecosystem Assessment Tool (Mandrak et al. 2023)

- Vascular Plants at Risk in Ontario (Leslie 2018)
- Existing aerial photography and site photographs taken by WSP staff

### 2.1.1 Species at Risk Screening

SAR considered in the screening included those listed as endangered, threatened, and special concern under the *Endangered Species Act, 2007* (ESA; Ontario 2007) and the *Species at Risk Act* (SARA; Canada 2002). A screening of the SAR that have the potential to be found on the Site and in the Study Area was conducted as a desktop exercise, using the sources listed above. Species with ranges overlapping the Site or Study Area, or recent occurrence records in the vicinity, were screened by comparing their habitat requirements to habitat conditions on the Site and in the Study Area, based on review of aerial photography and site photographs.

Data from the SAR screening were used in combination with site photographs to determine a final probability of SAR and/or SAR habitats within the Site and Study Area.

The potential for the species to occur was determined through a probability of occurrence. A ranking of NIL indicates no suitable habitat availability for that species within the Site or Study Area. Low probability ranking indicates a low potential for the species to occur as no suitable habitat occurs within the Site or Study Area, but recent occurrence of the species has been recorded. Moderate probability indicates greater potential for the species to occur, as suitable habitat may occur within the Site or Study Area, but no recent occurrence of the species has been recorded. High potential indicates a known species record on the Site and/or within the Study Area (i.e., from occurrence records collected during background data review) and good quality habitat may occur on the Site and/or in Study Area. Species screened as having a moderate to high potential to occur are considered to have potentially suitable habitat conditions within the Study Area and may require further field investigation to confirm the presence of habitats and/or use of habitats.

## 3.0 RESULTS

### 3.1 Background Data

The Project is located on a watercourse that flows west to east across Highway 41, ultimately outletting into Constant Lake approximately 1.75 km downstream (east) of the highway (Attachment 1 – Figure 1). At Highway 41, the channel is braided throughout a wetland upstream and downstream of the culvert crossing. Fish species recorded in this watercourse (LIO 2023) include Bluntnose Minnow (*Pimephales notatus*), Brook Stickleback (*Culaea inconstans*), Central Mudminnow (*Umbra limi*), Common Shiner (*Luxilus cornutus*), Iowa Darter (*Etheostoma exile*), Northern Pearl Dace (*Margariscus nachtriebi*), Northern Redbelly Dace (*Chrosomus eos*), and Pumpkinseed (*Lepomis gibbosus*).

Downstream of the Site, the following species are found or potentially found within Constant Lake (MNRF 2023a): Brown Bullhead (*Ameiurus nebulosus*), Burbot (*Lota lota*), Cisco (*Coregonus sp.*), Largemouth Bass (*Micropterus nigricans*), Northern Pike (*Esox lucius*), Pumpkinseed (*Lepomis gibbosus*), Rock Bass (*Ambloplites rupestris*), Smallmouth Bass (*Micropterus dolomieu*), Walleye (*Sander vitreus*), White Sucker (*Catostomus commersonii*), and Yellow Perch (*Perca flavescens*).

### 3.2 Species at Risk Screening

The following SAR species have been recorded within the watershed: Hill's Pondweed (*Potamogeton hillii*; Special Concern under the ESA and SARA), Hickorynut (*Obovaria olivaria*; Endangered under the ESA and

SARA), American Eel (*Anguilla rostrata*; Endangered under the ESA and not listed under SARA), Lake Sturgeon (*Acipenser fulvescens* pop. 3; Endangered under the ESA and not listed under SARA), Lake Whitefish (*Coregonus clupeaformis*; Threatened under the ESA and not listed under SARA), and River Redhorse (*Moxostoma carinatum*; Special Concern under the ESA and SARA). Although these species have occurrence records in the watershed, there's no habitat or record of occurrence in the watercourse crossing under Highway 41. Therefore, the potential for these species to occur within the Site or Study Area is Nil, and these species are not discussed further in this memorandum.

## 4.0 PROPOSED WORKS AND MITIGATION MEASURES

### 4.1 Overview of Proposed Work

The proposed in-water works includes drilling one borehole upstream and one borehole downstream of the Highway 41 culvert to assess cofferdam design requirements. Portable drilling equipment is proposed using a raft/platform to reach the borehole locations, fitted with a heavy-duty landscaping textile cloth material and perimeter lip to contain any sediment on the surface that would have otherwise been released to the watercourse. Cuttings (i.e., waste material from the drilling works) will also be contained and pumped to shore using a sump pump with a screened hose, or collected in a barrel on the raft (depending on site conditions). Gas generator and water pump will be in a plastic containment tray at all times in case of accidental leaks or spills. A spill kit and fire extinguisher will also be present at all times. This work will occur during the week of 23 October 2023.

### 4.2 In-Water Work Mitigation Measures

The following mitigation measures are recommended for implementation to address potential impacts on fish and fish habitat. These measures closely follow DFO's Measures to protect fish and fish habitat (DFO 2023b).

#### Prevention of death of fish:

- As spring spawning are present within the Site and the Study Area, it is recommended that no in-water works, including drilling, occur between March 15 and July 15 of any given year (i.e., in-water work should occur between July 16 and March 14), as outlined in the Ontario Provincial Standard Specification (OPSS) 182.
- Duration of in-water work will be minimized.

#### Maintenance of Riparian Vegetation:

- Removal of riparian vegetation in and around the watercourses shall be kept to a minimum and in accordance with OPSS 182.
- Vegetation protection and rehabilitation shall be in accordance with OPSS 182, OPSS 803 and OPSS 804.
- Exposed surfaces will be re-vegetated as soon as possible using standard seed mix as per OPSS 804.

#### Sediment and Erosion Control

- Temporary Erosion and Sediment Control Areas (i.e., silt fence or equivalent) will be established before starting work to prevent sediment from entering the watercourse in accordance with OPSS 805.
- Regularly inspect, maintain, and repair erosion and sediment control measures and structures.
- Limit machinery fording of the watercourse to a one-time event or use temporary crossing structures and use watercourse bank and bed protection measures.

*Conducting works/undertakings/activities on land:*

- Any temporarily stockpiled soil, debris or other excess materials, and any construction-related materials, will be properly contained (e.g., within silt fencing) in accordance with OPSS 180 and 182. All construction materials, excess materials and debris should be removed and appropriately disposed of following construction.
- Use of equipment in and around the watercourses and associated drainage features shall be in accordance with OPSS 182.
- Drilling activities should be controlled so as to prevent entry of any petroleum products, debris or other potential contaminants/deleterious substances, in addition to sediment as outlined above, to the watercourse.
- Wash, refuel and service equipment away from the watercourse.
- Develop and implement a site-specific spill management plan and have all components on site at all times in event of a spill.

Guidance provided in DFO's Standards and Codes of Practice should also be applied to protect fish and fish habitat. There is one Code of Practice that applies to the borehole drilling works:

- **Temporary Stream Crossings** – information can be used generally to determine the best method (i.e., raft or platform) to access the borehole areas within the wetlands, to confirm that fish and fish habitat are protected during the access works.

