FOUNDATION INVESTIGATION AND DESIGN REPORT – REV.2

Clay River Culvert Replacement at Station 11+501 (Site No. 38C-0157/C0)

Highway 17, Township of Goodwillie
Ministry of Transportation, Ontario
Assignment No. 5022-E-0002, GWP 5114-20-00, WP 5230-21-01

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PART A

FOUNDATION INVESTIGATION REPORT

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1.0 INTRODUCTION

WSP Canada Inc. (WSP) has been retained by D.M. Wills Associates Ltd. (DM Wills) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation investigation and design services required for the full replacement of the Clay River Culvert along Highway 17 at Station 11+501, Township of Goodwillie, Ontario.

This report presents the results of the foundation investigation carried out for the culvert replacement along Highway 17 at Station 11+501. The locations of the boreholes advanced at this site are shown in plan on Drawing 1. The foundation investigation services for this project have been delivered under MTO Assignment No. 5022-E-0002 as part of GWP 5114-20-00 and WP 5230-21-01.

2.0 SITE DESCRIPTION

The Clay River Culvert is located at Station 11+501 along Highway 17, approximately 72 km south of Highway 101. The site location is shown on the key plan in Drawing 1. The existing culvert is an approximate 3.7 m x 2.4 m (span x rise) structural plate corrugated steel pipe arch (SPCSPA) with a 3.9 m x 2.7 m (span x rise) extension, and crosses below Highway 17 northbound lanes (NBL) and southbound lanes (SBL) with a total length of about 28 m. We understand the existing culvert is to be replaced by a 25 m long, 4.0 m wide by 2.2 m high (minimum) open footing concrete rigid frame culvert.

Highway 17, in the vicinity of the culvert, currently consists of three-lanes (a single lane in each direction and a passing lane is present for the SBL) with a granular shoulder along the NBL and guide rail along the edge of the SBL. There is dense tree cover beyond the MTO right of way on both sides of the highway. Based on the survey data provided by D.M Wills, the highway grade is at approximately Elevation 211.7 m, and the adjacent ground surface at about Elevation 208 m to 209 m with the overall topography sloping upwards to the north and east. The existing embankment is sloped between about 1.25H:1V and 2H:1V in the vicinity of the culvert.

The watercourse (i.e. Clay River) flows from north to south with the water level in the river measured to be at about Elevation 208.8 m on at the inlet (north) side and about Elevation 208.0 m at the outlet (south) side of the existing culvert (as shown on the General Arrangement drawing).

The existing ground surface features and conditions at the culvert location are shown in Photographs 1 to 4 (taken during the field investigation in June 2023) following the text of this report. There are near vertical rock cuts exposed on both sides of the highway about 100 m north and 300 m south of the site, and cobble to boulder sized rock fill fragments were observed near the toes of the embankment directly north and south of the culvert.

Based on our site observations at the time of the field investigation and a review of the available site photographs/satellite images, the existing embankment in the culvert area appears to be performing satisfactorily. There was no visual evidence of global instability (i.e., soil movement) on the embankment side slopes, and no tension cracks near the embankment crest that would be indicative of instability. Pavement cracking in the vicinity of the culvert was observed and the connection between the original culvert and extension appeared to have partially separated and exposed plywood, and concrete was visible at the interface.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation consisted of four boreholes (Boreholes CR-1 to CR-4). Boreholes CR-1 and CR-2 were drilled on June 21 and 22, 2023, respectively, whereas Boreholes CR-3 and CR-4 were drilled on August 17 and July 10, 2023, respectively. The approximate borehole locations are shown on Drawing 1.

Boreholes CR-1 and CR-2 were located on Highway 17 to the south and north of the culvert and in the southbound and northbound lane respectively. Boreholes CR-3 and CR-4 were located to the north and south of Highway 17, in the vicinity of culvert inlet and outlet respectively. Boreholes CR-1 and CR-2 were advanced using a truck-mounted D-90 drill rig and Borehole CR-3 was drilled using a track-mounted CME 55 drill rig. Borehole CR-4 was advanced using portable drilling equipment. Boreholes CR-1 to CR-3 were advanced using 114 mm outer diameter solid stem augers, NW casing and NQ coring techniques. Drilling equipment was supplied and operated by Walker Drilling Ltd. (formerly RPM Drilling), of Utopia, Ontario.

Soil samples were generally obtained using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586[1]), unless otherwise noted. Soil samples were generally obtained at vertical sampling intervals of about 0.76 m and 1.5 m. Bedrock was continuously cored using NQ sized coring tools.

The groundwater levels in the open boreholes were observed during and upon completion of the drilling operations and are described on the Record of Boreholes sheets in Appendix A. Boreholes CR-2, CR-3 and CR-4 were dry upon completion of the drilling operations. In Borehole CR-1, the groundwater level was likely influenced by the addition of water during drilling operations. Boreholes were backfilled in general accordance with the intent of Ontario Regulation (O.Reg.) 903, as amended, and the site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of WSP technical staff who located the boreholes in the field, supervised the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil and bedrock core samples were identified in the field, placed in labelled containers or core boxes, and transported to the WSP laboratory in Sudbury for further examination and testing. Laboratory tests such as grain size distribution analyses, water content and organic content determination were carried out on selected soil samples, in general accordance with MTO and/or ASTM Standards, as applicable. Uniaxial compressive strength testing was performed on selected rock core samples.

The as-drilled borehole locations, in station and offset, were measured in reference to the centreline alignment staked on the highway shoulder and was subsequently converted into MTM NAD 83 coordinates. The ground surface elevation at the borehole locations was surveyed by WSP using rod and level equipment relative to the highway centreline where reference ground surface elevations were provided by Callon Dietz Incorporated. The borehole locations, including northing / easting and geographic coordinates, ground surface elevations referenced to Geodetic datum, and borehole drilled depths (including bedrock coring depths) are summarized below.

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

Borehole No.	NAD83 – MTM Zone 13 Coordinates (Geographic Coordinates)		Ground Surface Elevation (m)	Drilled Depth (m)	Length of Bedrock Cored (m)
	Northing (m) (Latitude (°))	Easting (m) (Longitude (°))			
CR-1	5254745.5 (47.429675)	250006.4 (-84.726361)	211.9	6.9	2.9
CR-2	5254760.5 (47.429810)	249996.7 (-84.726491)	211.1	6.4	3.3
CR-3	5254741.7 (47.429640)	249991.3 (-84.726560)	210.4	6.0	2.9
CR-4	5254767.7 (47.429876)	250016.5 (-84.726230)	208.9	0.9	0.0

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in the Northern Ontario Engineering Geological Terrain Study (NOEGTS)[2] Mapping, bedrock knobs are present in the vicinity of the culvert. The NOEGTS mapping also indicates the presence of primarily sandy material with gravel as a secondary material in the area of the culvert.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)[3], the bedrock at the site consists of gneissic tonalite to granodiorite (foliated) to gneissic (with minor supracrustal inclusions).

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes during the investigation, together with the results of laboratory tests carried out on selected soil samples are presented on the Record of Boreholes sheets in Appendix A. The detailed results of the geotechnical laboratory tests are presented in Appendix B. The results of the in-situ field tests (SPT N-values), as presented in the borehole records and in Section 4, are uncorrected. The results of the analytical testing completed on select soil samples are provided in Appendix C.

The borehole locations and the interpreted stratigraphic profile projected along the proposed culvert alignment are provided in Drawing 1. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic section in Drawing 1 are inferred from observations of the drilling progress and noncontinuous soil sampling and therefore, represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the borehole locations.

A summary description of the major soil deposits and groundwater conditions encountered in the boreholes is provided below.

4.2.1 Asphalt

An approximately 110 mm and 220 mm thick layer of asphalt was encountered at the Highway 17 pavement surface (measured to be at Elevations 211.9 m and 211.1 m) in Boreholes CR-1 and CR-2, respectively.

4.2.2 Silty Sand (SM) to Gravel (GP) (FILL)

A 0.4 m to 1.6 m thick layer of fill, comprised of silty sand, gravelly sand, sand and gravel and gravel was encountered below the asphalt or ground surface (between Elevations 208.9 m and 211.8 m) in Boreholes CR-1 to CR-3. In Borehole CR-4, a sandy silt to gravelly silty sand fill containing organic silt seams/interlayers was encountered from ground surface (Elevation 208.9 m) and was explored for 0.9 m depth before termination of the borehole due to auger refusal.

The SPT ‘N’-values measured within the fill layer typically ranged from 11 blows to 75 blows per 0.3 m of penetration indicating a compact to very dense state of compactness; however, spit spoon and auger refusal (as well as auger and casing grinding) were encountered at many of the sample depths.

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[2] Ministry of Natural Resources. 2005. Digital Northern Ontario Engineering Geology Terrain Study. Ontario Geological Survey, Miscellaneous Release – Data 160.

[3] Ministry of Northern Development of Mines. Bedrock Geology of Ontario – Southern Sheet, Ontario Geological Survey - Map 2544.

The moisture content measured on one sample of the sand and gravel fill in Borehole CR-3 is 9%. The results of grain size analyses testing carried out on one sample from the fill are shown in Figure B-1 in Appendix B. The organic content measured on one sample of the organic silt seams encountered within the granular fill is about 12%.

4.2.3 Cobbles and Boulders with Silty Sand and Gravel infill (ROCK FILL)

A 1.5 m to 3.2 m thick layer of rock fill comprised of predominantly cobble and boulder sized rock fragments with silty sand and gravel infill was encountered below the silty sand to gravel fill (between Elevations 208.8 m and 211.1 m) in Boreholes CR-1 to CR-3. In Borehole CR-1, a 270 mm and 200 mm diameter cobble were encountered at 3.4 m and 3.7 m depth, respectively, and confirmed by coring. In Borehole CR-3, a 100 mm and 225 mm diameter cobble and a 600 mm diameter boulder were encountered between 1.6 m and 3.1 m depth and confirmed by coring. The cobbles and boulders are inferred to be rock fill that was also observed to be present near the toe of the embankment near the culvert, especially on the south side.

Where penetrated with the split-spoon sampler within the granular infill, the SPT ‘N’-values measured typically ranged from 14 blows to 28 blows per 0.3 m of penetration indicating a compact state of compactness; however, split spoon and auger refusal (as well as auger and casing grinding) were encountered at many of the sample depths suggesting that frequent rock fragments (cobble to boulder sized) are present. One SPT ‘N’ value of 4 blows per 0.3 m of penetration was measured in an organic silt interlayer within the fill in Borehole CR-2.

The moisture content measured on a sample of the sandy gravel infill from the rock fill deposit was about 6%. A moisture content measured within the organic silt interlayer in Borehole CR-2 was 43%. The results of grain size analyses testing carried out on two samples from the granular infill are shown in Figure B-2 in Appendix B. The organic content measured on one sample of the organic silt interlayer encountered within the granular infill is about 6%.

4.2.4 Bedrock/Refusal

Bedrock was encountered at depths between 3.1 m and 4.0 m below ground surface (corresponding to between Elevation 208.1 m and 207.3 m) in Boreholes CR-1 to CR-3 where the bedrock surface was confirmed by coring for lengths between 2.9 m and 3.3 m. In Borehole CR-4, auger refusal was encountered at 0.9 m (Elevation 208.0 m) which could be bedrock or an obstruction (e.g. cobble/boulder). As noted in the borehole record for CR-4, an additional three boreholes were advanced in proximity to Borehole CR-4 and encountered refusal between 0.8 m and 1.1 m depth.

In general, the bedrock is classified as granite or gneiss rock. In Borehole CR-1, the 2.9 m of bedrock cored from Elevation 207.9 m was classified as granite. In Borehole CR-2, the bedrock was cored for 3.3 m from Elevation 206.1 m, with the upper 0.6 m being classified as granite and the lower 2.7 m being classified as gneiss. In Borehole CR-3, the 2.9 m of bedrock cored from Elevation 207.3 m was classified as gneiss. The retrieved granite rock is described as medium to very coarse grained, fresh, strong, and pinkish grey whereas the gneiss rock is described as fine to coarse grained, fresh, strong and pinkish grey. Photographs of the retrieved bedrock core samples (including the overlying cobbles / boulders were included in the rock core) are provided on Figure A1 in Appendix A.

The Total Core Recovery (TCR) measured on the core samples is 100%. The Solid Core Recovery (SCR) of the rock core samples ranges from 91 % to 100 %. The Rock Quality Designation (RQD) measured on the core samples ranges from 72 % to 100 %, indicating a rock mass of fair to excellent quality.

Laboratory Uniaxial Compressive Strength (UCS) tests were carried out on three selected bedrock core samples. The UCS values are presented on the Record of Drillhole sheets in Appendix A and are summarized below and indicate that the bedrock is strong.

