FOUNDATION INVESTIGATION AND DESIGN REPORT

Highway 66, Station 10+172, Township of McVittie Culvert Replacement
Ministry of Transportation, Ontario
GWP 5210-14-00

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GWP 5210-14-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services related to the replacement of the culvert on Highway 66 at Station 10+172, in the Township of McVittie, Ontario, approximately 30 m west of the intersection with Diamond Lake Road. The Key Plan of the general location of this section of Highway 66 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at the culvert replacement site by borehole drilling with laboratory testing carried out on selected soil samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated February 2018, and the subsequent clarifications/addenda, which forms part of the Consultant's Assignment Number 5017-E-0039 for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project dated November 2018.

2.0 SITE DESCRIPTION

The existing culvert consists of an approximately 1.3 m span by 1.2 m high and 22 m long double box timber structure. The culvert south end and north end inverts are approximately Elevations 277.0 m and 276.9 m, respectively. The culvert connects Fork Lake to the north and south of Highway 66. The topography within the vicinity of the culvert is generally undulating with thick forested vegetation beyond the right of way of the highway. The highway grade at the culvert centreline is approximately Elevation 279.9 m. The embankment is approximately 3.0 m high relative to the culvert invert at the south end and provides approximately 1.8 m of soil cover relative to the highway grade. The embankment side slopes are inclined at approximately 3.4 Horizontal to 1 Vertical (3.4H: 1V) and appear to be performing well, with no visible signs of slope instability or roadway settlement issues. At the time of the subsurface exploration field program, the south end of the culvert was damaged as evidenced by the southward leaning timber posts and misaligned top beam; and piles of vegetation debris had been cleared from the culvert south end and placed on the embankment side slope. The north end of the culvert did not show evidence of similar damage. The ground surface conditions at select locations near the culvert are shown on Photographs 1 to 4.

Recommendations for treatment of Pavement Distress Area between about station 10+172 and 10+186, McVittie township is provided in Golder Pavement Design Report.

3.0 INVESTIGATION PROCEDURES

Field work for this subsurface exploration was carried out on May 4, 5, 15, and 31, 2019, during which time five boreholes (Boreholes C267-1 to C267-5) were advanced at the approximate locations shown on Drawing 1. Boreholes C267-1 to C267-3 were advanced through the roadway embankment and Borehole C267-5 was advanced near the north toe of the highway embankment using a track mounted CME-55LC drilling rig supplied and operated by George Downing Estate Drilling (Downing) of Grenville-Sur-La-Rouge, Quebec. Borehole C267-4 was advanced near the south toe of the highway embankment, using a portable tripod rig supplied and operated by Landcore Drilling (Landcore) of Chelmsford, Ontario. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions. Water for wash boring operation was obtained from the adjacent lake/open water.

Boreholes C267-1 to C267-3 were advanced using 76 mm I.D. Hollow Stem Augers, NW casing with wash boring techniques. Borehole C267-5 was advanced using 108 mm I.D. Hollow Stem Augers, NW casing with wash boring techniques. Borehole C267-4 was advanced using NW casing with wash boring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by a full weight automatic or cathead hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). The groundwater level inside the augers/casing was observed and recorded after the completion of drilling. The boreholes were backfilled in accordance with Ontario Regulation 903 (wells), as amended. The roadway surface at the boreholes drilled through Highway 66 were capped at ground surface using cold patch asphalt.

Field work was supervised on a full-time basis by a member of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, and organic content was carried out on selected soil samples. The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable. One soil sample was submitted to Bureau Veritas Laboratories (formerly Maxxam) of Mississauga, an accredited analytical laboratory, for testing a suite of corrosivity indicator parameters.

The as-drilled borehole locations were measured by a member of our technical staff relative to highway chainages/stations marked on the pavement by AECOM's surveyors and converted into northing/easting coordinates on the plan drawing. The ground surface elevation at the borehole locations was surveyed by Golder, relative to the highway and culvert centreline, with the elevation of the centreline provided by AECOM. The MTM NAD 83-CSRS CBN v6-2010.0 (Zone 12) northing and easting coordinates, geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

Borehole Number	MTM NAD 83 Northing (m) (Latitude)	MTM NAD 83 Easting (m) (Longitude)	Ground Surface Elevation (m)	Borehole Depth (m)
C267-1	5330464.9 (48.106347)	397300.4 (-79.757784)	280.1	17.4
C267-2	5330462.7 (48.106329)	397285.6 (-79.757983)	280.0	15.9
C267-3	5330460.2 (48.106303)	397309.2 (-79.757667)	279.9	15.9
C267-4	5330452.7 (48.106236)	397305.1 (-79.757723)	278.7	9.8
C267-5	5330475.0 (48.106437)	397301.9 (-79.757761)	278.6	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) [1] mapping, the culvert site is located within a low trough of a bedrock ridge, covered generally by shallow deposits of sand and sand and gravel.

Based on geological mapping (MNDM) [2], the site is underlain by metasedimentary rocks.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the summary results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The plotted results of geotechnical laboratory testing are contained in Appendix B. The results of the in-situ field tests (i.e., SPT ‘N’- values), as presented on the Record of Borehole sheets and discussed in Section 4.2, are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profiles shown on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The results of the analytical laboratory testing (by Bureau Veritas Laboratories) are summarized in Section 4.4 and the detailed laboratory testing report is included in Appendix B.

The subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented on the Record of Borehole Sheets governs any interpretation of the site conditions. A summary description of the soil deposits and groundwater conditions encountered in the boreholes is provided below. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

4.2.1 Asphalt/Fill

An approximately 100 mm thick layer of asphalt was encountered in the roadway Boreholes C267-1 to C267-3, between Elevations 279.9 m and 280.1 m. A 2.1 m to 3.6 m thick layer of embankment fill consisting of an approximately 0.3 m thick upper layer of sand and gravel underlain by a 1.8 m to 3.3 m thick layer of sand, and sandy gravel at one borehole location, was encountered below the asphalt in Boreholes C267-1 to C267-3. Asphalt coated particles were encountered in all three road boreholes at between depths of 0.1 m to 0.3 m below the road surface. In Borehole C267-4, a 3.0 m thick layer of sand fill with trace rootlets/organics was encountered from ground surface (Elevation 278.7 m). In Borehole C267-5, a 0.3 m thick layer of topsoil fill was encountered at ground surface underlain by a 0.4 m thick layer of sand and gravel fill.

The SPT “N”-values measured within the fill range between 2 blows and 64 blows per 0.3 m of penetration with one “N”- value of 108 blows per 0.3 m of penetration on inferred frozen soil, indicating a very loose to very dense compactness condition.

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[1] Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 32DSW

[2] Ontario Ministry of Northern Development and Mines. Bedrock Geology of Ontario, East-Central Sheet. Map 2543

Grain size distribution analysis was carried out on one sample of the sand fill and the result is presented on Figure B-1 in Appendix B. The natural moisture content measured on one sample of the fill is 20 per cent.

4.2.2 Organic Sand and Organic Silt

A 0.2 m and 0.1 m thick layer of organic sand some silt, some gravel, and organic silt was encountered in Boreholes C267-3 and C267-5, respectively, at Elevations 277.7 m and 277.9 m.

An organic content test was carried out on one sample of the organic sand layer in Borehole C267-3 and measured and organic content of about 6 per cent. Grain size distribution analysis was carried out on one sample of the organic sand deposit and the result is presented on Figure B-2 in Appendix B. The natural moisture content measured on one sample of the deposit is 32 per cent.

4.2.3 Sand to Gravelly Sand

A 6.8 m to 13.7 m thick layer of sand to gravelly sand (including the sand and gravel interlayers in Boreholes C267-1 and C267-3 described on Section 4.2.4) was encountered below the fill in Borehole C267-1, C267-2, and C267-4 and below the organic layer in Boreholes C267-3 and C2637-5 at between Elevations 277.8 m and 275.7 m. Boreholes C267-1 and C267-3 to C267-5 were terminated within the sand deposit.

The SPT “N”-values measured within this deposit range between 2 blows to 48 blows per 0.3 m of penetrating with one “N” – value of 106 blows per 0.3 m of penetration, indicating that the deposit has a very loose to very dense compactness condition.

Grain size distribution testing was carried out on twelve samples of the deposit and the results are presented on Figure B-3 of Appendix B. The natural moisture content measured on twelve samples of the deposit ranges from 17 per cent to 24 per cent.

4.2.4 Sand and Gravel

A 1.5 m to 2.6 m thick deposit of sand and gravel was encountered interlayed within the sand deposit in Boreholes C267-1 and C267-3 and underlying the sand deposit in Borehole C267-2, at between Elevations 268.4 m and 266.6 m.

The SPT“N” values measured within the sand and gravel deposit / interlayers range between 19 blows and 31 blows per 0.3 m of penetration, indicating a compact to dense compactness condition.

A grain size distribution test was carried out on one sample of the sand and gravel deposit and the result is presented in Figure B-4 in Appendix B.

4.3 Groundwater Conditions

The unstabilized groundwater levels, relative to ground surface measured inside the casing or augers upon completion of drilling are summarized below. Groundwater and lake water levels in the area are subject to seasonal fluctuations and variations due to precipitation events. The lake water level was surveyed by AECOM's surveyors at Elevation 277.1 m in June 2019.

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
C267-1	2.3	277.8
C267-2	2.0	278.0
C267-3	1.8	278.1
C267-4	0.9	277.8
C267-5	0.1	278.5

4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a sample of native sand deposit recovered from Borehole C267-1. The soil sample was submitted to Bureau Veritas Laboratories for corrosivity testing. The analytical laboratory test results are summarized below, and the detailed analytical laboratory test report is included in Appendix B.

Borehole No.	Sample No.	Depth (m)	Parameters					
			Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Sulphate (SO4) Content (µg/g)	Chloride (Cl) Content (µg/g)	Sulphide (µg/g)	pH
C267-1	5	3.8 – 4.4	23,000	43	<20[1]	<20[2]	<0.30[3]	7.74

Note:

1. The sulphate chloride and sulphide concentrations are below the reportable detection limits of 20 µg/g, 20 µg/g and 0.30 µg/g respectively.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Mathew Riopelle, under the overall direction of Mr. André Bom, P.Eng., an Associate of Golder. This Foundation Investigation Report was prepared by Ms. Aronne-Kay De Souza, and Mr. André Bom, P.Eng., an Associate of Golder, provided a technical review of the report. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of this report.

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PART B

FOUNDATION DESIGN REPORT

HIGHWAY 66, STA 10+172, TOWNSHIP OF MCVITTIE

CULVERT REPLACEMENT

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5210-14-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the replacement of the culvert on Highway 66 at Station 10+172, in the Township of McVittie, approximately 30 m west of the intersection with Diamond Lake Road, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface exploration. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess feasible foundation alternatives and culvert types and to design the proposed replacement culvert. The foundation investigation report, discussion and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the 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.