## **5.0 ASSESSMENT OF MITIGATION MEASURES UNDER THE *FISHERIES ACT***

Compliance with the *Fisheries Act* involves incorporating mitigation measures to avoid death of fish or HADD in the borehole drilling works. The most critical mitigation measures associated with this drilling activities includes DFO's measures to protect fish and fish habitat, while also maintaining riparian vegetation to the extent possible and limiting intrusion on the channel bed through design of the temporary stream access platform/raft. Proper erosion and sediment control measures should be implemented on the banks to avoid sediment introduction into the watercourse including operating machinery on land in stable, dry areas and limiting impacts to watercourse banks. Measures to prevent entry of deleterious substances in water will be implemented including maintaining machinery on site in a clean condition and free of fluid leaks, washing, refueling, and servicing machinery and storing fuel away from the watercourse, disposing of waste material above the high water mark (i.e. cuttings pumped from access platform to barrels), and ensuring that material used in the watercourse is treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

In-water works cannot be avoided as the borehole drilling must occur in the channel bed using a temporary structure below the high-water mark. Nominal disturbance is expected on the waterbody bed from the drilling and drilling equipment and boreholes, and temporary impacts to the vegetation within the wetland are expected to be of short duration, with full vegetation recovering following the access and drilling works.

The in-water timing window will protect fish and fish habitat during the critical life cycle phases for the resident species, and the mitigation measures will confirm that sediment or deleterious substances do not enter the creek during the drilling works. It should be noted however that the in-water work timing window guidance of July 16 to March 14 is based on a review of background data, and has not been confirmed by MNRF.

## 6.0 SUMMARY

Application of the mitigation measures outlined above will confirm that fish and fish habitat are protected during the borehole drilling works. In water works will be completed during the timing window guidance provided by MNRF, access to the borehole locations will be temporary and via a raft or platform designed using DFO's temporary crossing guidelines and cuttings will be contained within barrels or pumped to containment areas on the highway. The in water works timing window is based on background data and has not been confirmed by MNRF, and therefore should be treated as guidance only until confirmed. Should the described scope of work change, please contact MTO and/or WSP.

## 7.0 LIMITATIONS

This technical memorandum (memo) was prepared for the exclusive use of the Ministry of Transportation Ontario. The memo, which specifically includes all tables, figures and attachments, is based on data and information collected by WSP Canada Inc. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by WSP Canada Inc. as described in this memo. The status of species listed in the noted Acts and Regulations are effective as of the date of authoring of this memo. No species-specific assessments were conducted, and the assessment may be subject to limitations associated with base mapping, other publicly available information used, and a non-targeted site visit.

Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore authenticity of any electronic media versions of WSP's report should be verified.

WSP Canada Inc. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the report as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

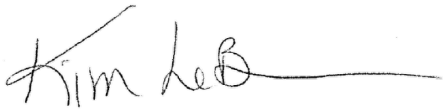
Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, WSP Canada Inc. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

## 8.0 CLOSURE

We trust this report meets your current requirements. If you have any questions regarding this report, please contact the undersigned.

### **WSP Canada Inc.**



Kim LeBrun, HBSc.  
*Senior Fisheries Ecologist*



Tamara Darwish, MSc.  
*Principal, Aquatic Biologist*

LK/TD/ljv

Attachments: Attachment 1 – Figure 1: Site Location Plan  
Attachment 2 – Representative Photographs

[https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared documents/06. deliverables/ecology/fisheries memo/ca0009744.5044 tm rev0 2023'11'06 hwy 41 fisheries memo.docx](https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared%20documents/06.%20deliverables/ecology/fisheries%20memo/ca0009744.5044%20tm%20rev0%202023%2711%2706%20hwy%2041%20fisheries%20memo.docx)

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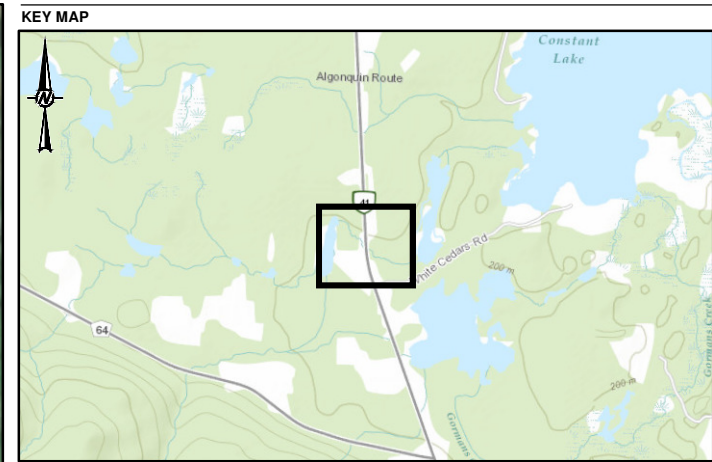
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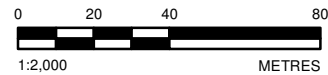
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- LEGEND**
- THE SITE
  - STUDY AREA (120m)
  - CULVERT
  - BOREHOLES



**NOTE(S)**  
1. ALL LOCATIONS ARE APPROXIMATE

**REFERENCE(S)**  
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO  
2. IMAGERY CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY  
SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY  
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

**CLIENT**  
MINISTRY OF TRANSPORTATION ONTARIO

**PROJECT**  
HIGHWAY 41 CULVERT 29X-0229/C0

**TITLE**  
BOREHOLE AND CULVERT LOCATIONS

	CONSULTANT	YYYY-MM-DD	2023-10-12
	DESIGNED	CE	
	PREPARED	PS	
	REVIEWED	CE	
	APPROVED	---	

PROJECT NO.	CONTROL	REV.	FIGURE
CA0009744.5044	0001	A	1

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





Photograph 1: General site photo facing north, June 2023



Photograph 2: General site photo facing east, June 2023



Photograph 3: General site photo facing south, June 2023



Photograph 4: General site photo facing west, June 2023





Photograph 5: Culvert 29X-0229 east opening, June 2023



Photograph 6: Culvert 29X-0229 east opening, June 2023



Photograph 7: Culvert 29X-0229 west opening, June 2023



Photograph 8: Culvert 29X-0229 west opening, June 2023





Photograph 9: Basking Midland painted turtle, June 2023



Photograph 10: Beaver lodge near west opening of Culvert 29X-0229, June 2023



Photograph 11: Beaver dams east of Culvert 29X-0229, June 2023



Photograph 12: Turtle nest along roadside, June 2023



## TECHNICAL MEMORANDUM

**DATE** November 3, 2023

**Project No.** CA0009744.5044

**TO** Ministry of Transportation Ontario

**FROM** Trysta Bastien and Gwendolyn Weeks, WSP

**EMAIL** gwendolyn.weeks@wsp.com

### **SPECIES AT RISK AND MITIGATION FOR HIGHWAY 41 CULVERT 29X-0229/C0 BOREHOLE DRILLING**

## **1.0 INTRODUCTION**

WSP Canada Inc. (WSP) was retained by the Ministry of Transportation Ontario (MTO) to prepare a Species at Risk (SAR) screening for the proposed geotechnical drilling to support eventual replacement of Highway 41 Culvert 29X-0229/C0 (the Site; Attachment 1 – Figure 1), located approximately 1 km north of Opeongo Road in Grattan, Ontario. For the purposes of this memorandum, the Site includes the entire expected area of disturbance from the proposed works, and the Study Area refers to the area within 120 m of the Site.