Borehole	Elevation (m)	Rock Classification	UCS (MPa)
CR-1	206.2	Granite	61.8
CR-2	207.4	Granite/Gneiss	62.9
CR-3	205.7	Gneiss	60.7

4.3 Groundwater Conditions

Groundwater levels were measured within the open boreholes upon completion of drilling. Boreholes CR-2, CR-3 and CR-4 were dry upon completion of drilling operations. A water level was observed and measured in CR-1 as summarized below; however, it is noted that water was introduced as part of drilling activities (wash boring during casing advancement and coring) and the water level is not considered representative of the stabilized groundwater level at the site.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Elevation (m)	Date	Reading
CR-1	211.9	1.7	210.2	June 21, 2023	Open Borehole after water was introduced

The water level in Clay River is shown on the General Arrangement drawing to be at about Elevation 208.8 m at the culvert inlet and about Elevation 208.0 at the culvert outlet. Based on observations of the water level in the river while on site and the water levels provided on the GA drawing, and considering the granular nature of the embankment fill, the groundwater level adjacent to the culvert is anticipated to be near the river water level. The groundwater levels (and river water level) at this site will be subject to fluctuations both seasonally and as a result of precipitation events.

4.4 Analytical Testing Results

One soil sample was submitted to Bureau Veritas for chemical testing/analysis of indicators related to potential corrosion of exposed buried steel and concrete. The test results are provided in Appendix C and are summarized below.

Borehole No.	Sample Depth (m)	Chloride (ug/g)	Sulphate (ug/g)	Conductivity (umho/cm)	pH	Resistivity (ohm-cm)
CR-1	3.0	89	27	223	5.86	4,500

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Tibor Berecz, Mr. Jordan Schaaf and Mr. Biswajit Nandi, under the overall direction of Mr. Matthew Thibeault, P.Eng. This Foundation Investigation Report was prepared by Sumesh Cherukatt, and reviewed by Mr. Tibor Berecz, P.Eng., a Geotechnical Engineer with WSP. Mr. Kevin Bentley, P.Eng., an MTO Principal Foundations Contact for WSP, conducted an independent technical and quality review of the report.

Signature Page

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https://wsponline.sharepoint.com/sites/gld-163060/project files/6 deliverables/002_issued/006-r05-clay river culvert/3-revised final-rev2/22525353-006-r05-r-rev2-clay river culv. hwy 17 fidr 07may_26.docx

PART B

FOUNDATION DESIGN REPORT

Clay River Culvert Replacement at Station 11+501 (Site No. 38C-0157/C0)
Highway 17, Township of Goodwillie
Assignment No. 5022-E-0002, GWP 5114-20-00, WP 5230-21-01

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 the Clay River Culvert (Site No. 38C-0157/C0). The recommendations are based on interpretation of the factual data obtained from the boreholes advanced as part of the current investigation and the design information in the General Arrangement (GA) drawing provided by D.M. Wills.

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 or design-build 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

It is understood that the Clay River Culvert (Site No. 38C-0157/C0) along Highway 17 will be replaced on the same alignment as the existing culvert, maintaining the existing Highway 17 three lane configuration (i.e., one northbound lane and two southbound lanes) at this site.

The existing culvert is about 28 m long and consists of a 3,660 mm span by 2,440 mm rise SPCSPA with a 3,890 mm span by 2,690 mm rise culvert extension. The existing culvert and extension are to be completely removed prior to installation of the new culvert.

Based on the GA drawing (dated January 2026), the replacement culvert structure will be a closed bottom precast box culvert about 27.5 m long, with a span of 3.6 m and a rise of 2.1 m installed approximately perpendicular to the highway alignment. The existing grade on Highway 17 will be maintained with a corresponding approximate embankment height of about 3.5 m relative to the river bottom. It is understood that concrete wingwalls (and headwall) will be installed at the inlet and outlet of the proposed culvert, extending approximately 5 m from each side of the culvert opening.

As the culvert will be replaced on the existing alignment, the watercourse flow needs to be maintained through a flow diversion / bypass system or contained and pumped throughout construction to allow for installation of the new culvert in dry conditions.

It is anticipated that the culvert will be replaced via open-cut excavation in two stages to allow for continuous traffic along Highway 17 during construction. A temporary embankment widening (up to about 3 m wide) is proposed to accommodate a temporary detour at the north side of the culvert as part of the traffic staging to allow for temporary 1H:1V cut slopes to eliminate the requirement for a temporary protection system.

6.3 Culvert Replacement and Foundation Options

Given the poor performance of the existing steel arch culvert, high hydraulic capacity and low soil cover conditions, ease of compatibility with concrete wingwalls/headwalls and design service life for the new structure, we understand that a concrete box or rigid frame culvert structure is preferred from a highway and structural design perspective. From a foundation perspective, a cast-in-place concrete open footing or precast concrete box (closed bottom) culvert are considered feasible options for this culvert replacement. The culvert replacement foundation options are briefly summarized below, and a comparison of advantages, disadvantages and risks is provided in Table 1 following the text of this report.

- A closed bottom culvert (i.e., precast concrete box) can be placed more expeditiously compared to a cast-in-place option, offering schedule advantages with respect to construction/traffic staging and flow diversion / dewatering. These culverts can typically be founded at a shallower level compared to open footing culverts (i.e., above frost depth), reducing excavation and dewatering requirements. If required, stream substrate can be incorporated above the base invert to create a more natural substrate for fish passage. However, closed bottom culverts are less tolerant of variable founding elevations over the length of the culvert. At this site, given that a closed box culvert invert would be around Elevation 208 m, portions of the culvert may be supported on rock fill and portions of the culvert will be supported on bedrock. At some locations, bedrock excavation will be required to achieve the design culvert profile. Also, a temporary bypass culvert outside of the existing culvert footprint would likely be required during construction.

- An open footing culvert will typically require deeper foundation excavations to reach frost depth (or competent bedrock) as compared to a closed box culvert. This culvert type is typically cast-in-place, which could extend the construction schedule and increase the excavation, dewatering, and shoring requirements compared to a concrete box culvert in some cases. 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. However, an opening footing culvert can also be cast to accommodate a variable founding elevation, which can be beneficial in areas of relatively shallow bedrock. In addition, the open bottom culvert typically provides a more natural substrate for fish passage. A temporary bypass culvert inside the existing culvert could be considered during construction.

Based on the above considerations, a closed-bottom culvert is preferred to limit the impacts of a variable bedrock surface, however, there will be a requirement to excavate the bedrock to facilitate the design culvert profile and allow for bedding placement.

Based on the GA drawing provided by D.M. Wills (dated January 2026), a precast concrete closed bottom box culvert has been selected as the preferred structure replacement type. The culvert will have a span of 3.6 m and rise of 2.1 m (minimum) based on hydraulic requirements, with the invert varying from approximately Elevation 208.2 m at the north (inlet) end to Elevation 207.7 m at the south (outlet) end.

6.4 General Foundation Design Context

6.4.1 Consequence and Site Understanding Classification

As the proposed replacement culvert crosses Highway 17, which carries significant 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, Ψ, and geotechnical resistance factors, Φ_{gu} and Φ_{gs}, from Tables 6.1 and 6.2 of the CHBDC have been used for design.

For seismic design, the consequence factor, ψ, and resistance factor, ϕ_{gu}, should be taken as unity, as per Section 6.14.4 of CHBDC as applicable.

6.4.2 Seismic Design

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

6.4.2.1 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, $\overline{N}_{60}$, below the founding level and the shallow bedrock identified in the boreholes, the site may be classified as Site Class B in accordance with Clause 4.4.3.2 and Table 4.1 of CHBDC (2019), in the absence of site-specific geophysical testing.

Additional site-specific geophysics testing such as Multi-Channel Analysis of Surface Waves (MASW) or vertical seismic profiling could be considered as it may provide a more favourable average shear wave velocity to improve the Site Class.

6.4.2.2 Spectral Response Values

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

Parameter	2% Probability of Exceedance in 50 Years (2,475-year return period) (g)
PGA	0.0335
Sa(0.2)	0.0773
Sa(0.5)	0.0447
Sa(1.0)	0.0235
Sa(2.0)	0.0107
Sa(5.0)	0.00258
Sa(10.0)	0.000985
PGV [m/s]	0.0265

6.4.2.3 Spectral Response Values

Based on the values noted above and in accordance with Table 4.10 of the CHBDC (2019), the site is located in Seismic Performance Zone 1 for major-route and other bridges. In accordance with Section 4.4.5.1 of the CHBDC (2019), no seismic analysis is required for structures located in Seismic Performance Zone 1.

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 overburden / fill materials at this culvert site consist of predominantly compact to very dense mixtures of sandy silt to gravel fill and/or rock fill overlying shallow bedrock. Based on the classification and compactness of the overburden, the soils 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 2.2 m as interpreted from Ontario Provincial Standard Drawing (OPSD) 3090.100 (Foundation Frost Penetration Depths for Northern Ontario). The open footing culvert should be founded below the frost penetration depth of 2.2 m or on non-frost susceptible material (e.g. competent bedrock). Precast concrete closed box culverts are generally tolerant and can accommodate small magnitudes of movement related to freeze-thaw cycles, should these occur; therefore, if a precast concrete closed box culvert is selected, consideration could be given to a shallower founding elevation.

6.5 Culvert Foundation Design Recommendations

6.5.1 Pre-cast Box Culvert

The bedding and levelling pad requirements for a pre-cast box culvert should be in general accordance with OPSS.PROV 422 (Pre-cast Reinforced Concrete Box Culverts). Provided adequate dewatering / flow diversion is in place and adequate design subgrade tolerances are achieved after excavating the existing rock fill and bedrock, a minimum 150 mm thick layer of OPSS.PROV 1010 (Aggregates) Granular A or Granular B Type II material is recommended for bedding purposes. The bedding is to be placed and compacted according to OPSS.PROV 422 and OPSS.PROV 501 (Compacting). In addition and above the bedding layer, 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) is required. Bedding, levelling pad, cover and backfill should be provided with a geometry similar to that provided on OPSD 803.010 (Backfill and Cover for Concrete Culverts).

Based on the design invert elevations, anticipated box culvert thickness of about 0.3 m, and allowance for bedding and levelling pad thickness, it is anticipated that the design subgrade (i.e. bottom of bedding material) will range from about El. 207.7 m to 207. 2 m. As a result, excavation through the existing rock fill and bedrock will be required for the majority of the culvert footprint. Additional bedding thickness may be placed and compacted in any areas where rock fill and/or bedrock levels are subexcavated below design subgrade (i.e. due to uneven removal of large rock pieces and rock fragments).

Rock excavation for the structural culvert should generally follow OPSS.PROV 206 and OPSS.PROV 403 (Construction Specification for Rock Excavation) with blasting methods excluded from the contract due to safety concerns. The use of mechanical excavation / scaling with a hoe ram or other approved non-blasting methods will be required to achieve a level founding surface at the design bedrock subexcavation level. A Non-Standard Special Provision (NSSP) for Rock Excavation for Structure to exclude blasting should be included in the Contract Documents; an example NSSP is provided in Appendix D.

For a 3 m to 5 m wide precast closed bottom box culvert founded on the thin layer of compacted pad over fresh bedrock, geotechnical axial resistances (ULS and SLS) values would exceed 600 kPa.

6.5.2 Open Footing Culvert

Strip footings should be placed on properly prepared and competent bedrock. Based on the bedrock elevations encountered in Boreholes CR-1, CR-2 and CR-3, the footings are to be founded between about Elevations 208.1 m and 207.3 m on the bedrock surface. The rock surface should be properly cleaned, and all loose material removed prior to pouring foundation concrete. Excavation and backfilling foundations are to be in accordance with OPSS.PROV 902 (Structures).

For 0.5 m to 1 m wide cast-in-place concrete footings founded on fresh bedrock, geotechnical axial resistances (ULS and SLS) values would exceed 1,000 kPa.

The use of mechanical excavation / scaling with a hoe ram or approved alternate will be required to achieve a level founding surface. Blasting operations are to be excluded from the contract. Alternatively or in combination with bedrock excavation, dowels could be incorporated into the design to limit excavation / scaling operations provided concrete forms can be installed to accommodate the variable bedrock surface. Where the rock mass is stronger than the concrete (as is the case at this site), the design of the dowels into the rock may be handled in the same way as a dowel embedment into concrete for a uniaxial compressive strength of grout similar to that of concrete. Dowels should have a minimum 1 m embedment into fair quality (i.e., RQD >50%) bedrock and the structural strength of the grout should not be exceeded. If dowels are incorporated into the design, a Non-Standard Special Provision for Dowels into Rock should be included in the Contract Documents; an example NSSP is provided in Appendix D.