6.1 Proposed Culvert Alignment and Installation Options

The existing structure consists of an approximately 1.3 m wide by 1.2 m high and 22 m long double box timber culvert. The culvert south end and north end inverts are approximately Elevations 277.0 m and 276.9 m, respectively. The highway grade at the culvert location is approximately Elevation 279.9 m and the highway embankment is about 3.0 m high relative to the culvert invert at the south end, and the thickness of soil cover is about 1.8 m. The culvert extends across a causeway thus connecting Fork Lake to the north and south of Highway 66.

Based on the drawings provided by AECOM via email on July 2, 2019, and our site observations during the foundation exploration work, the existing culvert crosses the Highway 66 embankment on a perpendicular alignment. We understand from AECOM that the proposed replacement culvert will cross the highway on or near the same alignment, and the proposed culvert will consist of a twin 1.3 m high by 1.2 m wide concrete box, to be constructed at similar invert elevations as the existing culvert. Assuming a 0.3 m thick base slab, the proposed replacement culvert will be founded at about Elevations 276.7 m and 276.6 m at the culvert south end and north end, respectively. The excavation for the proposed culvert replacement will extend to at least about Elevations 276.4 m and 276.3 m to accommodate a minimum 300 mm thick bedding layer.

Replacement of the existing box culvert by trenchless methods rather than open-cut is not practical for this site due to the presence of Fork Lake on either side of the embankment thus requiring water tight cofferdams for the entry/exit shafts and due to the larger size replacement pipe required to provide similar flow capacity as the box culvert reducing the thickness of cover and fill over the culvert.

We understand from AECOM that a temporary roadway protection system is being considered for staging of the culvert replacement in open cut, and that a permanent grade raise of the roadway embankment is not required but a widening of the roadway platform may be required.

6.2 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* (CHBDC, 2014) and its *Commentary*, Highway 66, the culvert and its foundation system at Station 10+172 are expected to carry medium traffic volumes and their performance will have potential impacts on other transportation corridors; hence, the culvert foundation system is classified as having a "typical consequence level" associated with exceeding limits states design. In addition, given the typical project-specific foundation investigation carried out at this site (as presented in Part A of the report), in comparison to the degree of site understanding in Section 6.5 of *CHBDC* (2014), the level of confidence for design is considered to be a "typical degree of site and prediction model understanding." Accordingly, the appropriate corresponding ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, Ψ, and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the *CHBDC* have been used for design, as applicable.

6.3 Assessment of Alternative Culvert Types

Based on a review of alternative culvert types constructed by open-cut methods, a concrete box culvert is considered most suitable as the replacement structure at this site. The required culvert is considered generally too small for construction as an open footing culvert, which would also require deeper excavations in a high groundwater/lake water level condition. A pipe culvert alternative to a box culvert, assuming a similar/equivalent size opening for water convergence as the existing culvert (i.e., two sections approximately 2 m diameter) is considered feasible but the soil cover thickness would be reduced to about 1 m in the event that a pipe culvert is more appropriate, given other considerations beyond foundation/geotechnical aspects, recommendations for the foundation/geotechnical design for a box culvert as well as for a pipe culvert are provided below.

6.4 Box Culvert Foundations

6.4.1 Founding Level

As discussed in Section 6.1, assuming a 0.3 m thick base slab, the proposed replacement box culvert will be founded at about Elevations 276.7 m and 276.6 m (end invert levels) on a minimum 300 mm thick Granular B Type II bedding layer partly over the native very loose to loose sand to gravelly sand deposit and partly on the existing embankment sand fill which overlies the native sand to gravely sand deposit.

It is not necessary to found a pre-cast box culvert at or below the depth of frost penetration for frost protection purposes, as pre-cast box structures are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur.

Prior to placement of the box culvert, any topsoil, unsuitable fill or deleterious material must be removed. Foundation excavation and backfill should be in accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts). Where any sub-excavation is required, the sub-excavated areas should be backfilled with granular material meeting OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type II, placed and compacted, in accordance with OPSS.PROV 501 (*Compacting*), as amended by SP 105S22. In wet conditions, it is recommended that Granular 'B' Type II be used as sub-excavation backfill and bedding. Based on the subsurface conditions encountered in the boreholes, the existing fill material up to the underside of the bedding layer may remain in place; however, the subgrade should be reviewed by a Foundations Specialist following excavation and prior to bedding placement to confirm the subgrade is suitable.

6.4.2 Geotechnical Resistances

The twin 1.3 m wide sections box culvert placed on a minimum 300 mm thick bedding layer the over properly prepared subgrade, at the proposed founding elevations noted above, should be designed based on a factored ultimate geotechnical resistance of 200 kPa and a factored serviceability geotechnical resistance (for 25 mm of settlement) of 100 kPa.

The factored geotechnical resistances and corresponding settlement are dependent on the culvert base width, depth of embedment, configuration, and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected culvert width or founding elevation differ from those given above. In addition, these geotechnical resistances are provided for loads applied perpendicular to the base surface of the culvert; where applicable, inclination of the load should be taken into account in accordance with Section 6.10.4 and Section C6.10.4 of CHBDC (2014) and its Commentary.

6.4.3 Resistance to Lateral Load/Sliding Resistance

Resistance to lateral forces/sliding between the pre-cast concrete box culvert and the subgrade should be calculated in accordance with Section 6.10.5 of the CHBDC (2014) applying the appropriate consequence and degree of site understanding factors as noted in Section 6.2. For a precast concrete box culvert founded on a compacted Granular ‘A’ or Granular ‘B’ Type II bedding layer, the sliding resistance may be calculated based on an unfactored coefficient of friction, tan δ = 0.5, as interpreted from NAVFAC (1982).