Based on photographs of the Site taken by WSP staff, the road crossing the culvert is a two-lane road with an asphalt shoulder less than 0.5 m and a gravel shoulder of approximately 2 m. The Study Area includes wetlands upstream and downstream of the culvert, and mature forests extending from edges of the wetlands. A few large trees are growing on the bank of the watercourse 5-10 m from the culvert.

## **2.0 METHODS**

This SAR screening was based on a desktop review of existing background data sources following the methods outlined below.

### **2.1 Review of Existing Data**

The information available for the Site and Study Area served to identify SAR known to be present or having the potential to be present. Information sources consulted included:

- Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Make-a-Map Explorer (MNRF 2023) for information on known occurrences of Species at Risk (SAR)
- Species at Risk Public Registry (ECCC 2021)
- Species at Risk in Ontario (SARO) List (MECP 2023)
- Atlas of Breeding Birds of Ontario (Cadman et al. 2007)
- eBird Species Range Maps (eBird 2023)
- Atlas of the Mammals of Ontario (Dobbyn 1994)
- Ontario Reptile and Amphibian Atlas (Ontario Nature 2019)

- Ontario Butterfly Atlas (Macnaughton et al. 2023)
- Ontario Moth Atlas (Kaposi et al. 2023)
- Bat Conservation International (BCI) range maps (BCI 2023)
- MNRF Land Information Ontario (LIO) mapping (LIO 2023)
- Vascular Plants at Risk in Ontario (Leslie 2018)
- Existing aerial photography and site photographs taken by WSP staff

### 2.1.1 Species at Risk Screening

SAR considered in the screening included those listed as endangered, threatened, and special concern under the *Endangered Species Act, 2007* (ESA; Ontario 2007) and the *Species at Risk Act* (SARA; Canada 2002). A screening of the SAR that have the potential to be found on the Site and in the Study Area was conducted as a desktop exercise, using the sources listed above. Species with ranges overlapping the Site or Study Area, or recent occurrence records in the vicinity, were screened by comparing their habitat requirements to habitat conditions on the Site and in the Study Area, based on review of aerial photography and site photographs.

Data from the SAR screening were used in combination with site photographs to determine a final probability of SAR and/or SAR habitats within the Site and Study Area.

The potential for the species to occur was determined through a probability of occurrence. A ranking of NIL indicates no suitable habitat availability for that species within the Site or Study Area. Low probability ranking indicates a low potential for the species to occur as no suitable habitat occurs within the Site or Study Area, but recent occurrence of the species has been recorded. Moderate probability indicates greater potential for the species to occur, as suitable habitat may occur within the Site or Study Area, but no recent occurrence of the species has been recorded. High potential indicates a known species record on the Site and/or within the Study Area (i.e., from occurrence records collected during background data review) and good quality habitat may occur on the Site and/or in Study Area. Species screened as having a moderate to high potential to occur are considered to have potentially suitable habitat conditions within the Study Area and may require further field investigation to confirm the presence of habitats and/or use of habitats.

## 3.0 POLICY CONTEXT

### 3.1 Migratory Birds Convention Act

The *Migratory Birds Convention Act* (MBCA; Canada 1994) prohibits the killing or capturing of migratory birds, as well as any damage, destruction, removal or disturbance of active nests. It also allows the Canadian government to pass and enforce regulations to protect various species of migratory birds, as well as their habitats.

While Environment and Climate Change Canada (ECCC) can issue permits allowing the destruction of nests for scientific or agricultural purposes, or to prevent damage being caused by birds, it does not typically allow for permits in the case of industrial or construction activities.

Recent changes to the regulations associated with the MBCA have added sixteen species of birds that are protected by the act year-round. There are certain conditions that must be met prior to destroying or disturbing a nest of these species.

## 3.2 Species at Risk

### 3.2.1 Species at Risk Act (SARA)

At a federal level, Species at Risk (SAR) designations for species occurring in Canada are initially determined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). If approved by the federal Minister of the Environment and Climate Change, species are added to the federal List of Wildlife Species at Risk (Canada 2002). Species that are included on Schedule 1 as endangered or threatened are afforded protection of critical habitat on federal lands under the *Species at Risk Act* (SARA). On private or provincially-owned lands, only aquatic species listed as endangered, threatened or extirpated and migratory birds are protected under the SARA, unless ordered by the Governor in Council.

### 3.2.2 Endangered Species Act (ESA)

SAR designations for species in Ontario are initially determined by the Committee on the Status of Species at Risk in Ontario (COSSARO), and if approved by the provincial Minister of Environment, Conservation and Parks, species are added to the provincial *Endangered Species Act* (ESA) which came into effect June 30, 2008 (Ontario 2007). The legislation prohibits the killing or harming of species identified as endangered or threatened in the various schedules to the Act. The ESA also provides habitat protection to all species listed as threatened or endangered. As of June 30, 2008, the Species at Risk Ontario (SARO) list is contained in O. Reg. 230/08.

Subsection 9(1) of the ESA prohibits the killing, harming or harassing of species identified as ‘endangered’ or ‘threatened’ in the various schedules to the Act. Subsection 10(1)(a) of the ESA states that “*No person shall damage or destroy the habitat of a species that is listed on the Species at Risk in Ontario (SARO) list as an endangered or threatened species*”.

General habitat protection is provided, by the ESA, to all threatened and endangered species. Species-specific habitat protection is only afforded to those species for which a habitat regulation has been prepared and passed into law as a regulation of the ESA. The ESA has a permitting process to allow alterations to protected species or their habitats as well as a registration process for certain activities and species.

## 4.0 RESULTS

### 4.1 Species at Risk Screening

The results of the SAR screening are provided in Attachment 2. Species screened as having no or low potential to be present on the Site are provided in Attachment 2 but are not discussed further in this memorandum. Those species having a moderate or high potential to be present are discussed below. Species listed as having potential to be present in the Study Area, but not on the Site, are provided in Attachment 2 but not discussed in this report, as no off-Site impacts are expected to result from the proposed works.

Based on WSP’s desktop review and site photographs, there is high potential for five SAR to be present on the Site, including:

- Barn swallow (*Hirundo rustica*; Special Concern under the ESA and Threatened under SARA) – The Site provides suitable nesting habitat (i.e., culvert) over water. Barn swallows build nests in natural habitats and man-made structures, including bridges and culverts, and they are known to reuse nests (COSSARO 2021). Individuals and their habitat (i.e., an active nest) is protected under the SARA and MBCA.