6.5.3 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 6.4.1. The following interface friction angle(s) and interface shear strengths may be utilized to assess the critical conditions for sliding resistance:

Interface	Interface Strength
Between cast-in-place concrete (i.e. culvert and/or headwall and wingwall footings) and bedrock	δ'_i = 35°, c' = 0 kPa
Between pre-cast concrete and levelling pad / bedding	δ'_i = 20°, c' = 0 kPa

Where additional lateral restraint is needed or if the bedrock is found to be sloping at greater than 10 degrees, the base of the concrete footing should be doweled into the bedrock as outlined in Section 6.5.2.

6.5.4 Culvert Backfill and Cover

Backfill and cover above/behind the culvert walls and any headwalls or wingwalls / retaining walls should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular A or Granular B Type I or II above the groundwater level and Granular B Type II (not clear stone) below the water level, if required. The backfill and cover should be placed and compacted 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. The backfill and cover should be in general accordance with OPSD 803.010 and embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS.PROV 206.

6.5.5 Culvert Erosion and Scour Protection

To prevent surface water from flowing 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 at highway surface), we understand a concrete cut-off wall, and concrete headwall and wingwalls will be constructed.

It is also recommended that rip-rap treatment at the outlet of the culvert be provided and should be consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment). Erosion protection for the inlet of the culvert should also be similar to the standard presented in OPSD 810.010 (Rip Rap Treatment).

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 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).

We understand that river substrate may be used to form the culvert invert, if required for fisheries purposes, which is considered acceptable provided it is resistant to erosion for the design waterflows.

6.6 Lateral Earth Pressures

The lateral earth pressures acting on culvert walls or associated headwalls or wingwalls 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 walls and associated wingwalls / headwalls.

- Select, free draining, non-frost susceptible granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular ‘A’ or Granular ‘B’ (Type I or II) should be used as backfill behind the culvert walls and associated 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 the 2019 CHBDC Section 6.12.3 and Figure 6.8. 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 the width equal to at least 2.2 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).

The following parameters and lateral earth pressure coefficients may be used in the design of culvert walls, headwalls and wingwalls:

The lateral earth pressure coefficients provided in the table below have been developed for flat (i.e., non-sloping) ground above/behind the culvert walls, headwalls and wingwalls. If the inclination of the slope above the wall differs, revised lateral earth pressures 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).

FILL MATERIAL	EXISTING EMBANKMENT FILL $\Phi'=32°$	GRANULAR A AND B TYPE II $\Phi'=36°$	GRANULAR B TYPE I $\Phi'=32°$
Unit Weight (kN/m^3)	19	22	21
Ground Surface Inclination	Horizontal	Horizontal	Horizontal
Active Earth Pressure (K_a)	0.31	0.26	0.31
At-Rest Earth Pressure (K_o)	0.47	0.41	0.47
Passive Earth Pressure (K_p) [1]	3.25	3.85	3.25

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.

6.7 Embankment / Wingwall Stability and Settlement

6.7.1 Stability

Based on site observations at the time of the foundation investigation and available site photographs/satellite images, the existing highway embankments in the culvert area appear to be performing satisfactorily. There was no evidence of global instability or major settlement (i.e., soil movement) of the existing embankment side slopes.

The existing embankments are up to approximately 3.5 m in height relative to the surrounding ground surface. Based on the GA drawing, it is understood that the existing embankment height at the culvert location will generally be maintained (i.e., no grade raise) and the temporary detour removed to restore the existing Highway 17 embankment configuration. The new / restored embankment side slopes should be sloped at 2H:1V or flatter in the vicinity of the culvert and wingwalls.

For these relatively low embankment heights (less than 4 m high) with side slopes equal to or 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.

The global stability of the wingwalls will also have a factor of safety greater than 1.5 provided that sufficient lateral resistance is provided to resist global instability (sliding) between the wall footing and bedrock interface by designing a sufficient footing width and/or supplementing with rock dowels.

6.7.2 Settlement

The existing embankment height at the culvert location will generally be maintained (i.e., no grade raise); however, the temporary embankment widening of about 3 m on the north (inlet) side will create additional loading to the foundation soils. Provided that the culvert walls and wingwalls are founded on the bedrock, which is considered a non-yielding material for the loading under consideration, and that the granular fill for the temporary embankment widening is properly compacted, negligible settlement is anticipated to occur. Cohesive (non-granular) earth fill materials are not recommended for temporary embankment construction as they may exhibit some additional settlement over time depending on their gradation, plasticity, and field compaction effort.

6.8 Analytical Testing for Construction Materials

The results of analytical testing on one sample recovered in Borehole CR-1 is summarized in Section 4.4 and included in Appendix C. The potential for 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 ensuring that all aspects of CSA A23.1-14 (2014) Section 4.1.1 “Durability Requirements” are followed when designing concrete elements, as applicable.

6.8.1 Potential for Sulphate / Chloride Exposure

The analytical test result was compared to Table 3 of CSA A23.1-09 Concrete Materials and Methods of Construction for the potential sulphate attack on concrete. The water soluble-sulphate concentration measured in the soil sample is 27 ug/g, which is below the exposure class of S-3 (Moderate) and is considered negligible according to Table 7.2 in the MTO Gravity Pipe Design Guidelines (2014). Also given that the culvert location will be exposed to de-icing salts, it is recommended that the minimum requirements of a C-1 (reinforced concrete) or C-2 (non-structurally reinforced concrete) class exposure concrete be considered, as appropriate.

6.8.2 Potential for Corrosion

The soil has a pH of 5.86 and according to the MTO Gravity Pipe Design Guidelines (2014), pH levels between 5.5 and 8.5 are not considered detrimental to culvert durability. The measured resistivity, R, of 4,500 ohm-cm indicates that the soil corrosiveness is moderate, as per Table 3.2 of the MTO Gravity Pipe Design Guidelines (2014), and appropriate materials should be used to resist corrosion over the design life of the culvert structure.

6.9 Construction Considerations

6.9.1 Temporary Excavation and Temporary Protection Systems

The temporary excavations for the culvert replacement and new wingwalls will extend through the existing granular embankment fill, rock fill and into bedrock. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act (OHSA) for Construction Projects (as amended).

According to the OHSA, the existing granular fill and rock fill are considered to be 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. It is anticipated that the rock fill can be excavated to 1H:1V slope below the groundwater table, although the sandy silt to gravel infill may flow through the rock fill and it is recommended that temporary slopes be no steeper than 3H:1V. Temporary erosion protection on exposed cuts / fills may be required and must be in accordance with OPSS.PROV 804 (Temporary Erosion Control).

Alternately based on the proposed half-and-half staged construction on Highway 17, temporary roadway protection systems may be required. For conceptual design purposes, protection systems could consist of either driven sheet piling or soldier piles and lagging where H-piles would be driven to a suitable depth (i.e. likely to be socketed into the bedrock at this site), with horizontal lagging installed as the excavation proceeds. Given the relatively shallow bedrock, there will be limited embedment depth within the overburden for protections systems and additional lateral support is likely required in the form of struts, walers, rakers, or anchors. The contractor will need to consider the presence of obstructions (i.e., rock fill containing cobble and boulder-sized rock fragments), shallow bedrock and groundwater conditions that will be sensitive to the river water level in the design and construction of the temporary protection system. For these reasons, conventional design and construction of temporary protection systems is considered marginally feasible and the proposed embankment widening, and detour option is preferred.

If temporary protections systems are considered, the contractor is responsible for the selection and detail design of the temporary protection / dewatering systems. The following soil parameters are provided for conceptual design and to aid in the detail design of the temporary protection systems, if selected.

Soil / Rock Type	Bulk Unit Weight, γ (kN/m^3)	Internal Angle of Friction ϕ (degrees)	Lateral Earth Pressure Coefficients [(1)]		
			Active, K_a	At Rest, K_o	Passive, K_p [(2)]
New Granular A or B Type II Engineered Fill	22	36	0.26	0.41	3.85
New Granular B Type I Engineered Fill	21	32	0.31	0.47	3.25
Existing Embankment Fill (compact to dense)	19	32	0.31	0.47	3.25
Bedrock	24	See Note 3	n/a	n/a	n/a

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.
3) Bedrock can be classified as strong, UCS = 50 MPa to 100 MPa.

Temporary protection systems are to be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). The lateral movement of the temporary protection systems should meet Performance Level 2 as specified in OPSS.PROV 539. 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 (CFEM 2023).

6.9.2 Control of Groundwater and Surface Water

During construction, it is anticipated that the river flow will need to be maintained by a flow diversion or dam and pump system. Given the permeable cohesionless fill soils encountered at this site, the depth of the anticipated groundwater table near the existing river level and excavation depths to expose bedrock, a temporary dewatering system, likely in conjunction with a cofferdam / surface water cut-off system is anticipated to be required to maintain a dry and stable subgrade within the culvert replacement and wingwall foundation footprint.

It is likely that a cofferdam system (e.g. sand bags, water bladder systems, etc.) is required to adequately divert and/or cut-off water flow (using dam and pump system) through a temporary pipe such that the excavations for the new culvert foundations can be dewatered using properly filtered pumps/sumps (possibly with secondary flow diversion barriers on the surrounding bedrock surface) to allow for cleaning / scaling of the founding bedrock surface and rock excavation to provide a level founding surface, installation of rock dowels (if required), construction of formwork and placement of cast-in-place reinforced concrete (if required). Depending on the surrounding groundwater level and water flow in the river, cofferdam and flow diversion / dewatering efforts may be low (i.e. during summer); however, given the permeable nature of the non-cohesive soils overlying bedrock at this site, an active flow diversion / dewatering system may be required. The extent/depth of flow diversion /

dewatering requirements shall be determined by the Contractor and their dewatering specialist, based on their proposed construction methods/ procedures and schedule for the work.

An Environmental Activity Section Registry (EASR) is typically not required for temporary surface water diversion through an existing culvert. However, if active dewatering is required, an EASR (for pumping volumes greater than 50 m^3/day) or PTTW (for pumping volumes greater than 400 m^3/day) may be required, depending on the effectiveness of the cofferdam / cut-off system and groundwater conditions at the time of construction and estimated pumping volumes. The Contractor should be required to evaluate the estimated seepage and groundwater removal quantity and discharge plan, based on their proposed flow diversion and construction methods/procedures and the groundwater conditions at the time of construction, to make the final assessment/determination whether an EASR (or PTTW) is ultimately required.

In accordance with OPSS.PROV 902 (Excavating and Backfilling - Structures), as modified by Special Provision 109S61 (Dewatering and Protection Systems), dewatering and temporary flow passage systems shall be according to OPSS517 (as amended by Special Provision 517F01). Given the cohesionless fills and relatively shallow bedrock 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 due to flow diversion / dewatering is considered low from a foundation perspective. As such, the Foundation fill-in in Table 1 of Special Provision 517F01 should indicate that a preconstruction survey is not applicable and the minimum lowered groundwater depth below base of excavation or work area should be 1.0 m or to competent bedrock.

6.9.3 Subgrade Preparation

Prior to placing the culvert bedding and wingwall footings or supporting granular foundation soils on bedrock, it is recommended that all existing fill, any organic materials (including topsoil, peat, and/or mixed organic soil), and any disturbed/loosened native soils be sub-excavated from below the plan limits of the proposed foundation system to expose the clean bedrock in general accordance with OPSS.PROV 902 (Excavating and Backfilling – Structures).

The founding bedrock surface should be inspected to ensure that all organics and other unsuitable materials have been removed, the founding surface has been scaled and is relatively level (and/or rock dowels installed as required). The bedrock surface may be highly variable across the foundation footprint and localized bedrock sub-excavation will be required, especially for the closed bottom box culvert option. Refer to Section 6.9.5 for bedrock sub-excavation recommendations.

Following bedrock and excavation and inspection, the excavated areas should be backfilled with granular material meeting the requirements of OPSS.PROV 1010 Granular ‘A’ or Granular ‘B’ Type II that is placed and compacted in accordance with OPSS.PROV 501 (Compacting) for culvert bedding and/or the granular fill pad for the wingwalls. The use of Granular ‘B’ Type II fill (and not clear stone) is recommended in wet conditions or below water.

We understand that river substrate backfill may be used to form the culvert invert for open footing option or within the closed box culvert for fisheries purposes, provided it is resistant to erosion for the design waterflows.