6.5 Lateral Earth Pressures for Design

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

The following recommendations are made concerning the design of the culvert walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (*Materials Specification for Aggregates*) Granular ‘A’ or Granular ‘B’ Type II, should be used as backfill behind the culvert walls and on top of the culvert as per OPSD 803.010 (*Backfill and Cover for Concrete Culverts).* Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*), as amended by SP 105S22.
- 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 CHBDC (2014) Section 6.12.3 and Figure 6.6. Hand-operated compaction equipment should be used to compact the backfill soils, immediately behind the walls as per OPSS.PROV 501, as amended by SP 105S22. Other surcharge loadings should be accounted for in the design, as required.

- For restrained walls in box culvert design, granular fill should be placed in a zone with the width equal to at least 2.3 m behind the back of the wall (equivalent width to the depth of frost penetration as interpreted from OPSD 3090.100 *Foundation Frost Penetration Depth for Northern Ontario*) in accordance with Figure C6.20(a) of the *Commentary* to the *CHBDC 2014*. The pressures acting on the culvert walls/wingwalls-headwalls are based on the adjacent embankment fill material and the following parameters (unfactored) may be used:

Fill Type	Soil Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Sand	20 kN/m^3	0.50	0.33

If the culvert structure does not allow lateral yielding, at-rest earth pressures should be assumed for the foundation design. If the culvert structure allows for lateral yielding, active earth pressures should be used in the foundation design. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the Commentary to the CHBDC (2014).

6.6 Embankment Settlement and Stability

Provided the existing / proposed reconstructed embankment is not widened or raised during or following culvert replacement, stability or settlement of the foundation soils beneath the culvert is not anticipated to be a concern.

6.7 Box Culvert Construction by Open Cut Excavation

6.7.1 Bedding / Embedment and Cover

It is not necessary to found a box culvert below the depth of frost penetration, as pipe culverts are generally tolerant of small magnitudes of movement related to freeze-thaw cycles. Box culvert bedding and cover should be placed in accordance with OPSD 803.010 (*Backfill and Cover for Concrete Culverts*) and OPSS 422 (*Precast Reinforced Concrete Box Culverts*). The levelling pad could consist of OPSS.PROV 1010 Granular ‘A’ or OPSS.PROV 1002 concrete fine aggregate.

All unsuitable, deleterious, organic materials and fill materials are to be removed from the base/below the culvert (and bedding) footprint along its entire alignment. Based on the foundation exploration and existing/proposed culvert invert levels, the subgrade under the replacement culvert will consist of native very loose to loose sand to gravelly sand deposit and competent sand fill and is considered suitable for support of the bedding materials and culvert; the subgrade should be reviewed by the Foundation Specialist prior to bedding placement to confirm it has been suitably prepared for bedding.

It is recommended that a minimum 300 mm thick layer of OPSS.PROV 1010 (*Aggregates*) Granular ‘A’ or Granular ‘B’ Type II material be used for bedding and cover purposes. Depending on the success of the contractor’s groundwater control methods, and the quality of the bearing stratum exposed at the base of the excavation, a thicker bedding layer may be required if wet and softened soil conditions, unsuitable fill, or organic material are present at the base of the excavation.

All bedding, embedment and cover materials should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*), as amended by Special Provision (SP) 105S22.

A Class II non-woven geotextile (as per OPSS.PROV 1860 (Geotextiles) with a filtration opening size (FOS) smaller than 212 µm) should be installed between the bedding and the subgrade soil.

6.7.2 Trench Backfill

The excavated embankment fill materials from the culvert site will likely be comprised of sand and gravel fill to sand fill as encountered in the boreholes but may vary in quality and composition. This material may be used as trench backfill over the culvert granular cover provided it is free of organic and deleterious materials.

Granular material which meets the requirements of OPSS.PROV 1010 (Aggregates) Select Subgrade Material (SSM) or Granular 'B' Type I may be used as trench backfill.

The trench backfill materials should also be placed and compacted in accordance with OPSS.PROV 501 (Compacting), as amended by SP 105S22.

6.8 Circular Pipe Culvert Installation by Open Cut Excavation

6.8.1 Bedding / Embedment and Cover

Pipe culverts (less than 3 m diameter) should be designed in general accordance with the MTO Gravity Pipe Design Guidelines (2014). It is not necessary to found a pipe culvert below the depth of frost penetration, as pipe culverts are generally tolerant of small magnitudes of movement related to freeze-thaw cycles.

A circular concrete pipe culvert installed by open cut method should be completed in accordance with Ontario OPSD 802.031 (*Rigid Pipe Bedding, Cover and Backfill)*. If the replacement culvert is to consist of a corrugated steel pipe (CSP) or plastic (HDPE or PVC) pipe installed by open cut method, it should be constructed in accordance with OPSD 802.010 (*Flexible Pipe Embedment and Backfill*) for Type 3 soil.

All unsuitable, deleterious, organic materials, and fill materials are to be removed from the base/below the pipe culvert (and bedding) footprint along its entire alignment. Based on the foundation exploration and existing/proposed culvert invert levels, the subgrade under the replacement culvert will consist of very loose to loose sand and is considered suitable for support of the culvert and bedding materials. The bedding layer should be at least 300 mm thick under rigid pipe, and 500 mm under flexible pipe. The bedding shall be compatible with the type / class of pipe material, the surrounding subsoil and anticipated loading conditions, and should consist of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II material. Depending on the success of the contractor's groundwater control methods, and the quality of the bearing stratum exposed at the base of the excavation, a thicker bedding layer may be required if wet and softened soil conditions, unsuitable fill, or organic material are present at the base of the excavation.