- Blanding's turtle (*Emydoidea blandingii*; Threatened under the ESA and Endangered under SARA) – This species may access the Site by the slow-moving watercourse crossing through the culvert and may nest in the sandy and grassy areas found on the side of the road on the Site. This species may over-winter in the watercourse and associated wetlands up and downstream of the culvert. Individuals and their habitat are protected under the ESA during all parts of the year.
- Midland painted turtle (*Chrysemys picta marginata*; not listed under the ESA and Special Concern under SARA) – This species may access the Site by its proximity to water and may nest in the sandy, gravel and grassy areas found roadside on the Site. An injured turtle shell was observed roadside. This species does not receive individual or habitat protection under the ESA or SARA.
- Monarch (*Danaus plexippus*; Special Concern under the ESA and SARA) – Milkweed (*Asclepias* spp.) were observed in low densities on the side of the road, providing larval host plants. This species does not receive individual or habitat protection under the ESA or SARA.
- Snapping turtle (*Chelydra serpentina*; Special Concern under the ESA and SARA) – This species may access the Site by its proximity to water and may nest in the sandy, gravel and grassy areas found roadside on the Site. This species does not receive individual or habitat protection under the ESA or SARA.

SAR were observed during site investigations by WSP and are further discussed in Section 4.2. Protection of individuals and habitats of these species, in accordance with the ESA, is discussed in Section 5.

## 4.2 Wildlife Observations

No targeted surveys or site reconnaissance were completed by WSP's qualified biologists; however, while WSP engineers were determining access and feasibility for in-water drilling and borehole layout, several signs and sightings of wildlife were identified on the Site and in the Study Area on 14 June and 14 August 2023. Their observations are discussed in following below.

Nesting birds were noted in the area surrounding the culvert and creek access points and proposed work areas. From site photographs, waterfowl (i.e., swans) were observed near the Site. The Site offers breeding habitat to barn swallows (*Hirundo rustica*; Special Concern under the ESA and Threatened under SARA) and other migratory birds known to nest in culverts or roadside habitat.

Beaver dams and a beaver lodge were photographed. Although this species is not listed as SAR, its proximity to the work site is worth noting as any harm to beaver dams may change the hydrology characteristics of the Site and cause downstream flooding, damage to natural habitats and properties. Prior to proposed work, Fisheries and Oceans Canada (DFO) Code of Practice for beaver dam removal should be reviewed, and if beaver dam removal is required, DFO must be notified, and best practices outlined in the Code of Practice should be followed in order to avoid causing harm to fish and fish habitat.

Most notably, turtles were observed basking on both sides of the Site. From Site photographs, midland painted turtles (*Chrysemys picta marginata*; not listed under the ESA and Special Concern under SARA) were identified basking on logs and in the water across from the beaver lodge west of the Site. A midland painted turtle cracked shell was found over the culvert. Additionally, multiple turtle nesting evidence was observed on both the west and east sides of the roadside edge on the Site. There is a high potential that any roadside work could encounter an over-wintering turtle nest.

## 5.0 IMPACTS AND MITIGATION MEASURES

### 5.1 Overview of Proposed Work

The proposed in-water works includes drilling one borehole upstream and one borehole downstream of the Highway 41 culvert to assess cofferdam design requirements. Portable drilling equipment is proposed using a raft/platform to reach the borehole locations, fitted with a heavy-duty landscaping textile cloth material and perimeter lip to contain any sediment on the surface that would have otherwise been released to the watercourse. Cuttings (i.e., waste material from the drilling works) will also be contained and pumped to shore using a sump pump with a screened hose, or collected in a barrel on the raft (depending on site conditions). Gas generator and water pump will be in a plastic containment tray at all times in case of accidental leaks or spills. A spill kit and fire extinguisher will also be present at all times. This work will occur during the week of 23 October 2023.

### 5.2 Potential Impacts

The anticipated direct impacts for geotechnical drilling to support eventual replacement of Highway 41 Culvert 29X-0229 are discussed in Section 5.2.1. In addition to the direct impacts of the work on the Site, there is potential for indirect impacts to the adjacent vegetation and wildlife habitat features. These indirect impacts are outlined in Section 5.2.2.

#### 5.2.1 Direct Impacts

The proposed drilling does not require any vegetation removal, but may cause disturbance to the ground within the proposed work area (driving equipment), and will cause disturbance at the two borehole locations, as shown on Figure 1. As the proposed works are to be conducted outside the main active period for most of Ontario's wildlife, impacts are expected to be limited. The potential for the proposed drilling to impact the SAR determined to have moderate or high potential to be present at the Site is discussed below.

- Barn Swallow – this species is not likely to be impacted as the proposed works will not affect the culvert itself and will occur outside the active season for this species in Ontario (i.e., outside of May through August).
- Monarch – this species is not likely to be impacted as the proposed works will occur outside the active season for this species in Ontario (i.e., outside of May through September).
- SAR Turtles – SAR turtles may be impacted by the proposed works through disturbance to individuals during in-water drilling, and through disturbance to roadsides where turtle nests may be over-wintering in the substrates. The disturbance to hatchlings over-wintering in nests is restricted to snapping turtle and midland painted turtle, and not Blanding's turtle as this species' hatchlings do not over-winter in nests.

Potential impacts to fish and fish habitat are discussed in a separate memorandum (WSP 2023).

#### 5.2.2 Indirect Impacts

In addition to the direct impacts discussed above, the proposed works may also result in indirect impacts to SAR habitat. The potential indirect impacts that may occur are discussed below:

- Release of construction-generated sediment to adjacent vegetation and wetland areas;
- Increased noise and disturbance.

The use of heavy machinery adjacent to the watercourse and wetlands has the potential for accidental spills, which can harm the aquatic habitat for SAR turtles.

Potential construction disturbances and noise will tend to displace wildlife temporarily during the construction period, and increased construction traffic and associated noise may also increase local disturbance of wildlife such as breeding birds and SAR reptiles. To a certain extent, traffic noise from the existing highway already affects the sensitive species that would be vulnerable to these impacts are not expected to be present.

## 5.3 Standard Mitigation Measures

The impacts to SAR and habitat associated with the proposed works must be minimized to the extent possible to avoid contravention of the ESA.

Employing the general mitigation measures outlined below will minimize impacts to SAR and their associated habitats, as well as protecting adjacent vegetation/habitat features during and following construction. Some features are more sensitive than others, as reflected in incorporation of site-specific mitigation measures in addition to the standard mitigation measures.

### 5.3.1 Vegetation and Wildlife Habitat

Recommended mitigation measures to minimize effects to SAR habitat include:

- Install temporary erosion and sediment control measures prior to construction and maintain throughout construction (See Ontario Provincial Standard Specification [OPSS] 805).
- Routinely inspect sediment and erosion control structures, including after storms, and repair as required.
- In dust-sensitive areas, control dust using water or approved chemical suppressants, in accordance with MTO's general conditions.
- Carry out vehicle maintenance and fueling at the defined maintenance areas in the works yards (contained and well removed from any natural areas) or at commercial garages whenever possible.
- The Contractor will retain an Environmental Inspector to inspect and ensure proper implementation and maintenance of the mitigation measures.