6.9.4 Temporary Embankment Widening / Embankment Reinstatement

The existing embankment will need to be temporary widened on the north side (near the inlet) to accommodate the staged detour, and both the north and south side of the embankment will need to be reinstated to a 2H:1V slope after the culvert and wingwalls have been constructed. Where new embankment fill is to be placed over the existing embankment fill, the existing embankment side slope will need to be stripped of vegetation / topsoil (if present) and benched ("keyed") in general accordance with OPSD 208.010. Embankment fill should consist of OPSS.PROV Granular 'A' or 'B' Type II and be constructed in accordance with OPSS.PROV 206. Existing granular embankment fill and/or rock fill may be reused for embankment reconstruction as per OPSS.PROV 206.

6.9.5 Obstructions / Bedrock Subexcavation

The contractor should be alerted to the presence of granular fill and rock fill containing cobble and boulder sized rock fragments, as confirmed by visual observation of the embankment fill near the culvert and inferred and confirmed by auger refusal / grinding of casing and coring through the fill in Boreholes CR-1 to CR-3. The location, depth and extent of the obstructions is provided on the borehole records and may vary beyond and between the borehole locations. The contractor should also be alerted to the presence of strong bedrock at shallow variable depth and will need to be prepared to use the suitable mechanical equipment or alternative methods (excluding blasting) for temporary works and to clean, scale, and sub-excavate / level the bedrock surface to design subgrade elevation and/or to install dowels, formwork and pour concrete as per the design drawings.

Based on conversations with the designers and MTO, it was agreed that blasting operations would not be permitted due to safety concerns. Refer to Appendix D for applicable Special Provisions related to obstruction and bedrock subexcavation.

7.0 CLOSURE

This Foundation Design Report was prepared by Tibor Berecz, P.Eng. and reviewed by Andre Bom, P.Eng., a Senior Geotechnical Engineer. Kevin Bentley, P.Eng., an MTO Principal Foundations Contact for WSP, conducted an independent technical and quality review of this report.

Signature Page

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https://wsponline.sharepoint.com/sites/gld-163060/project files/6 deliverables/002_issued/006-r05-clay river culvert/3-revised final-rev2/22525353-006-r05-r-rev2-clay river culv. hwy 17 fidr 07may_26.docx

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Bowles, Joseph, E., 1997. Foundation Analysis and Design, Fifth Edition. McGraw-Hill International Editions, Civil Engineering Series, Singapore.

Canadian Geotechnical Society, 2023. Canadian Foundation Engineering Manual, 5th Edition.

Canadian Standards Association (CSA), 2019. Canadian Highway Bridge Design Code and Commentary on CSA S6:19.

Canadian Standards Association (CSA), 2014. CSA A23.1-09 Concrete Materials and Methods of Construction (R2014).

Ministry of Northern Development of Mines. Bedrock Geology of Ontario, MRD126 – Rev 1.

Ministry of Transportation, MTO Gravity Pipe Design Guidelines, MTO Drainage and Hydrology Design and Contract Standards Office, May 2014.

Ministry of Natural Resources. 2005. Digital Northern Ontario Engineering Geology Terrain Study. Ontario Geological Survey, Miscellaneous Release – Data 160.

Occupational Health and Safety Act and Regulation for Construction Projects (as amended).

ASTM International

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

Ontario Provincial Standard Specifications (OPSS)

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 Construction Specification for Dewatering and Temporary Flow Passage Systems.

OPSS.PROV 539 Construction Specification for Temporary Protection Systems.

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 Standard Special Provisions

SSP 102S05 Amendment to OPSS 206.

SSP 105S09 Amendment to OPSS 539.

SSP 105S22	Amendment to OPSS 501.
SSP 109S61	Amendment to OPSS 902.
SSP 110S16	Amendment to OPSS 1004.
SSP 110S17	Amendment to OPSS 1002.
SSP 206F06	Amendment to OPSS 206.
SSP 517F01	Amendment to OPSS 517.

Ontario Provincial Standard Drawings (OPSD)

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 3090.100	Foundation, Frost Penetration Depths for Northern Ontario.

Ontario Water Resource Act

Regulation 903	Wells (as amended).

Table 1: Comparison of Culvert Replacement Options

Option	Advantages	Disadvantages	Risks/Consequences
Precast Box Culvert	▪ Minimizes depth of excavation, staged detour area and/or protection systems, and dewatering requirements compared to open-footing option. ▪ Allows faster construction resulting in shorter duration for dewatering and surface water diversion / pumping. ▪ More tolerant of total and differential settlements. ▪ A portion of the backfill/bedding under the culvert could be placed in-the-wet (i.e., Granular 'B' Type II) potentially reducing unwatering requirements. ▪ Allows for greater flow volume than circular/arch geometries.	▪ May not satisfy fisheries requirements related to natural channel substrate, if applicable. ▪ Cut-off wall (or clay seal) likely required at inlet to mitigate potential scour under the culvert. ▪ Transportation to site, and on-site lifting of large heavy precast sections will be required. ▪ Bedrock excavation required to achieve design profile for culvert.	▪ High risk of encountering / contacting bedrock above founding level within footprint of proposed culvert replacement. Bedrock would need to be sub-excavated (using mechanical methods or suitable alternative) to facilitate installation of the culvert and bedding to achieve design invert elevations. ▪ Risk of encountering mixed founding subgrade consisting of rock fill, granular fill, and/or bedrock. Rock fill may introduce challenges (over excavation and possibly subgrade disturbance) in order to achieve level subgrade, although these can be mitigated with the use of a granular working pad / increased thickness of bedding layer. Differential settlement on mixed subgrade can be mitigated using mechanically connected precast segments to distribute load on foundations. ▪ Low risk related to settlement performance as box segments can accommodate some total and differential settlements and can be mechanically connected. ▪ Presence of rock fill, obstructions in existing fill and shallow bedrock could cause potential construction challenges and higher risk of delays / claims.

Table 1: Comparison of Culvert Replacement Options

Option	Advantages	Disadvantages	Risks/Consequences
Open Footing Culvert	▪ May be feasible to construct precast three-sided culvert sections to be installed on cast-in-place footings and walls on bedrock to accelerate construction schedule and reduce time for dewatering/unwatering (diversion / pumping through existing culvert). ▪ Readily suitable for construction using a variety of concrete or metal culvert sections (rectangular, box, arch, etc.), although rigid frame concrete structure allows for greater flow volume than circular/arch geometries with limited soil cover. ▪ Would satisfy fisheries requirements related to natural channel substrate, if applicable. ▪ Footings founded on bedrock reduce risk of settlement / differential settlement. ▪ Adaptable to variable bedrock surface within footprint of the culvert footings.	▪ Excavation depths to expose bedrock are greater than for a closed box culvert option, resulting in increased excavation effort, cofferdam and dewatering requirements, and additional fill material to be stored and re-used or disposed off-site. ▪ Bedrock cleaning, scaling and potential variable bedrock surface will need to be considered. ▪ Constructing cast-in-place footings and walls in the dry will take longer than installing precast units.	▪ Larger staging / excavation area and wider detour is required compared to precast, however, temporary excavation support systems likely not required. ▪ Increased surface water cut-off / flow diversion and dewatering requirements needed to install formwork, dowels, and cast-in-place reinforced concrete foundations compared to precast box units. ▪ Low risk of variable / high bedrock surface impacting design or construction as footings / walls will be founded directly on bedrock with dowels (i.e. low risk of bedrock sub-excavation compared to precast box units). ▪ Presence of rock fill and obstructions in overburden may cause excavation challenges although this can be addressed in contract documents. ▪ Risk of bedrock surface being much lower in some areas requiring increased excavation and dewatering efforts, and increased wall heights.

MINISTRY OF TRANSPORTATION, ONTARIO

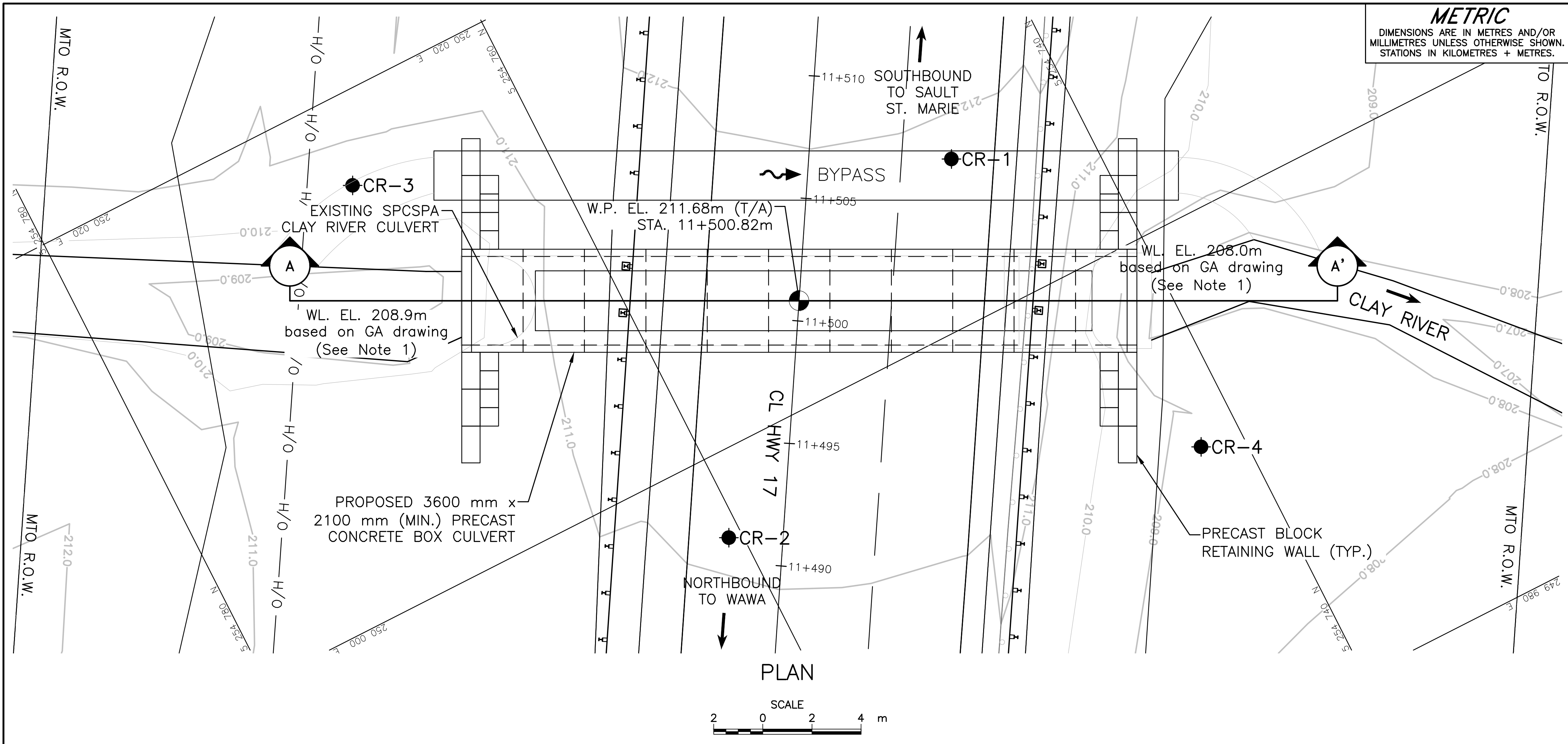
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5114–20–00