From the top of the bedding to 300 mm above the top of the culvert, Granular 'A' should be used as cover around the culvert. All bedding, embedment and cover materials should be placed, and culvert construction carried out in accordance with OPSS.PROV 421 (*Pipe Culvert Installation in Open Cut*) and OPSS.PROV 401 (*Trenching, Backfilling and Compacting*), and the bedding/embedment/cover soil should be compacted in accordance with OPSS.PROV 501 (*Compacting*), as amended by SP 105S22. If the bottom of the excavation is wet and dewatering is not satisfactorily maintaining the water level sufficiently below the base of the excavation to allow compaction, it is recommended that OPSS.PROV 1010 (*Aggregates*) Granular ‘B’ Type II material be used as additional sub-excavation backfill below the bedding, as may be required. In wet subgrade conditions, Granular ‘B’ Type II should be used for bedding.

A geotextile (i.e., filter cloth) should be installed between the bedding and the subgrade soil.

6.8.2 Trench Backfill

The excavated embankment fill materials from the culvert will likely be comprised of sand and gravel fill to sand fill, as encountered in the boreholes but may vary in quality and composition. This material may be reused as backfill over the culvert granular cover, provided it is free of organic and deleterious materials, for reconstruction of the highway embankment.

Granular material which meets the requirements of OPSS.PROV 1010 (Aggregates) Select Subgrade Material (SSM) or Granular ‘B’ Type I may be used as trench backfill.

The trench backfill materials should also be placed and compacted in accordance with OPSS.PROV 501 (Compacting), as amended by SP 105S22.

6.9 Analytical Testing of Existing Soil

The results of analytical tests on one sample of the native sand deposit recovered from Borehole C267-1 is summarized in Section 4.4. The potential for sulphate attack and corrosion are discussed in the following paragraphs; 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. The culvert should be designed with consideration given to Table 7.1 of the MTO Gravity Pipe Design Guidelines (2014).

6.9.1 Potential for Sulphate Attack

The analytical test results were compared to CSA A23.1-14 Table 3 ("Additional requirements for concrete subjected to sulphate attack”) for the potential sulphate attack on concrete. The water soluble-sulphate concentration measured in the soil sample is less than the reportable detection limit of 0.002 per cent, 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). Therefore, based on the test result for the sample, when the designer is selecting the exposure class for the culvert/structure, the effects of sulphates from within the near surface/culvert invert native soil(s) may not need to be considered. However, as the culvert will extend under the roadway shoulders and be exposed to de-icing salt, concrete should be designed for a “C” type exposure class as defined by CSA A23.1-14 Table 1.

6.9.2 Potential for Corrosion

The soil has a pH of 7.7 and according to the MTO Gravity Pipe Design Guidelines (2014), the pH is not considered detrimental to culvert durability. The resistivity is 23,000 ohm-cm, which indicates that the soil corrosiveness potential is very low (10,000>R>6,000 ohm-cm), as per Table 3.2 of the MTO Gravity Pipe Design

Guidelines (2014). It is also noted that sulphide is considered very corrosive to cast iron/steel materials (Cashman and Preene, 2001), but the sulphide concentration is below the reportable detection limit of 0.30 µg/g in the analyzed test sample.

6.10 Construction Considerations

6.10.1 Open Cut Excavation

The proposed open cut excavation through the embankment and into the subgrade to the base of the culvert bedding level, associated with the removal of the existing culvert and construction of the new culvert and re-construction of the embankment, will advance through the granular embankment fill and potentially into native soils, comprised of sand to gravelly sand, and is anticipated to extend to/below the groundwater level. Where space permits for an open cut excavation into these materials, the open-cut excavation must be carried out in accordance with the guidelines outlined in the Occupation Health and Safety Act (OHSA) for Construction Activities. Above the water table, the existing fill materials are classified as Type 3 soil, according to OHSA and temporary excavations (i.e., those which are open for a relatively short time period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V). Below the water table, the existing fill materials and underlying native soils are classified as Type 4 soil, according to OHSA and temporary excavations (i.e., those which are open for a relatively short time period) into this soil type should be made with side slopes no steeper than 3 horizontal to 1 vertical (3H:1V).

Depending upon the construction procedures adopted by the contractor, groundwater seepage conditions, and weather conditions at the time of construction, some local flattening of the slopes of open-cut excavations may be required, especially in looser/softer zones or where localized seepage is encountered. Further, layering of soils and the effectiveness of the contractor's dewatering systems could affect the OHSA classification and, therefore, the classification of soils for OHSA purposes must be made at the time the excavation is open and can be directly observed during construction.

6.10.2 Groundwater / Surface Water Control

The groundwater level is expected to be above the proposed culvert founding level along most of its alignment and therefore the excavation for the culvert replacement should be expected to extend below the groundwater level. The groundwater should be lowered to at least 1 m below the base of the excavation to maintain basal stability and allow for construction in dry conditions. Groundwater may be controlled by providing an active dewatering system consisting of an adequate number of sumps and pumps installed and operated in advance/during the excavation, or in combination with temporary support systems such as a sheet piling wall and/or cofferdams (as required).