Follow all in-water work mitigation measures specified in the separate Fish and Fish Habitat memorandum (WSP 2023) summarized here:

- Removal of riparian vegetation in and around the watercourses shall be kept to a minimum and in accordance with OPSS 182.
- Vegetation protection and rehabilitation shall be in accordance with OPSS 182, OPSS 803 and OPSS 804.
- Temporary Erosion and Sediment Control Areas will be established before starting work to prevent sediment from entering the watercourse in accordance with OPSS 805.
- Any exposed surfaces will be re-vegetated as soon as possible using standard seed mix as per OPSS 804.
- Any temporarily stockpiled soil, debris or other excess materials, and any construction-related materials, will be properly contained (e.g., within silt fencing) in accordance with OPSS 180 and 182. All construction

materials, excess materials and debris should be removed and appropriately disposed of following construction.

- Use of equipment in and around the watercourses and associated drainage features shall be in accordance with OPSS 182.
- Drilling activities should be controlled so as to prevent entry of any petroleum products, debris or other potential contaminants/deleterious substances, in addition to sediment as outlined above, to the drainage feature.
- DFO's Code of Practice for **Beaver dam breaching and removal** – information can be used generally to determine the best practices for beaver dam removal, should it be required, to ensure that fish and fish habitat is protected during the borehole drilling. Should beaver dam removal be required, a notification form must be submitted to the DFO regional office 10 working days before starting work.
- DFO's Code of Practice for **Temporary Stream Crossings** – information can be used generally to determine the best method (i.e., raft or platform) to access the borehole areas within the wetlands, to ensure that fish and fish habitat is protected during the access works.

### 5.3.2 Wildlife

For protection of wildlife in general, the following guidance is provided:

- In the event that an animal encountered during construction does not move from the construction zone, the Contractor Administrator will be notified.

To prevent harm to fish and fish habitat, the following guidance is provided:

- As spring spawning are present within the Site and the Study Area, it is recommended that no in-water works, including drilling, occur between March 15 and July 15 of any given year (i.e., in-water work should occur between July 16 and March 14), as outlined in the Ontario Provincial Standard Specification (OPSS) 182.

In relation to the protection of SAR:

- If a turtle nest is encountered or disturbed, contact the Contract Administrator immediately. Protect the hatchlings from desiccation and cold by covering the disturbed nest with soil immediately, and marking it clearly.
- Conduct all in-water work in accordance with mitigation measures for in-water work as outlined in Section 5.3.1. As turtles are still mobile during over-wintering, it is expected that any turtles in the vicinity of the drilling will be able to move away from the disturbance.

## 6.0 CONCLUSIONS

This technical memorandum addresses the terrestrial SAR impacts and mitigations of the proposed geotechnical drilling in support of replacement of Highway 41 Culvert 29X-0229, Grattan, Ontario. Provided the mitigation measures discussed in this memorandum are implemented, we do not anticipate any impacts to SAR or their habitat, or the need for any permits or approvals under the ESA.

## 7.0 LIMITATIONS

This technical memorandum (memo) was prepared for the exclusive use of the Ministry of Transportation Ontario. The memo, which specifically includes all tables, figures and attachments, is based on data and information collected by WSP Canada Inc. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by WSP Canada Inc. as described in this memo. The status of species listed in the noted Acts and Regulations are effective as of the date of authoring of this memo. No species-specific assessments were conducted, and the assessment may be subject to limitations associated with base mapping, other publicly available information used, and a non-targeted site visit.

Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore authenticity of any electronic media versions of WSP's report should be verified.

WSP Canada Inc. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the report as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, WSP Canada Inc. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

## 8.0 CLOSURE

We trust this report meets your current requirements. If you have any questions regarding this report, please contact the undersigned.

### WSP Canada Inc.



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*Lead Ecologist*



Tamara Darwish, MSc.  
*Principal, Aquatic Biologist*

GW/TD/ljv

Attachments: Attachment 1 – Figure 1: Site Location Plan  
Attachment 2 – Species at Risk Screening  
Attachment 3 – Representative Photographs

[https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared documents/06. deliverables/ecology/sar memo/ca0009744.5044\\_tm rev0 2023'11'03\\_sar and mitigation memo.docx](https://wsponlinecan.sharepoint.com/sites/ca-ca00097445044/shared%20documents/06.%20deliverables/ecology/sar%20memo/ca0009744.5044_tm_rev0_2023%2711%2703_sar%20and%20mitigation%20memo.docx)

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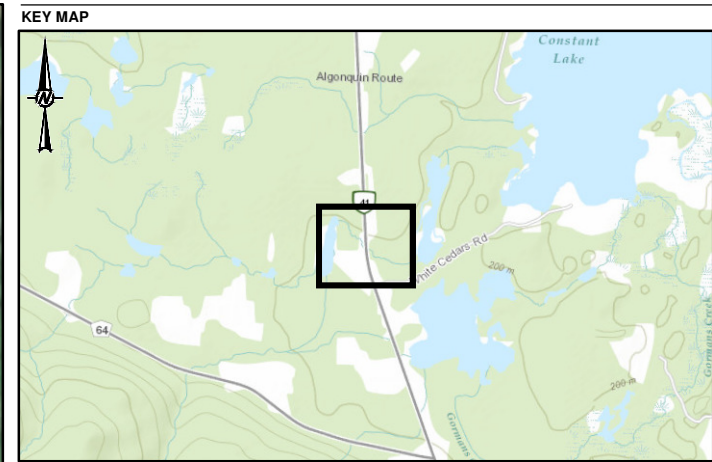
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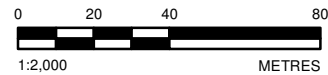
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- LEGEND**
- THE SITE
  - STUDY AREA (120m)
  - CULVERT
  - BOREHOLES



**NOTE(S)**  
1. ALL LOCATIONS ARE APPROXIMATE

**REFERENCE(S)**  
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO  
2. IMAGERY CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY  
SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY  
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