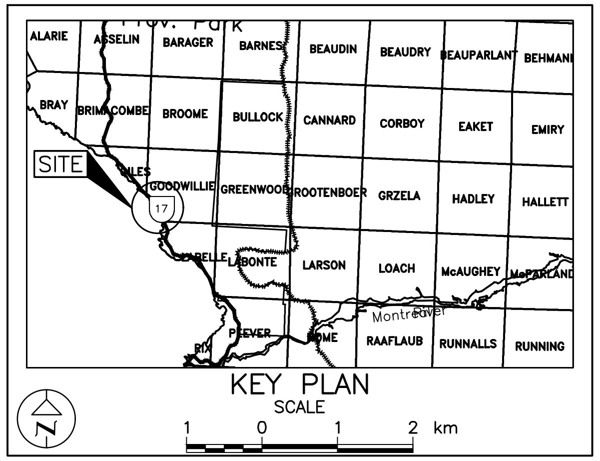
SHEET

HIGHWAY 17
CLAY RIVER CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

wsp



PLAN



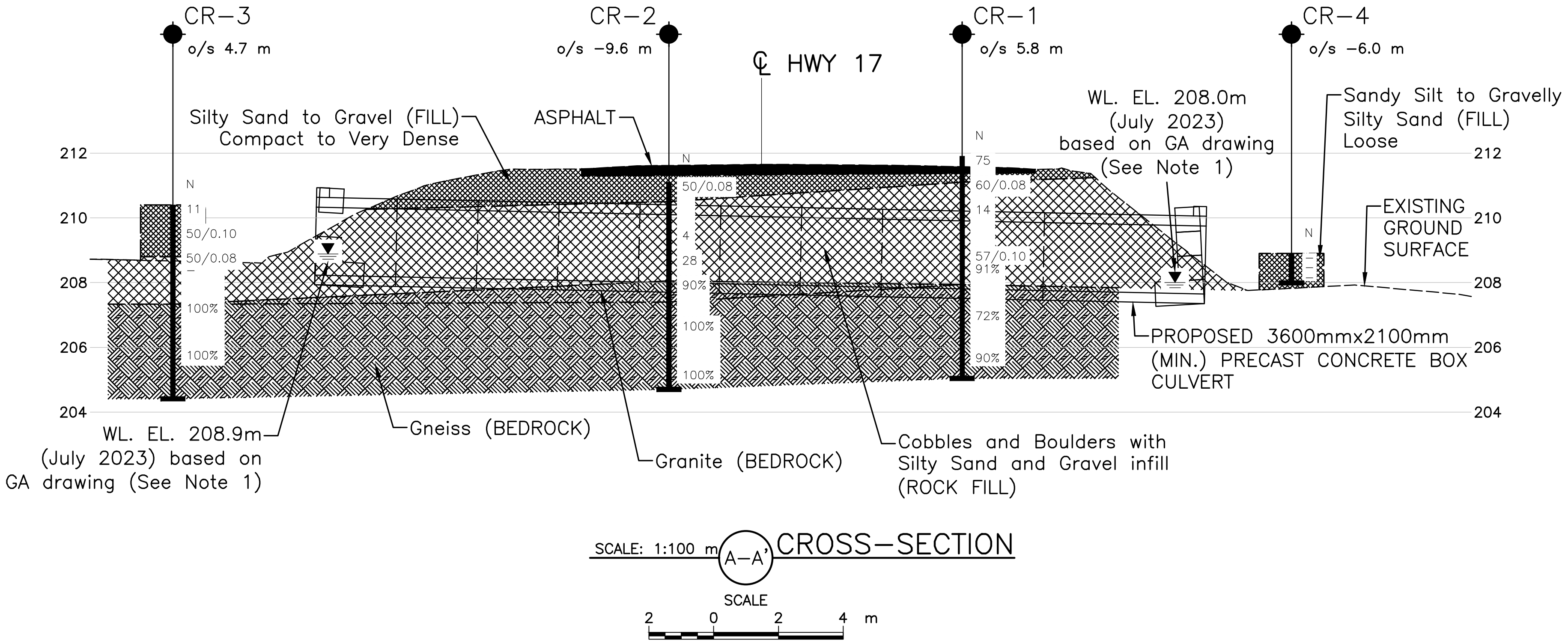
KEY PLAN

LEGEND

●	Borehole – Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL measured in river (July, 2023)

T. BERECZ
100543249
MAY 06, 2026

K. J. BENTLEY
MAY 06, 2026



SCALE: 1:100 m (A–A) CROSS–SECTION

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 13)

No.	ELEVATION	NORTHING	EASTING
CR–1	211.9	5254745.5	250006.4
CR–2	211.1	5254760.5	249996.7
CR–3	210.4	5254767.7	250016.4
CR–4	208.9	5254741.7	249991.3

NOTES

1. Approximate groundwater level inferred to be near the existing culvert invert based on the soil types encountered in the boreholes and observations of the water level in the culvert during the drilling operations.

2. 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.

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

4. Plan and profile GA's were scaled and aligned by WSP. Actual locations may vary.

REFERENCE

Base plan and Topography provided in digital format by Callon Dietz, drawing file no. B0885017001 GWP 5114–20–00.dwg, Received October 31, 2023.
GA's provided in digital format by DM Wills, drawing file no. Clay River Culvert – GA for WSP.dwg, Received February 5, 2026.

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 41N07–005A

HWY. 17		PROJECT NO. 22525353	DIST. .
SUBM'D. .	CHKD. .	DATE: 5/6/2026	SITE: 38C–0157/C0
DRAWN: TR	CHKD. TB	APPD. KJB	DWG. 1

PLOT DATE: May 6, 2026
FILENAME: R:\Ministry_of_Transportation_Ontario–MTO\Hwy17\99_PROJECTS\22525353\1000\1400\001–CR_Geotech_Invest\02_PRODUCTION\DWG\22525353–1000–1400–001–01.dwg

Photograph 1: Highway 17 – Clay River Culvert – Embankment West Slope at Culvert Outlet, Looking North

Photograph 2: Highway 17 – Clay River Culvert – Embankment West Slope at Inlet, Looking East

Photograph 3: Highway 17 – Clay River Culvert – Embankment East Slope at Inlet, Looking North

Photograph 4: Highway 17 – Clay River Culvert – Outlet

APPENDIX A

Borehole Records

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

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

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

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

PENETRATION RESISTANCE

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

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

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

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

SAMPLES

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

SOIL TESTS

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

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

COARSE-GRAINED SOILS

Compactness[1]

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

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

FINE-GRAINED SOILS

Consistency

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

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

Field Moisture Condition

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

LIST OF SYMBOLS
MINISTRY OF TRANSPORTATION, ONTARIO

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_{\alpha(e)}$	secondary compression index
C_α	rate of secondary compression
$C_{\alpha(\varepsilon)}$	modified secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q or q'	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

---

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

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
BD	Bedding
BC	Broken Core
CC	Continuous Core
CL	Closed
CO	Contact
CU	Curved
CT	Coated
FLT	Fault
FOL	Foliation
FR	Fracture
GO	Gouge
IN	Infilled
IR	Irregular
JN	Joint
KV	Karstic Void
K	Slickensided
LC	Lost Core
MB	Mechanical Break
PL	Planar
PO	Polished
RO	Rough
SA	Slightly Altered
SH	Shear
SM	Smooth
SR	Slightly Rough
SY	Stylolite
UN	Undulating
VN	Vein
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 22525353

RECORD OF BOREHOLE No. CR-1

1 OF 1 **METRIC**

G.W.P. 5114-20-00

LOCATION N 5254745.5; E 250006.4 NAD83 MTM ZONE 13 (LAT. 47.429675; LONG. -84.726361)

ORIGINATED BY TB

DIST HWY 17

BOREHOLE TYPE 114 mm O.D. Solid Stem Augers, NW Casing, NQ Coring

COMPILED BY TR

DATUM GEODETIC

DATE June 21, 2023

CHECKED BY MT

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

SOIL PROFILE			SAMPLES							REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR SA SI CL
211.9	GROUND SURFACE									
0.0	ASPHALT (110 mm)	■								
0.1	Gravelly SAND (SP) to GRAVEL (GP) (FILL) Compact to very dense Brown to grey Moist to wet	☒	1	SS	75					
211.1 0.8	Cobbles and boulders with sandy gravel infill (ROCK FILL) - Split-spoon refusal at 0.8 m depth. - Auger grinding at 1.0 m depth, switched the NW Casing. - Casing grinding between 1.5 m and 3.0 m depth. - Split-spoon refusal at 3.4 m depth. (Hammer Bouncing) - 270 mm diameter cobble / boulder encountered at 3.4 m depth. - NQ coring from 3.4 m to 4.0 m depth. - 200 mm diameter cobble encountered at 3.7 m depth.	☒	2	SS	60/0.08		211			
			3	SS	14	∇	210	○		80 20 (0)
			4	SS	57/0.10		209			
207.9 4.0	GRANITE (BEDROCK) Bedrock cored from 4.0 m to 6.9 m depth. For coring details refer to Record of Drillhole CR-1.	▨	1	RC	REC 100%		208			RQD = 91%
			2	RC	REC 100%		207 206			RQD = 72%
			3	RC	REC 100%					RQD = 90%
205.0 6.9	END OF BOREHOLE NOTES: 1. Water added during casing/coring advancement during drilling operations. 2. Water level measured at a depth of 1.7 m below ground surface (Elev. 210.2 m) upon completion of drilling.									

+3, ×3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 22525353

RECORD OF DRILLHOLE: CR-1

SHEET 1 OF 1

LOCATION: N 5254745.5; E 250006.4 (LAT. 47.429675; LONG. -84.726361)

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: June 21, 2023

DRILL RIG: Diedrich D-90

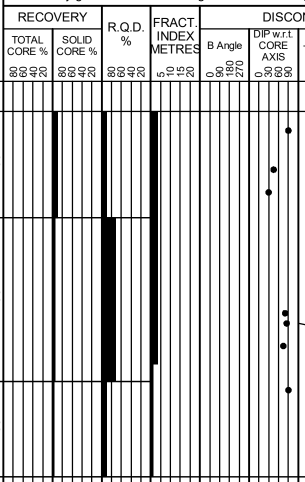
DRILLING CONTRACTOR: Walker / RPM Drilling

DATUM: GEODETIC

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	TYPE AND SURFACE DESCRIPTION	
		BEDROCK						
4	NQ Coring	GRANITE Medium to very coarse grained Fresh Strong Light pink to light grey		207.9 4.0	1	Grey 100	JNIRRo JNIRRo JNIRRo	
5 6		- Fractured between 5.8 m and 6.0 m depth.			2	Grey 100	JNIRRo JNIRRo JNIRRo	UCS = 61.8 MPa
				205.0 6.9	3	Grey 100	JNIRRo	
7		END OF DRILLHOLE						
8								
9								
10								
11								
12								
13								
14								
15								



HYDRAULIC CONDUCTIVITY k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} | Jr | Ja | Jn | Diametral Point Load Index (MPa) 2 4 6 | RMC -Q' AVG.

DEPTH SCALE

1 : 60

LOGGED: TB

CHECKED: MT

RECORD OF BOREHOLE No. CR-2

1 OF 1 **METRIC**

PROJECT 22525353

G.W.P. 5114-20-00

DIST ______ HWY 17

DATUM GEODETIC

LOCATION N 5254760.5; E 249996.7 NAD83 MTM ZONE 13 (LAT. 47.429811; LONG. -84.726491)

BOREHOLE TYPE 114 mm O.D. Solid Stem Augers, NW Casing, NQ Coring

DATE June 22, 2023

ORIGINATED BY TB

COMPILED BY TR

CHECKED BY MT

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
211.1	GROUND SURFACE
210.9 0.0	ASPHALT (220 mm)
0.2	SILTY SAND (SM) to GRAVEL (GP) and sand (FILL) Loose to very dense Brown Dry
210.5 0.6	Cobbles and boulders with silty sand and gravel infill (ROCK FILL) - Auger refusal at 0.6 m depth, switched to NW Casing. - Casing grinding between 0.6 m and 1.5 m depth. - Organic silt pockets at 1.5 m depth. - Casing grinding at 2.9 m depth and switched to NQ coring. - 150 mm diameter cobble encountered at 2.9 m depth.
208.1 3.1	GRANITE (BEDROCK) Bedrock cored from 3.1 m to 6.4 m depth.
207.4 3.7	For coring details refer to Record of Drillhole CR-2. GNEISS (BEDROCK)
204.7 6.4	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	50/0.08	211					
			210					
2	SS	4		OC=6.4%	2	53	(45)	
			209					
3	SS	28						
			208					
1	RC	REC 100%			RQD = 90%			
			207					
2	RC	REC 100%	206		RQD = 100%			
3	RC	REC 100%	205		RQD = 100%			

GROUND WATER CONDITIONS

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

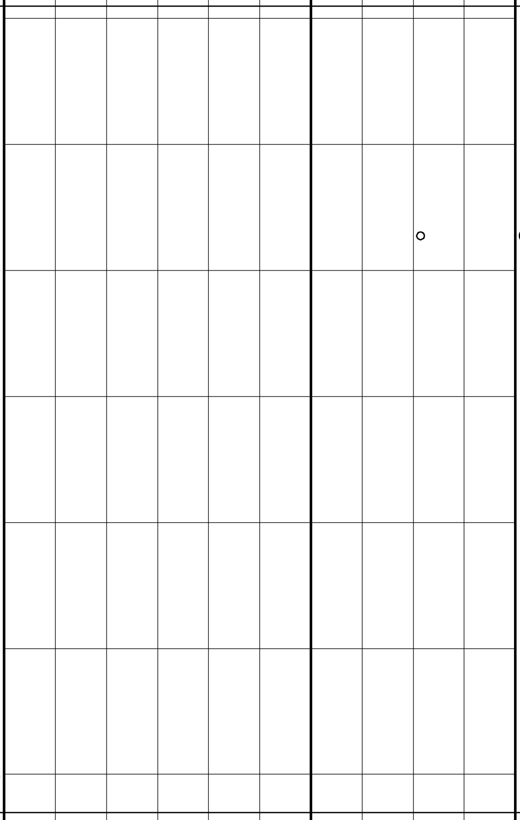
SHEAR STRENGTH kPa: 20 40 60 80 100

○ UNCONFINED + FIELD VANE

● QUICK TRIAXIAL × REMOULDED

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60



+^{3}, ×^{3}: Numbers refer to Sensitivity

○$^{3\%}$ STRAIN AT FAILURE

PROJECT: 22525353

RECORD OF DRILLHOLE: CR-2

SHEET 1 OF 1

LOCATION: N 5254760.5; E 249996.7 (LAT. 47.429811; LONG. -84.726491)

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: June 22, 2023

DRILL RIG: Diedrich D-90

DRILLING CONTRACTOR: Walker / RPM Drilling

DATUM: GEODETIC

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	NOTES
		BEDROCK					
	NQ Coring	GRANITE Coarse grained Fresh Strong Pink-cream white	208.1 3.1	1	Grey / brown 100	JNIRRo JNIRRo	UCS = 62.9 MPa
4		GNEISS Medium to fine grained with leucocratic banding Fresh Strong Light to medium grey	207.4 3.7				
5				2	Grey / brown 100		
6				3	Grey / brown 100		
		END OF DRILLHOLE	204.7 6.4				
7							
8							
9							
10							
11							
12							
13							
14							
15							

Column headings: SYMBOLIC LOG; RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20); R.Q.D. % (80 60 40 20); FRACT. INDEX METRES (5 10 15 20); DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn; HYDRAULIC CONDUCTIVITY k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); Diametral Point Load Index (MPa) (2 4 6); RMC -Q' AVG.