The contractor is responsible for the assessment of dewatering requirements, which depends on their chosen method of open cut excavation for replacement, as well as on the method and procedure for construction/operation/maintenance and decommissioning. The design of dewatering, unwatering, and temporary flow passage system is the responsibility of the contractor. The contractor is also responsible for confirming that the radius of groundwater drawdown does not impact the existing embankment and any surrounding features.

Active dewatering should draw down the groundwater level to not less than approximately 1 m below the base of the excavation and shall be designed/carried out in accordance with OPSS.PROV 517 (*Dewatering*), as amended by SP 517F01 (*Dewatering System/Temporary Flow Passage System*) recommending that a design engineer be required, to carry out the design of the system. The return period flow estimates in Table A of SP 517F01 (included in Appendix C) shall be filled in by the hydraulic design engineer. Given the loosening potential of the sand to gravelly sand and sand to sand and gravel subgrade at this site, the Designer Engineer fill in for Note 1 in Table A shall indicate “yes”. Given the apparent lack of infrastructure present in the vicinity of the culvert, a preconstruction survey is not considered to be required at this site and the fill in for Note 2 should be N/A. Considering that relatively minor groundwater lowering is anticipated to be required to facilitate the culvert replacement, the risk of settlement impacts on the roadway is considered to be low from a foundation perspective, so long as pumping is carried out from properly filtered sumps/well points.

It should be noted that construction water takings in excess of 50 m^3/day are regulated by the Ministry of the Environment, Construction and Parks (MECP). Takings of groundwater/stormwater for construction dewatering purposes with a combined total less than 400 m^3/day, qualify for self-registration on the MECP’s Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a PTTW for water taking less than 400 m^3/day and a Section 53 approval for discharge to the environment; however, a “Water Taking Plan” and a “Discharge Plan” are required by the MECP if water is taken in accordance with an EASR. If construction water taking will be required at this site, the construction water taking permit and registration under the AESR should be prepared by the Contractor adequality in advance of site excavation work, so as not to unduly affect the construction schedule.

Surface water should be directed away from open excavation areas to prevent ponding of water that could result in disturbance and weakening of the subgrade and/or affect constructions. Depending on the water flow through the watercourse at the time of construction and staging/diversion requirements/limitations, temporary cofferdams may also be required.

6.10.3 Temporary Protection/Dewatering Systems

A temporary protection system will likely be required across the culvert alignment in order to allow one lane of live traffic to pass during culvert replacement/construction operations. The temporary excavation protection and support systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*) as amended by SP 105S09. The lateral movement of the protection systems shall meet Performance Level 2 as specified in OPSS.PROV 539, provided that any utilities, if present, can tolerate this magnitude of deformation.

It is anticipated that a driven interlocking steel sheet pile system is suitable at this site. The contractor may alternatively use a soldier pile and lagging system; however, the site would need to be adequately dewatered prior to installation of the lagging boards as the cohesionless fills and saturated sand deposit will not have adequate stand-up time to permit installation of the lagging boards.

The sheet piles or soldier piles will need to extend to a sufficient depth to provide the necessary passive resistance for the retained soil height, plus any surcharge loads behind the protection system. Lateral support to the sheet pile wall or soldier pile wall could be provided in the form of struts, rakers, or temporary anchors, if/and as required to carry out the design of the system.

The installation of temporary protection systems should be monitored to ensure that vibration levels produced by such construction activity are within tolerable limits and in consultation with the infrastructure/utility and property owners within the zone of influence of the site.

Vibratory equipment for the installation of temporary protection systems may be used at this site. The installation of temporary protection systems by vibratory equipment should be monitored to ensure the vibration levels produced by such construction activity are within tolerable limits and in consultation with the infrastructure/utility and property owners within the zone of influence of the site if such infrastructure or present nearby (i.e., within 100 m).

While the selection and design of the temporary protection system will be the responsibility of the contractor, the following information is provided to MTO and its designers to aid in the assessment of feasible alternatives:

Stratigraphic Unit	Bulk Unit Weight, γ (kN/m^3)	Angle of Internal Friction, φ (degrees)	Undrained Shear Strength, s_u (kPa)	Lateral Earth Pressure Coefficients[1/2]		
				Active, K_a	At-rest, K_o	Passive, K_p[3]
Existing Embankment Fill – Very loose to very dense sand and gravel to sandy gravel	20	31	-	0.32	0.48	3.12
Organic silt / Organic sand	17	28	-	0.36	0.53	2.77
Very loose to very dense sand to gravelly sand/ compact to dense sand and gravel	20	31	-	0.32	0.48	3.12

Notes:
1. The design groundwater level may be assumed to be Elevation 278 m, based on the water levels in the boreholes.
2. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected, the coefficients should be corrected accordingly.
3. The total passive resistance below the base of the excavation (i.e., 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 C6.16 of the CHBDC (2014) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

It is recommended that the ground surface extending back/upwards from the top of the protection system to the existing Highway 66 surface be graded to an inclination no steeper than 2H:1V at this site. This should be shown on the Contract staging drawings.

The loading from construction equipment as well as any material stockpiles within a distance defined by a 1 horizontal to 1 vertical line drawn from the bottom of the excavation to the existing ground surface should be included as a surcharge in the design of the temporary protection system.

Consideration could be given to either partial or full removal of the temporary protection system upon completion of construction or each stage of construction (as required). Vibration and noise controls during extraction of any temporary systems should meet the same tolerable limits used for installation.