**CLIENT**  
MINISTRY OF TRANSPORTATION ONTARIO

**PROJECT**  
HIGHWAY 41 CULVERT 29X-0229/C0

**TITLE**  
BOREHOLE AND CULVERT LOCATIONS

	CONSULTANT	YYYY-MM-DD	2023-10-12
	DESIGNED	CE	
	PREPARED	PS	
	REVIEWED	CE	
	APPROVED	---	

PROJECT NO.	CONTROL	REV.	FIGURE
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Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Birds	Barn Swallow	<i>Hirundo rustica</i>	S4B	SC	THR	SC	SC	In Ontario, barn swallow breeds in areas that contain a suitable nesting structure, open areas for foraging, and a body of water. This species nests in human made structures including barns, buildings, sheds, bridges, and culverts. Preferred foraging habitat includes grassy fields, pastures, agricultural cropland, lake and river shorelines, cleared rights-of-way, and wetlands (COSEWIC 2011). Mud nests are fastened to vertical walls or built on a ledge underneath an overhang. Suitable nests from previous years are reused (Brown and Brown 2019).	Moderate - The culvert is a suitable nesting structure over water that would support nesting for this species on the Site.	Moderate - Suitable open areas for foraging occurs in the Study Area.	N/A - work will occur outside the breeding season and will not impact the culvert.
Birds	Bobolink	<i>Dolichonyx oryzivorus</i>	S4B	THR	THR	SC	THR	In Ontario, bobolink breeds in grasslands or graminoid dominated hayfields with tall vegetation (Gabhauer 2007). Bobolink prefers grassland habitat with a forb component and a moderate litter layer. They have low tolerance for presence of woody vegetation and are sensitive to frequent mowing within the breeding season. They are most abundant in established, but regularly maintained, hayfields, but also breed in lightly grazed pastures, old or fallow fields, cultural meadows and newly planted hayfields. Their nest is woven from grasses and forbs. It is built on the ground, in dense vegetation, usually under the cover of one or more forbs (Renfrew et al. 2015).	NIL - There are no suitable large, open grasslands at the Site.	NIL - There are no suitable large, open grasslands in the Study Area.	N/A
Birds	Canada Warbler	<i>Cardellina canadensis</i>	S5B	SC	THR	SC	SC	In Ontario, breeding habitat for Canada warbler consists of moist mixed forests with a well-developed shrubby understory. This includes low-lying areas such as cedar and alder swamps, and riparian thickets (McLaren 2007). It is also found in densely vegetated regenerating forest openings. Suitable habitat often contains a developed moss layer and an uneven forest floor. Nests are well concealed on or near the ground in dense shrub or fern cover, often in stumps, fallen logs, overhanging stream banks or mossy hummocks (Reitsma et al. 2010).	NIL - There are no suitable forest habitats at the Site.	Moderate - Suitable swamp, forest, and riparian habitats in the Study Area.	N/A

Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Birds	Common Nighthawk	<i>Chordeiles minor</i>	S4B	SC	SC	SC	SC	In Ontario, these aerial foragers require areas with large open habitat. This includes farmland, open woodlands, clearcuts, burns, rock outcrops, alvars, bogs, fens, prairies, gravel pits and gravel rooftops in cities (Sandilands 2007)	Low - No suitable habitats occur on the Site.	Low - No suitable habitats occur in the Study area.	N/A
Birds	Eastern Meadowlark	<i>Sturnella magna</i>	S4B,S3N	THR	THR	THR	THR	In Ontario, eastern meadowlark breeds in pastures, hayfields, meadows and old fields. Eastern meadowlark prefers moderately tall grasslands with abundant litter cover, high grass proportion, and a forb component (Hull 2019). They prefer well drained sites or slopes, and sites with different cover layers (Roseberry and Klimstra 1970).	NIL - No suitable large meadow habitat occurs at the Site.	NIL - No suitable large meadow habitat occurs in the Study Area.	N/A
Birds	Eastern Whip-poor-will	<i>Antrostomus vociferus</i>	S4B	THR	THR	THR		In Ontario, whip-poor-will breeds in semi-open forests with little ground cover. Breeding habitat is dependent on forest structure rather than species composition, and is found on rock and sand barrens, open conifer plantations and post-disturbance regenerating forest. Territory size ranges from 3 to 11 ha (COSEWIC 2009). No nest is constructed, and eggs are laid directly on the leaf litter (Mills 2007).	NIL - No suitable semi-open forests with low ground cover occurs at the Site.	NIL - No suitable semi-open forests occur in the Study Area.	N/A
Birds	Eastern Wood-pewee	<i>Contopus virens</i>	S4B	SC	SC	SC	SC	In Ontario, eastern wood-pewee inhabits a wide variety of wooded upland and lowland habitats, including deciduous, coniferous, or mixed forests. It occurs most frequently in forests with some degree of openness. Intermediate-aged forests with a relatively sparse midstory are preferred. In younger forests with a relatively dense midstory, it tends to inhabit the edges. Also occurs in anthropogenic habitats providing an open forested aspect such as parks and suburban neighborhoods. Nest is constructed atop a horizontal branch, 1-2 m above the ground, in a wide variety of deciduous and coniferous trees (COSEWIC 2012).	NIL - No treed areas occur on the Site to support nesting of this species.	Moderate - There are wooded habitats in the Study Area that could support nesting of this species.	N/A

Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Birds	Evening Grosbeak	<i>Coccothraustes vespertinus</i>	S4	SC	SC	SC	SC	In Ontario, evening grosbeak breeds across northern Ontario, as far south as southern Georgian Bay, in open mature coniferous or mixed forests dominated by fir species, white spruce and/or trembling aspen (MECP 2019).	NIL - No treed areas occur on the Site to support nesting of this species.	Moderate - There are wooded habitats in the Study Area that could support nesting of this species.	N/A
Birds	Olive-sided Flycatcher	<i>Contopus cooperi</i>	S4B	SC	SC	SC	SC	In Ontario, olive-sided flycatcher breeding habitat consists of natural openings in coniferous or mixed forests, including bogs, burns, riparian zones, and cutover areas. They are also found in semi-open forest stands and early successional forest when tall snags and residual live trees are present. In the boreal forest it is often associated with muskeg, bogs, fens and swamps dominated by spruce and tamarack. Open areas with tall trees or snags for perching are used for foraging (COSEWIC 2007). Nests are usually built on horizontal branches of conifers (Peck and James 1987).	NIL - No treed areas occur on the Site to support nesting of this species.	Moderate - There are natural openings in wooded habitat in the Study Area that could support nesting of this species.	N/A
Insects	Monarch	<i>Danaus plexippus</i>	S2N, S4B	SC	SC	END	SC	In Ontario, monarch is found throughout the northern and southern regions of the province. This butterfly is found wherever there is milkweed ( <i>Asclepias</i> spp.) plants for its caterpillars and wildflowers that supply a nectar source for adults. It is often found on abandoned farmland, meadows, open wetlands, prairies and roadsides, but also in city gardens and parks. Important staging areas during migration occur along the north shores of the Great Lakes (COSEWIC 2010).	Moderate - Open areas and the presence of milkweed on the Site may provide suitable habitat for this species.	Moderate - Open areas and the presence of milkweed on the Site may provide suitable habitat for this species.	N/A - no vegetation removal is planned and works will occur outside the active season for this species.
Lichens	Flooded Jellyskin	<i>Leptogium rivulare</i>	S3		SC	SC	NAR	In Ontario, flooded jellyskin is found in the eastern region of the province. This lobed, leaf-like lichen grows on the lower trunks of trees in hardwood swamps where flooding occurs in the spring. The most common tree host is black ash, but it has also been recorded on silver maple, trembling aspen, bur oak and white cedar. Trees must be live to support the lichen. These seasonal pond habitats typically occur over top of calcareous bedrock, such as limestone. There is unlikely to be a minimum size requirement for the area of flooded forest habitat available to the lichen, as long as adequate flooding is present (Environment Canada 2013; COSEWIC 2015).	NIL - No trees occur on the Site to host this species.	Moderate - Treed swamp habitat occurs in the Study Area, with adequate flooding, tree species may host this lichen species.	N/A

Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Lichens	Pale-bellied Frost Lichen	<i>Physconia subpallida</i>	S3	END	END	END	END	In Ontario, pale-bellied frost lichen grows on trees in mature, deciduous forests with relatively open understory, but moderate to high canopy cover. Common host trees include ash, black walnut, hop-hornbeam, and elm, although in Ontario, it is most often found on hop-hornbream. This lichen has also been found growing on fence rails and rocks (Lewis 2011).	NIL - No trees occur on the Site to host this species.	Moderate - Forested habitat able to host this species occurs in the Study Area.	N/A
Mammals	Eastern Small-footed Myotis	<i>Myotis leibii</i>	S2S3	END			END	In Ontario, eastern small-footed myotis is not known to roost in trees, but there is very little known about its roosting habits. The species generally roosts on the ground under rocks, in rock crevices, talus slopes and rock piles, but it occasionally inhabits buildings. Entrances of caves or abandoned mines where humidity is low, and temperatures are cool and sometimes subfreezing may be used as hibernacula (Humphrey 2017).	Low - No suitable roosting habitat occurs on the Site.	Low - No suitable roosting habitat occurs in the Study area.	N/A
Mammals	Little Brown Myotis	<i>Myotis lucifugus</i>	S3	END	END	END	END	In Ontario, this species' range is extensive and covers much of the province. It will roost in both natural and man-made structures. Roosting colonies require a number of large dead trees, in specific stages of decay and that project above the canopy in relatively open areas. May form nursery colonies in the attics of buildings within 1 km of water. Caves or abandoned mines may be used as hibernacula, but high humidity and stable above freezing temperatures are required (ECCC 2018).	Low - No suitable roosting habitat occurs on the Site.	Moderate - Suitable large dead trees occur in the Study Area.	N/A
Mammals	Northern Myotis	<i>Myotis septentrionalis</i>	S3	END	END	END	END	In Ontario, this species' range is extensive and covers much of the province. It will usually roost in hollows, crevices, and under loose bark of mature trees. Roosts may be established in the main trunk or a large branch of either living or dead trees. Caves or abandoned mines may be used as hibernacula, but high humidity and stable above freezing temperatures are required (ECCC 2018).	Low - No suitable roosting habitat occurs on the Site.	Moderate - Suitable large dead trees occur in the Study Area.	N/A

Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Mammals	Tricolored Bat	<i>Perimyotis subflavus</i>	S3?	END	END	END	END	In Ontario, tri-colored bat may roost in foliage, in clumps of old leaves, hanging moss or squirrel nests. They are occasionally found in buildings although there are no records of this in Canada. They typically feed over aquatic areas with an affinity to large-bodied water and will likely roost in close proximity to these. Hibernation sites are found deep within caves or mines in areas of relatively warm temperatures. These bats have strong roost fidelity to their winter hibernation sites and may choose the exact same spot in a cave or mine from year to year (ECCC 2018).	Low - No suitable roosting habitat occurs on the Site.	Moderate - Suitable large dead trees occur in the Study Area.	N/A
Reptiles	Blanding's Turtle	<i>Emydoidea blandingii</i>	S3	THR	END	END	THR	In Ontario, Blanding's turtle will use a range of aquatic habitats, but favor those with shallow, standing or slow-moving water, rich nutrient levels, organic substrates and abundant aquatic vegetation. They will use rivers but prefer slow-moving currents and are likely only transients in this type of habitat. This species is known to travel great distances over land in the spring in order to reach nesting sites, which can include dry conifer or mixed forests, partially vegetated fields, and roadsides. Suitable nesting substrates include organic soils, sands, gravel and cobble. They hibernate underwater and infrequently under debris close to water bodies (COSEWIC 2016).	Moderate - Suitable slow-moving water and nesting habitat occur on the Site.	Moderate - Suitable slow-moving water with abundant aquatic vegetation occurs in the Study Area.	N/A - no potential for nest disturbance due to timing of works; no harm to individuals in-water expected; follow all mitigation measures for in-water works (WSP 2023).
Reptiles	Midland Painted Turtle	<i>Chrysemys picta marginata</i>	S4		SC	SC		In Ontario, painted turtles use waterbodies, such as ponds, marshes, lakes and slow-moving creeks, with a soft bottom and abundant basking sites and aquatic vegetation. This species hibernates on the bottom of waterbodies (Ontario Nature 2018).	High - Suitable slow-moving water occurs on the Site. An injured turtle shell was observed on the Site.	High - Suitable slow-moving water, abundant basking sites, and aquatic vegetation occur in the Study Area. Multiple individuals were observed basking on logs and in the water on both sides of the culvert in June 2023.	Report presence of turtle nests in the work area to the Contract Administrator. Cover disturbed nests with soil and mark location. Follow all mitigation measures for in-water work (WSP 2023)

Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Reptiles	Northern Map Turtle	<i>Graptemys geographica</i>	S3	SC	SC	SC	SC	In Ontario, northern map turtle prefers large waterbodies with slow-moving currents, soft substrates, and abundant aquatic vegetation. Ideal stretches of shoreline contain suitable basking sites, such as rocks and logs. Along Lakes Erie and Ontario, this species occurs in marsh habitat and undeveloped shorelines. It is also found in small to large rivers with slow to moderate flow. Hibernation takes place in soft substrates under deep water (COSEWIC 2012).	Low - No suitable large waterbody occurs on the Site.	Low - No suitable large waterbody occurs in the Study Area.	N/A
Reptiles	Snapping Turtle	<i>Chelydra serpentina</i>	S4	SC	SC	SC		In Ontario, snapping turtle uses a wide range of waterbodies, but shows preference for areas with shallow, slow-moving water, soft substrates and dense aquatic vegetation. Hibernation takes place in soft substrates under water. Nesting sites consist of sand or gravel banks along waterways or roadways (COSEWIC 2008).	Moderate - Suitable slow-moving water and nesting habitat occur on the Site.	Moderate - Suitable slow-moving water with abundant aquatic vegetation and nesting habitat occur in the Study Area.	Report presence of turtle nests in the work area to the Contract Administrator. Cover disturbed nests with soil and mark location. Follow all mitigation measures for in-water work (WSP 2023)
Reptiles	Wood Turtle	<i>Glyptemys insculpta</i>	S2	END	THR	THR	END	In Ontario, wood turtle spends spring and fall in or near waterbodies, including clear rivers and streams with sandy or gravel-sand substrates and moderate to fast current. During the summer, this species is often found on land in habitats with moderate or patchy shrub and tree cover, often more than 500 m from water. Hibernation takes place in substrates under water. Nesting sites are found on sand or gravel-sand beaches and banks with patchy vegetation cover. Other sites less often used include gravel holes, roadsides, railways, utility corridors, farmland and pastures (Ontario Wood Turtle Recovery Team 2010).	Low - No suitable moderate to fast moving stream or forested habitat occur on the Site.	Moderate - Suitable forested habitat near water occurs in the Study Area.	N/A