DEPTH SCALE

1 : 60

LOGGED: TB

CHECKED: MT

RECORD OF BOREHOLE No. CR-3

1 OF 1 **METRIC**

PROJECT 22525353

G.W.P. 5114-20-00

DIST ______ HWY 17

DATUM GEODETIC

LOCATION N 5254767.7; E 250016.4 NAD83 MTM ZONE 13 (LAT. 47.429876; LONG. -84.726229)

BOREHOLE TYPE 114 mm O.D. Solid Stem Augers, NQ Coring

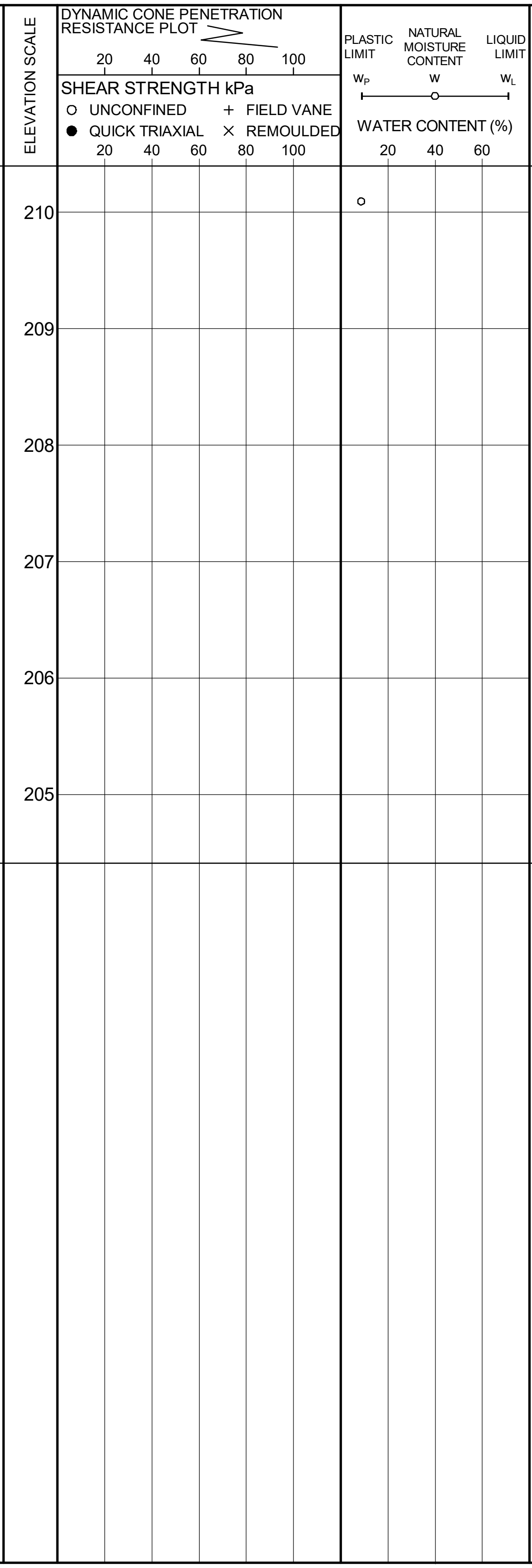
DATE August 17, 2023

ORIGINATED BY BN

COMPILED BY TR

CHECKED BY MT

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES		GR SA SI CL
210.4	GROUND SURFACE					
0.0	SAND (SP) and gravel to GRAVEL (GP) and sand, trace non-plastic fines (FILL) Compact to very dense Brown Moist - 100 mm and 225 mm diameter cobbles and 600 mm diameter boulder was encountered between 1.6 m and 3.1 m depth. - Auger / split-spoon refusal at 1.6 m depth and switched to NQ coring.	1	SS	11		50 44 (6)
		2	SS	50/0.1		
		3	SS	50/0.08		
208.8 1.6	Cobbles and boulders with gravel infill (ROCK FILL)	1	RC	-		
207.3 3.1	GNEISS (BEDROCK) Bedrock cored from 3.1 m to 6.0 m depth. For coring details refer to Record of Drillhole CR-3.	2	RC	REC 100%		RQD = 100%
		3	RC	REC 100%		RQD = 100%
204.4 6.0	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.					



UNIT WEIGHT γ kN/m^3

+^{3}, ×^{3}: Numbers refer to Sensitivity

○ $^{3\%}$ STRAIN AT FAILURE

PROJECT: 22525353

RECORD OF DRILLHOLE: CR-3

SHEET 1 OF 1

LOCATION: N 5254767.7; E 250016.4 (LAT. 47.429876; LONG. -84.726229)

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: August 17, 2023

DRILL RIG: CME 55

DRILLING CONTRACTOR: Walker / RPM Drilling

DATUM: GEODETIC

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock	
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided		
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth		
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough		
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break		

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	
		BEDROCK	207.3			
	NQ Coring	GNEISS Coarse grained with leucocratic banding Fresh Strong Grey / pink	3.1	2	JNIRRo	
4						
5				3	JNIRRo JNIRRo	UCS = 60.7 MPa
6		END OF DRILLHOLE	204.4 6.0			

DEPTH SCALE

1 : 60

LOGGED: BN

CHECKED: MT

PROJECT 22525353

RECORD OF BOREHOLE No. CR-4

1 OF 1 **METRIC**

G.W.P. 5114-20-00
LOCATION N 5254741.7; E 249991.3 NAD83 MTM ZONE 13 (LAT. 47.429641; LONG. -84.726559)
ORIGINATED BY JS
DIST
HWY 17
BOREHOLE TYPE Portable Equipment
COMPILED BY TR
DATUM GEODETIC
DATE July 10, 2023
CHECKED BY MT

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
208.9	GROUND SURFACE										
0.0	Organic SILT (OL) to Gravelly SILTY SAND (SM), trace organics (FILL) Loose Brown Moist	▨	1	AS	-					OC=11.6%	
			2	AS	-						
			3	AS	-						
208.0 0.9	END OF BOREHOLE AUGER REFUSAL NOTES: 1. Additional three boreholes were advanced within 1.0 m of CR-4 and encountered refusal between 0.8 m and 1.1 m depth. 2. Bedrock was visible along the river bed, approximately 5.0 m from Borehole CR-4. 3. State of compactness inferred from SPT carried out in adjacent borehole. 4. Borehole was dry upon completion of drilling.						208				

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

Core Box Photographs
Borehole:CR-1, CR-2 & CR-3

FIGURE A-1
Box

CR-1
3.4 m to 4.0 m (Gravels, 270 mm and 200 mm Cobbles)
4.0 m to 6.9 m (Bedrock)

CR-2
2.9 m to 3.1 m (Gravels, 150 mm Cobble)
3.1 m to 6.4 m (Bedrock)

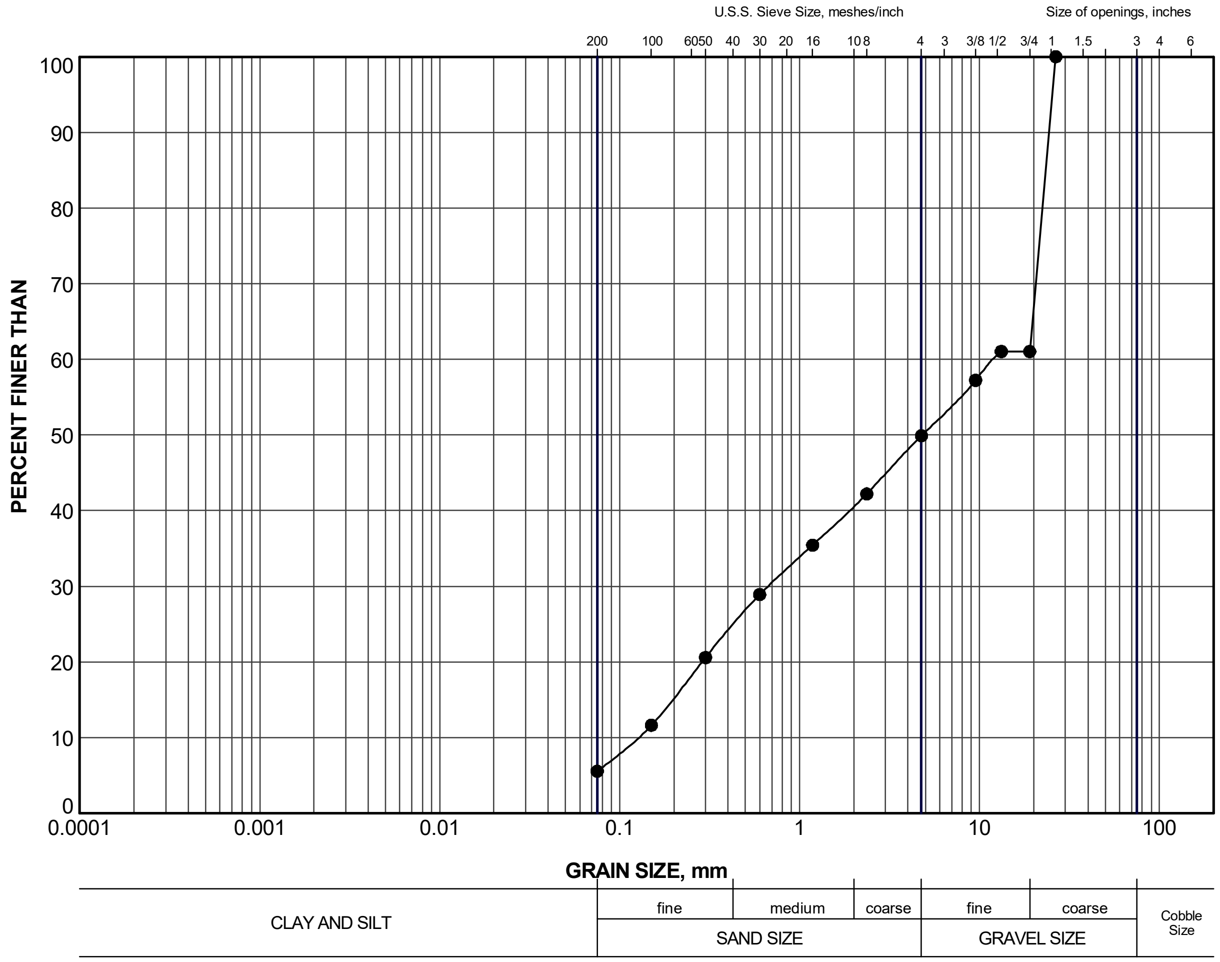
CR-3
1.6 m to 3.1 m (Gravel, 100-225 mm Cobbles, 600 mm Boulder)
3.1 m to 5.9 m (Bedrock)

Date: May 2024
Project: 22525353

Drawn: SC
Checked: MT

APPENDIX B

Geotechnical Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CR-3	1	210.1

PROJECT

HIGHWAY 17
CLAY RIVER CULVERT
STATION 11+501 (SITE NO 38C-0157/C0)