6.10.4 Subgrade Protection

For open-cut culvert installation, the subgrade soils at the base of the excavation will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that the granular bedding layer be placed immediately after preparation and approval of the subgrade.

6.10.5 Embankment Reconstruction

Engineered fill for reconstruction of the embankment after open-cut culvert replacement above the culvert granular cover should consist of OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type I or SSM material, but may also comprised of the sand to sand and gravel excavated embankment fill. The embankment back fill should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*), as amended by SP 105S22, and OPSS.PROV 206 (*Grading*). Embankment side slopes should be constructed no steeper than 2H:1V in granular fill.

6.10.6 Surficial Embankment Stability and Erosion Protection

Depending on the selected embankment reconstruction fill material used, slope geometry, surface treatment and weather conditions (i.e., precipitation, cycles of wetting-drying, and/or freezing-thawing), surficial instability of the embankment side slopes may occur, which could include localized sloughing and erosion. As such, in order to maintain the integrity of the reconstructed new embankment sections, erosion protection measures may be required.

Based on the material types and hence the gradation envelope for embankment reconstruction materials as recommended in Section 6.10.5, granular fill such as OPSS.PROV 1010 (*Aggregates*) Granular 'A', or Granular 'B' Type I, have a low potential for erosion. For embankments constructed of granular fill, erosion control may be limited to seeding following the construction specifications of OPSS 802 (*Topsoil*) and OPSS.PROV 804 (*Seed and Cover*). On-going maintenance for embankments constructed of this material is not expected to be required once the vegetation has been established.

The specification for OPSS.PROV 1010 (*Aggregates*) SSM allows for much more variation in the gradation of the material compared to Granular 'A', or Granular 'B' Type I, and therefore has the potential to be low - erodible to moderate - erodible. Erosion protection for slopes constructed of SSM should consist of erosion control blankets and seeding. Slopes constructed of SSM and properly protected from erosion should require limited on-going maintenance.

7.0 CLOSURE

This foundation design report was prepared by Mr. Tibor Berecz, a geotechnical EIT with Golder, and the technical aspects were reviewed by Mr. André Bom, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant with Golder conducted an independent and quality control review of the report.

Signature Page

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https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2. reporting/r14 - mcv 267/3. final/1896349-r14 r-rev0 aecom culvert mcv 267 hwy 66 27feb_2020.docx

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Canadian Standards Association (CSA), 2014. CSA A23.1-14 Concrete Materials and Methods of Construction (R2014).

Cashman, P.M. and Preene M. (2001) Groundwater Lowering in Construction, A Practical Guide. Spoon Press Publisher.

Ministry of Transportation, Ontario, MTO Gravity Pipe Design Guidelines, April 2014.

Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41PNE.

Ontario Ministry of Northern Development and Mines. Bedrock Geology of Ontario, East-Central Sheet. Map 2543.

Ontario Regulation 903 (Wells).

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

Unified Facilities Criteria, U.S. Navy 1982. NAVFAC DM-7.02

ASTM International:

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

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 802.010	Flexible Pipe Embedment and Backfill, Earth Excavation
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario
OPSD 802.031	Rigid Pipe Bedding, Cover, and Backfill, Type 3 Soil – Earth Excavation

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS.PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS.PROV 422	Construction Specification for Precast Reinforced Concrete Box Culvert in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1002	Material Specification for Aggregates – Concrete
OPSS.PROV 1860	Material Specification for Geotextiles

Special Provisions

SP 105S22	Amendment to OPSS 501
SP 105S09	Amendment to OPSS 539

Table 1: Culvert Replacement Alternative Types and Installation Methods – Station 10+172 Township of McVittie

Replacement Alternatives	Advantages	Disadvantages	Risks / Consequences
Trenchless Installation	▪ Pipe ramming without significant removal of soils prior to full casing penetration through embankment would likely be suitable. ▪ Relatively low cost for pipe ramming. ▪ Relatively small site operations footprint. ▪ Within size range typical in Ontario. ▪ Less traffic disruptions than open cut methods. ▪ Various potential trenchless installation methods available, although most would not be suitable/feasible for this site.	▪ Adjacent water body will require water-tight cofferdam and may preclude construction of exit shaft and the use of a trenchless installation. ▪ Site conditions and pipe/casing size potentially preclude installation by HDD, TBM, PTMT, and TBM methods as well as Jack and Bore; likely restricted to Pipe Ramming. ▪ Combination of final pipe (casing) diameter, and length of installation may be near the upper limit of feasibility for a pipe installation. ▪ Vibrations from pipe driving can lead to densification and settlement of loose granular materials surrounding and overlying the casing/pipe and result in settlement of roadway surface. ▪ Limited soil cover (less than 1 m thickness) over the casing if used, or culvert pipe, is inadequate for a trenchless installation.	▪ Need for removal of soil from within casings because of driving resistance (binding of casings, weight of spoil, obstructions) could lead to excess ground losses and surface settlement. ▪ Nominal cover thickness results in high-risk trenchless crossing. ▪ Subsurface soil conditions are suitable for a trenchless installation but limited/inadequate soil cover (thickness or ratio to culvert diameter) potentially leading to loss of soil, road heave and/or settlement.