Taxon	Common Name	Scientific Name	S-rank	ESA Status	SARA Status	COSEWIC Status	COSSARO Status	Habitat Requirements	Probability to Occur on the Site	Probability to Occur in the Study Area	Potential Project Impact and Mitigation
Vascular Plants	American Ginseng	<i>Panax quinquefolius</i>	S2	END	END	END		In Ontario, American ginseng is found in moist, undisturbed and relatively mature deciduous woods often dominated by sugar maple. It is commonly found on well-drained, south-facing slopes. American ginseng grows under closed canopies in well-drained soils of glacier origin that have a neutral pH (ECCC 2018).	NIL - No suitable mature deciduous habitat occurs on the Site.	Moderate - Suitable mature forest occurs in the Study Area.	N/A
Vascular Plants	Black Ash	<i>Fraxinus nigra</i>	S4	END		THR	END	Found throughout Ontario in moist ecosystems; commonly found in northern swampy woodlands (MNRF 2018). This species typically grows on mucky or peaty soils and is considered a facultative wetland species (Reznicek et al. 2011).	NIL - No suitable habitat occurs on the Site.	Moderate - Suitable wetland habitat occurs in the Study Area.	N/A
Vascular Plants	Butternut	<i>Juglans cinerea</i>	S2?	END	END	END	END	In Ontario, butternut is found along stream banks, on wooded valley slopes, and in deciduous and mixed forests. It is commonly associated with beech, maple, oak and hickory (Voss and Reznicek 2012). Butternut prefers moist, fertile, well-drained soils, but can also be found in rocky limestone soils. This species is shade intolerant (Farrar 1995).	NIL - No suitable habitat occurs on the Site.	Moderate - Suitable stream banks and forests occur in the Study Area.	N/A
Vascular Plants	Hill's Pondweed	<i>Potamogeton hillii</i>	S2S3	SC	SC	SC		In Ontario, Hill's pondweed grows in the muddy substrates of cold, clear, slow-moving, calcareous streams, ditches, and ponds. It is found in water up to 1 m in depth. Often found near flow obstructions including the upstream side of road culverts, among stumps and fallen trees, or in shallow water among rushes and sedges (Parks Canada Agency 2014).	Low - The watercourse does not offer suitable habitat and Site is outside current known range of this species.	Low - The watercourse does not offer suitable habitat and Site is outside current known range of this species.	N/A

1 Global Ranks (GRANK) are Rarity Ranks assigned to a species based on their range-wide status. GRANKS are assigned by a group of consensus of Conservation Data Centres (CDCs), scientific experts and the Nature Conservancy. These ranks are not legal designations. G1 (Extreemly Rare), G2 (Very Rare), G3 (Rare to uncommon), G4 (Commc

2 Provincial Ranks (SRANK) are Rarity Ranks assigned to a species or ecological communities, by the Natural Heritage Information Centre (NHIC). These ranks are not legal designations. SRANKS are evaluated by NHIC on a continual basis and updated lists produced annually. SX (Presumed Extirpated), SH (Possibly Extirpated - Historical), S1 (C

3 Endangered Species Act (ESA), 2007. General (O.Reg 242/08 last amended 1 April 2021 as O. Reg 228/21). Species at Risk in Ontario List (O.Reg 230/08 last amended 25 January 2023 asO. Reg. 9/23); Schedule 1 (Extirpated - EXP), Schedule 2 (Endangered - END), Schedule 3 (Threatened - THR), Schedule 4 (Special Concern - SC)

4 Species at Risk Act (SARA), 2002. Schedule 1 (Last amended 3 February 2023 ); Part 1 (Extirpated), Part 2 (Endangered), Part 3 (Threatened), Part 4 (Special Concern)

5 Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

6 Committee on the Status of Species at Risk in Ontario (COSSARO)

7 General Habitat Protection is applied when a species is newly listed as endangered or threatened on the SARO list under the ESA, 2007. The definition of general habitat applies to areas that a species currently depends on. These areas may include dens and nests, wetlands, forests and other areas essential for breeding, rearing, feeding, hit

8 Refer to the individual species' federal recovery strategy for a full description of the critical habitat ([http://www.sararegistry.gc.ca/sar/recovery/recovery\\_e.cfm](http://www.sararegistry.gc.ca/sar/recovery/recovery_e.cfm))

+Species Codes derived from the following sources: Birds – 53rd AOU Supplement (2012); Amphibians – Marsh Monitoring Program (Bird Studies Canada 2003); Fish – Golder; Reptiles – Golder.

\*NHIC (Natural Heritage Information Centre); ROM (Royal Ontario Museum); OBBA (Ontario Breeding Bird Atlas); Herp Atlas (Reptiles and Amphibians of Ontario); Odonata Atlas (of Ontario); Mammal Atlas (of Ontario); BCI (Bat Conservation International); Butterfly Atlas (Ontario Butterfly Atlas)

Blank = No status

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Photograph 1: General site photo facing north, June 2023



Photograph 2: General site photo facing east, June 2023



Photograph 3: General site photo facing south, June 2023



Photograph 4: General site photo facing west, June 2023





Photograph 5: Culvert 29X-0229 east opening, June 2023



Photograph 6: Culvert 29X-0229 east opening, June 2023



Photograph 7: Culvert 29X-0229 west opening, June 2023



Photograph 8: Culvert 29X-0229 west opening, June 2023





Photograph 9: Basking Midland painted turtle, June 2023



Photograph 10: Beaver lodge near west opening of Culvert 29X-0229, June 2023



Photograph 11: Beaver dams east of Culvert 29X-0229, June 2023



Photograph 12: Turtle nest along roadside, June 2023

**APPENDIX F**  
**Site Photographs**





*Photograph 1: Looking east toward existing culvert inlet; March 13, 2024*



*Photograph 2: Looking southwest toward borehole 23-03 along Highway 41; March 13, 2024*





*Photograph 3: Looking north toward borehole 23-05 along Highway 41; March 13, 2024*



*Photograph 4: Looking southwest toward borehole 23-04 along Highway 41; March 13,*

**APPENDIX G**  
**Special Provisions**

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

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Special Provision No. 517F01

February 2024

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**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		
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)		
Culvert 29X-0229/C0	N/A	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 <a href="https://idfcurlves.mto.gov.on.ca/">https://idfcurlves.mto.gov.on.ca/</a> 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.							

### **Existing Subgrade Conditions**

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#### **Notice to Contractor – Cobble and Boulder Obstructions**

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The Contractor shall be alerted to the potential for cobbles (and/or boulder) obstructions within the native subgrade soils as confirmed to be present at Boreholes 23-01 to 23-05. The extent and depth of obstructions may vary beyond and between the borehole locations. Consideration of the presence of these obstructions must be made in selection of appropriate equipment and procedures for temporary works and/or construction/installation of the culvert foundation, as may be required.





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