TITLE

GRAIN SIZE DISTRIBUTION

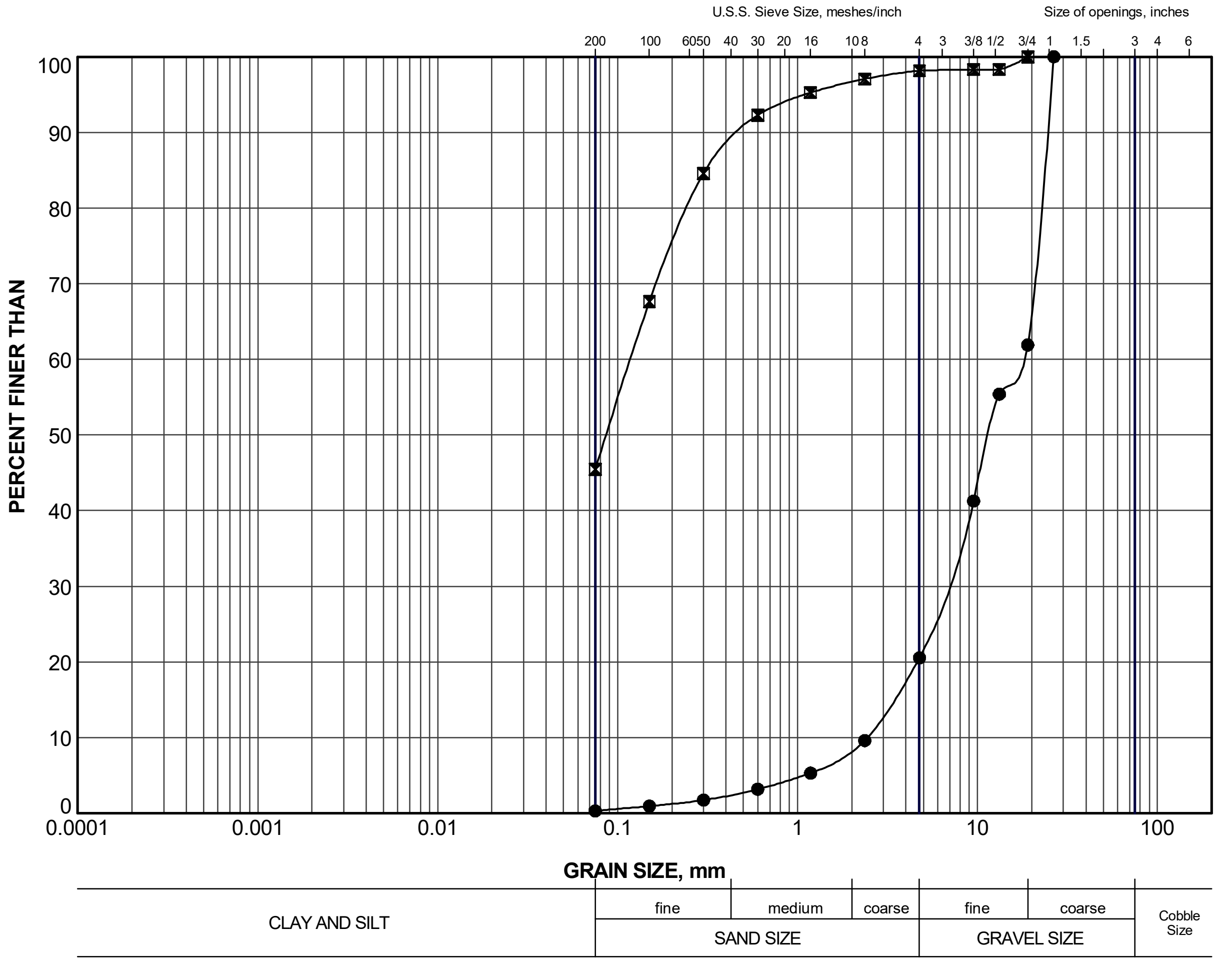
SILTY SAND (SP) to GRAVEL (GP) (FILL)

SUDBURY, ONTARIO

PROJECT No.		22525353	FILE No.	22525353.GPJ
DRAWN	TR	Oct 2024	SCALE N/A	REV.
CHECK	MT	Oct 2024		
APPR	JPD	Oct 2024		

FIGURE B-1

SUD-MTO GSD GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CR-1	3	210.1
☒	CR-2	2	209.3

PROJECT

HIGHWAY 17
CLAY RIVER CULVERT
STATION 11+501 (SITE NO 38C-0157/C0)

TITLE

GRAIN SIZE DISTRIBUTION

SILTY SAND (SP) and GRAVEL (GP) INFILL (ROCK FILL)

SUDBURY, ONTARIO

PROJECT No.		22525353
DRAWN	TR	Oct 2024
CHECK	MT	Oct 2024
APPR	JPD	Oct 2024

FILE No. 22525353.GPJ
SCALE N/A
REV.

FIGURE B-2

SUD-MTO GSD GLDR_LDN.GDT

APPENDIX C

Analytical laboratory Test Results

Your Project #: 22525353/1400
Site Location: HWY 17 WAWA
Your C.O.C. #: N/A

Attention: Matthew Thibeault

WSP Canada Inc.
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2024/05/31
Report #: R8171529
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BUREAU VERITAS JOB #: C4E2018
Received: 2024/05/09, 15:30

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	1	2024/05/15	2024/05/16	CAM SOP-00463	MOE E3013 m
Conductivity	1	2024/05/16	2024/05/16	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2024/05/16	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2024/05/16	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2024/05/15	2024/05/15	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	1	2024/05/15	2024/05/16	CAM SOP-00421	SM 24 2580 B
Resistivity of Soil	1	2024/05/13	2024/05/16	CAM SOP-00414	SM 24 2510 m
Sulphate (20:1 Extract)	1	2024/05/15	2024/05/16	CAM SOP-00464	MOE E3013 m

Remarks:

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

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE , Calgary, AB, T2E 6P8
(2) Offsite analysis requires that subcontracted moisture be reported.
(3) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode. The test is therefore, not SCC accredited for this matrix.

Your Project #: 22525353/1400
Site Location: HWY 17 WAWA
Your C.O.C. #: N/A

Attention: Matthew Thibeault

WSP Canada Inc.
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2024/05/31
Report #: R8171529
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BUREAU VERITAS JOB #: C4E2018
Received: 2024/05/09, 15:30

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Julie Clement, Technical Account Manager
Email: Julie.CLEMENT@bureauveritas.com
Phone# (613)868-6079
==

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Total Cover Pages : 2

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		ZDL071			ZDL071		
Sampling Date		2023/06/21 12:00			2023/06/21 12:00		
COC Number		N/A			N/A		
	UNITS	**CR-1 SA #4**	**RDL**	**QC Batch**	**CR-1 SA #4 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters							
Resistivity	ohm-cm	4500		9388975			
CONVENTIONALS							
Redox Potential	mV	350	N/A	9394126			
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	89	20	9394545	100	20	9394545
Conductivity	umho/cm	223	2	9396777	222	2	9396777
Available (CaCl2) pH	pH	5.86		9395189			
Soluble (20:1) Sulphate (SO4)	ug/g	27	20	9394555	29	20	9394555
Sulphide	mg/kg	0.6 (1)	0.5	9398411			
Physical Testing							
Moisture-Subcontracted	%	16	0.30	9398410			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Extracted past method specified hold time
Sample contained greater than 10% headspace at time of extraction.

TEST SUMMARY

Bureau Veritas ID: ZDL071
Sample ID: CR-1 SA #4
Matrix: Soil

Collected: 2023/06/21
Shipped:
Received: 2024/05/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9394545	2024/05/15	2024/05/16	Alina Dobreanu
Conductivity	AT	9396777	2024/05/16	2024/05/16	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9398410	N/A	2024/05/16	Basilla Ashrafi
Sulphide in Soil	SPEC	9398411	N/A	2024/05/16	Ly Vu
pH CaCl2 EXTRACT	AT	9395189	2024/05/15	2024/05/15	Kien Tran
Redox Potential	COND	9394126	2024/05/15	2024/05/16	Gurparteek KAUR
Resistivity of Soil		9388975	2024/05/16	2024/05/16	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9394555	2024/05/15	2024/05/16	Alina Dobreanu

Bureau Veritas ID: ZDL071 Dup
Sample ID: CR-1 SA #4
Matrix: Soil

Collected: 2023/06/21
Shipped:
Received: 2024/05/09

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9394545	2024/05/15	2024/05/15	Alina Dobreanu
Conductivity	AT	9396777	2024/05/16	2024/05/16	Gurparteek KAUR
Sulphate (20:1 Extract)	SKAL/EC	9394555	2024/05/15	2024/05/16	Alina Dobreanu

GENERAL COMMENTS

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

Package 1	11.7°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
9394126	Redox Potential	2024/05/16			101	95 - 105			9.4	35
9394545	Soluble (20:1) Chloride (Cl-)	2024/05/15	NC	70 - 130	102	70 - 130	<20	ug/g	11	35
9394555	Soluble (20:1) Sulphate (SO4)	2024/05/16	NC	70 - 130	101	70 - 130	<20	ug/g	7.7	35
9395189	Available (CaCl2) pH	2024/05/15			100	97 - 103			0.82	N/A
9396777	Conductivity	2024/05/16			102	90 - 110	<2	umho/cm	0.47	10
9398410	Moisture-Subcontracted	2024/05/15					<0.30	%		
9398411	Sulphide	2024/05/15	84	75 - 125	106	75 - 125	<0.5	mg/kg	23	30

N/A = Not Applicable

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

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

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

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

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

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

Veronica Falk

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

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

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www.BVNA.com

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

Received in Sudbury

CHAIN OF CUSTODY RECORD

ENV COC - 00014v5

Page ____ of ____

NONT-2024-05-1385

Invoice Information	Invoice to (requires report)	Report Information (if differs from invoice)		Project Information	
Company:	WSP Canada Inc.	Company:		Quotation #:	~~[illegible]~~
Contact Name:	Matt Thibeault	Contact Name:		P.O. #/ AFE#:	
Street Address:	33 Mackenzie Street	Street Address:		Project #:	22525353/1400
City:	Sudbury Prov: ON Postal Code: P3C 4Y	City:	Prov: Postal Code:	Site #:	Hwy 17 Wawa
Phone:	705-561-7012	Phone:		Site Location:	
Email:	matt.thibeault@wsp.com	Email:		Site Location Province:	
Copies:		Copies:		Sampled By:	

Regulatory Criteria

REG 153: Table 1 / Table 2 / Table 3 / Table ____ ☐ Res/Park ☐ Ind/Comm ☐ Agri/other Med/Fine Coarse ☐ For RSC

OTHER: ☐ CCME ☐ Reg 558* *min 3 day TAT ☐ MISA PWQO ☐ Reg 406, Table: ____ ☐ Sanitary Sewer Bylaw ☐ Storm Sewer Bylaw Municipality ____ ☐ Other:

Include Criteria on Certificate of Analysis (check if yes): ☐

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

	Sample Identification (Please print or Type)	Date Sampled YYYY	MM	DD	Time (24hr) HH	MM	Matrix	1 FIELD FILTERED	2 FIELD PRESERVED	3 LAB FILTRATION REQUIRED	4 BTEX/ F1	5 F2 - F4	6 VOCs	7 Reg 153 metals and inorganics	8 Reg 153 ICPMS metals	9 Reg 153 metals (Hg, Cr VI, ICPMS metals, HWS - B)	10	11	12	13	14	15	16	17	18	19	20	21 # OF CONTAINERS SUBMITTED	22 HOLD - DO NOT ANALYZE	Comments
1	CR-1 Salt 4	2023	06	21	12	00	Soil																							
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
10																														
11																														
12																														

Regular Turnaround Time (TAT)

☐ 5 to 7 Day ☑ 10 Day

Rush Turnaround Time (TAT)
Surcharges apply

Same Day ☐ 1 Day
2 Day ☐ 3 Day
☐ 4 Day

Date Required: YYYY ____ MM ____ DD ____

*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS-AND-CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present		✓		13	11	11
Seal intact		✓				
Cooling media present		✓				

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present	✓			5	5	5
Seal intact	✓					
Cooling media present	✓					

LAB USE ONLY	Yes	No	°C	1	2	3	Temperature reading by:
Seal present							
Seal intact							
Cooling media present							

	Relinquished by: (Signature/ Print)	Date YYYY	MM	DD	Time HH	MM	Received by: (Signature/ Print)	Date YYYY	MM	DD	Time HH	MM	Special instructions
1	Matt Thibeault	2024	05	09	15	05	Victor Esparza	2024	05	09	15	30	
2							JING DEEP KAUR	2024	05	11	11	06	

APPENDIX D

Special Provisions

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

Special Provision No. 517F01 February 2024

Amendment to OPSS 517, November 2023

Return Period Flow and Preconstruction Survey Distance

517.04 DESIGN AND SUBMISSION REQUIREMENTS

517.04.01 Design Requirements

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

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

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

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

TABLE 1
Site Location and Reference Information

TEMPORARY FLOW PASSAGE SYSTEMS

Source of Return Period Flow Estimates:

Site Name / Station Reference	**Minimum Return Period (Years)**	**Return Period Flow Estimates (m^3/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)
Clay River Culvert 38C-0157/C0	N/A	1 m (or to competent bedrock)	Yes

Notes:

1. a) The Design Engineer is to satisfy themselves to the accuracy and applicability of the provided flows.
   b) The intensity-duration-frequency (IDF) information can be accessed through MTO's IDF Curve Lookup web-based application tool at https://idfcurves.mto.gov.on.ca/
   c) The design, operation and maintenance of the temporary flow passage system is the sole responsibility of the Contractor.
2. "Yes" means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. "No" means a minimum experience level is not required for the design Engineer and design-checking Engineer.
3. "Yes" means that the design Engineer must design the temporary flow passage system to meet the fish passage requirements. "No" means fish passage is not required.
4. "N/A" means a preconstruction survey is not required.
5. Groundwater shall be lowered within the excavation or work area to below this minimum depth.

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

NOTES TO DESIGNER:

Designer Fill-Ins for Table 1:

1. Fill-in the source of the return period flow estimates.

2 Fill-in the site name, work, and station reference as appropriate for the dewatering system and/or temporary flow passage system item locations. Add additional rows as necessary.

3. For temporary flow passage system item locations, fill-in the minimum return period flow for each site based on MTO Drainage Design Standard TW-1. The return period flow shall not be less than 2 years.

4. For temporary flow passage system item locations, fill-in the design flow rate estimates for the various return periods.

5. Fill-in “Yes” under Design Engineer Requirements when recommended by the Foundation Engineer. Fill-in “No” otherwise.

6. For temporary flow passage system item locations, fill-in “Yes” under Fish Passage Required, when maintaining fish passage is a condition of a permit/ authorization or as recommended by the MTO Fisheries Assessment Specialist, in consultation with the MTO Environmental Planner. Fill-in “No” otherwise.

7. Fill-in the required distance under Preconstruction Survey Distance, when recommended by the Foundation Engineer. Fill-in “N/A” if not recommended.

8. Fill-in the Minimum Lowered Groundwater Depth Below Base of Excavation or Work Area provided by the Foundation Engineer.

9. When applicable, add a point d) to Note 1 of the table notes to indicate when Return Period Flow Estimates do not include base flows, for example:

   d) The Return Period Flow Estimates do not include base flows.
   d) The Return Period Flow Estimates at [enter Site Name/Description] do not include base flows.

WARRANT: Always with these tender items.

DOWELS INTO ROCK - Item No. 31

Special Provision

CONSTRUCTION SPECIFICATION FOR THE SUPPLY, INSTALLATION AND TESTING OF DOWELS INTO ROCK

1.0 SCOPE

The work for the above noted tender item shall be in accordance with OPSS 904, including all Special Provisions, except as extended herein. This document specifies additional requirements for the supply, installation, and testing of Dowels into Rock.

2.0 REFERENCES

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

ASTM International D1143M	Standard Test Methods for Deep Foundations Under Static Axial Compressive Load
ASTM International D3689M	Standard Test Methods for Deep Foundation Element Under Static Axial Tensile Load

3.0 DEFINITIONS

For the purpose of this Special Provision, the following definitions apply:

Dowels into Rock means reinforcing steel dowels installed within rock bores and secured with non-shrink grout within the annular space surrounding the dowel.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Working Drawings

The Contractor shall submit Working Drawings two weeks prior to construction to the Contract Administrator as follows:

a) All Working Drawings shall be sealed and signed by the Design Engineer and Design Check Engineer.

b) A plan illustrating the layout of the dowels.

c) Detail drawing of the dowel into bedrock (typical).

d) The method for constructing of the holes, maintaining the holes, and placing reinforcing steel dowels, grout and other materials in the holes, including casing sizes, bit sizes and tremie grouting methods.

e) The procedures to verify hole length.

f) Test procedures for Dowels into Rock.

g) Drawings and design calculations for a suitable reaction system for the applied test loads.

h) Drawings and details for reference system arrangement.

i) Calibration curves for all gauges.

5.0 MATERIALS

5.01 Non-Shrink Grout

The non-shrink grout shall be an approved product from the MTO's Pre-Qualified Products List.

5.02 Anti-Washout Agent

The anti-washout agent shall be used with the non-shrink grout for the Dowels into Rock.

5.03 Manufacturer Information

The Contractor shall provide the following information from the manufacturer for non-shrink grout and anti-washout agent:

a) Data sheets for the non-shrink grout and anti-washout agent,

b) Technical information that proves that the non-shrink grout and anti-washout agent are compatible, and

c) Installation procedures.

5.04 Steel Dowels

Steel dowels shall conform to the requirements of OPSS 905 and OPSS 1440.

Dowels shall be new, clean, and free of deleterious material.

6.0 EQUIPMENT

All equipment for the installation of the Dowels into Rock shall be suitable for the intended purposes and capable of working on the site under the prevailing access and clearance conditions.

The equipment shall not cause damage to the reinforcing steel dowels.

7.0 CONSTRUCTION

7.01 General

The Contractor shall supply equipment, materials, and skilled personnel to install production Dowels into Rock. The Contractor shall conduct the specified acceptance tests.

The Contractor is responsible for materials and workmanship. Any remedial measures, required because of defects in materials or workmanship, shall be completed by the Contractor at no cost to the Owner.

7.02 Subsurface Conditions

The subsurface conditions at the site are described in the Foundation Investigation Report for this Contract.

The Owner warrants the data in the Foundation Investigation Report, except that interpretations of the data and opinions expressed in the Foundation Investigation Report are not warranted.

7.03 Construction of Holes

The sides and end of the hole shall not be disturbed. The Contractor shall construct the holes, maintain the holes, and place reinforcing steel dowels, grout, and other necessary materials in the holes.

The hole diameter should be at least 2 times the nominal dowel diameter. The hole diameters and hole length for this project are as specified on the Contract Drawings.

At all times, the Contractor shall keep a record of all drilling procedures, rock conditions encountered, installation times, and drilled hole lengths. The Contractor shall submit these records to the Contract Administrator upon completion of the work.

7.04 Installation of Reinforcing Steel Dowels

Reinforcing steel dowels shall be installed in strict accordance with the Contract Drawings.

Centering devices shall be provided to ensure that the reinforcing steel dowels are located centrally in the hole.

Dowels shall extend into sound bedrock at least to the embedment depth noted on the Contract Drawings.

The Contractor shall submit records of the installed length of each dowel to the Contract Administrator.

7.05 Grout and Anti-Washout Agent

The non-shrink grout shall entirely fill the annular space between the reinforcing steel dowels and the sides of the dowel hole. The grout shall be of the same strength as the footing concrete or at least 30 MPa at 28 days.

Anti-washout agent shall be used in accordance with the specifications of the manufacturer.

The Contractor shall submit test results verifying the 28-day strength of non-shrink grout to the Contract Administrator. Testing shall be completed for each lot of dowels installed, where a lot shall consist of dowels of the same dowel type installed on a given day, in a single stage. Where a given day’s production is less than 50 dowels, the day’s work may be combined with the next day’s production to form a single lot.

7.06 Testing for Dowels

Upon completion of installation and testing of each group of dowels, the Contractor shall submit to the Contract Administrator a Request to Proceed.

The next operation after the completion of testing shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

8.0 QUALITY ASSURANCE

In each group, 10% of the dowels rounded up to the next whole number, but no fewer than two dowels, shall be tested.

8.01 General Inspection and Testing Requirements

The Contractor shall supply materials and equipment to conduct the tests for the dowels into rock. The equipment and materials shall be capable of stressing the dowels into rock to the specified loads. It shall be the responsibility of the Contractor to constantly monitor the test, maintain specified test loads and to record test measurements. The testing device shall not apply compression to the bedrock surrounding the dowels into rock within the area delimited by a circle concentric with the dowel hole and a diameter equal to 5.0 m.

The inspection of dowels shall be carried out by the Contract Administrator in advance of the installation of Dowels into Rock.

Testing for Dowels into Rock shall be conducted by the Contractor as scheduled by the Contract Administrator. The Contract Administrator will be present to inspect the testing of the Dowels into Rock. The Contractor shall notify the Contract Administrator of the testing schedule at least 10 working days prior to commencement of the testing program.

8.01.01 Testing Equipment

The Dowels into Rock will be carried out generally in accordance with the prevailing requirements of ASTM International D1143M and D3689M superseded where applicable by the procedures specified in the Contract Drawings.

Jacks must be secured with chains to provide adequate protection for the personnel in the event of breakage of the reinforcing steel dowels or stressing system.

The Contractor shall construct suitable enclosures to provide complete protection for all equipment from variations in the weather conditions and disturbances.

8.01.02 Documentation of Testing for Dowels into Rock

At all times, the Contractor shall keep records of vertical and horizontal movements of the reaction system, elongation of reinforcing steel dowels, and the record of test enclosure temperature. The movements shall be recorded with respect to an independent fixed reference point. The Contractor shall submit the above noted records to the Contract Administrator.

Dial gauges shall have at least a 76.2 mm (3.0 in.) travel. Longer gauge stems or sufficient gauge blocks shall be provided to allow for greater travel if required. Gauges shall have precision of at least 0.025 mm (0.0001 in.). The dial gauges shall be placed on smooth bearing surfaces mounted perpendicular to the direction of movement. All gauges, scales or reference points attached to the test anchor shall be mounted so as to prevent movement relative to the test anchor during the test. The Contractor shall submit details for current calibration and curves for all gauges to the Contract Administrator.

8.01.03 Testing Loading

Jacks used for reinforcing steel bars shall have a minimum stroke extension of 152.4 mm (6.0 in.).

Rock dowels shall be loaded and unloaded in 2 cycles and measurements of the displacement of the dowel shall be carried out at each load increment (step) in accordance with the following schedule:

Cycle-Step	1-1	1-2	1-3	2-1	2-2	2-3	2-4
% Design Load	50	75	25	50	75	100	25

The design load shall be taken as 108 kN for 20M dowels.

Displacement measurements shall be carried out at each load increment using calibrated displacement gauges capable of measuring movements of 0.0025 cm. Measurements shall be referenced to an independent fixed referenced pint.

8.02 Acceptance Criteria

The following acceptance criteria apply:

a) Tests for Dowels into Rock shall have a capacity of at least 108 kN. The dowels are acceptable if the total elastic movement is greater than 80 percent of the theoretical elastic elongation of the free stressing and is less than the theoretical elongation of the free stressing length plus 50 percent of the bond length.

9.0 MEASUREMENT FOR PAYMENT

For measurement purposes, a count shall be made of the number of dowels installed in accordance with the Contract Drawings.

10.0 BASIS OF PAYMENT

Payment at the contract unit price for the above tender item shall include full compensation for all labour, equipment, and materials to do the work.

Schedule Of Materials To Be Supplied By The Owner

The Ministry shall supply NO materials for this contract.

EARTH AND ROCK EXCAVATION FOR STRUCTURE– Item No.

Non-Standard Special Provision

Amendment to OPSS 902.PROV, November 2019

Excavating and Backfilling – Structures

902.07 CONSTRUCTION

Section 902.07.05.02 of OPSS 902 shall be amended by the addition of the following:

The Contactor is alerted to the presence of cobble and boulder sized rock fragments (i.e. rock fill) within the embankment fill at this site based on the conditions encountered in Boreholes CR-1 to CR-3. Rock fill was also visually observed at the surface of the embankments directly adjacent to the culvert location.

In addition, shallow strong bedrock was encountered in Boreholes CR-1 to CR-3 and the surface of the bedrock is variable. The depth and extent of obstructions (i.e. cobble and boulder sized rock fragments) as well as the bedrock elevation may vary beyond and between the borehole locations.

Consideration of the presence of these obstructions and the shallow variable bedrock conditions must be made in selection of appropriate equipment and procedures for temporary works, cofferdams / flow diversion systems, excavation and construction/installation of the culvert foundation and walls / wingwalls, as may be required.

ROCK EXCAVATION FOR STRUCTURE - Item No.

Special Provision

Amendment to OPSS 902, November 2019

902.04 Design and Submission Requirements

Section 902.04.02 of OPSS 902 is deleted in its entirety.

902.07 Construction

Section 902.07 of OPSS 902 is amended by the addition of the following:

902.07.10 Rock Excavation

The Contractor shall use appropriate equipment and methodologies to remove rock by mechanical means or other approved method. Due to the potential negative impacts/complications of blast-related damage, blasting will not be permitted to remove bedrock.

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