Replacement Alternatives	Advantages	Disadvantages	Risks / Consequences
Cut and Cover (Pipe or Box Type Culvert)	■ Risks of ground losses affecting traffic are better controlled than for trenchless methods. ■ Depth of excavation is well within typical limits for conventional excavation support, slopes and dewatering systems. ■ Can accommodate a culvert of various sizes or twin sections to provide the required flow capacity. ■ Box type culvert can be made adequately large, or twined, to accommodate required flow capacity.	■ Traffic disruption (staging of crossing construction). ■ Roadway protection required for staged excavation. ■ Proactive dewatering required (e.g., vacuum well points). ■ A larger diameter pipe type culvert (CSP/Concrete/HDPE) of adequate size to accommodate the required flow would result in reduced cover thickness likely inadequate for a roadway embankment.	■ Traffic staging problems (e.g., temporary concrete barriers, seasonal construction). ■ Dewatering planning as part of bid may not be adequate and result in real or strategic claims. ■ A pipe culvert likely not suitable at this site due to the limited (~1 m) thickness of coil cover.

MINISTRY OF TRANSPORTATION, ONTARIO

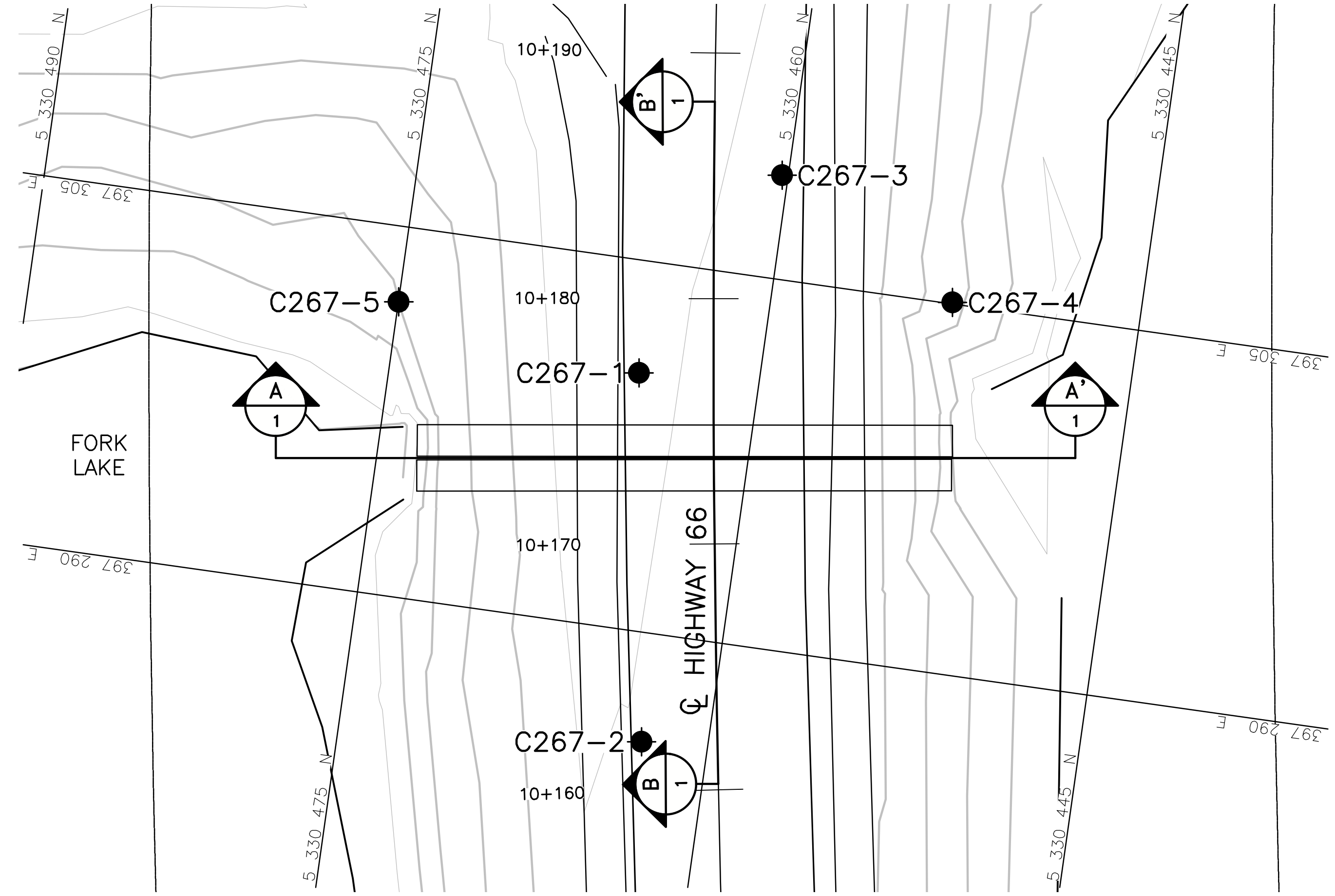
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5210-14-00

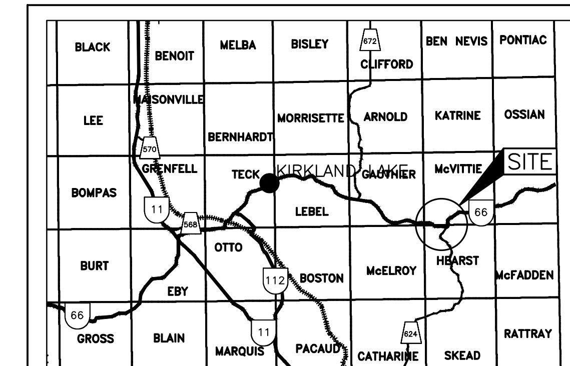
SHEET

HIGHWAY 66
STATION 10+172
TOWNSHIP OF MCVITTIE CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER



PLAN
SCALE
3 0 3 6 m



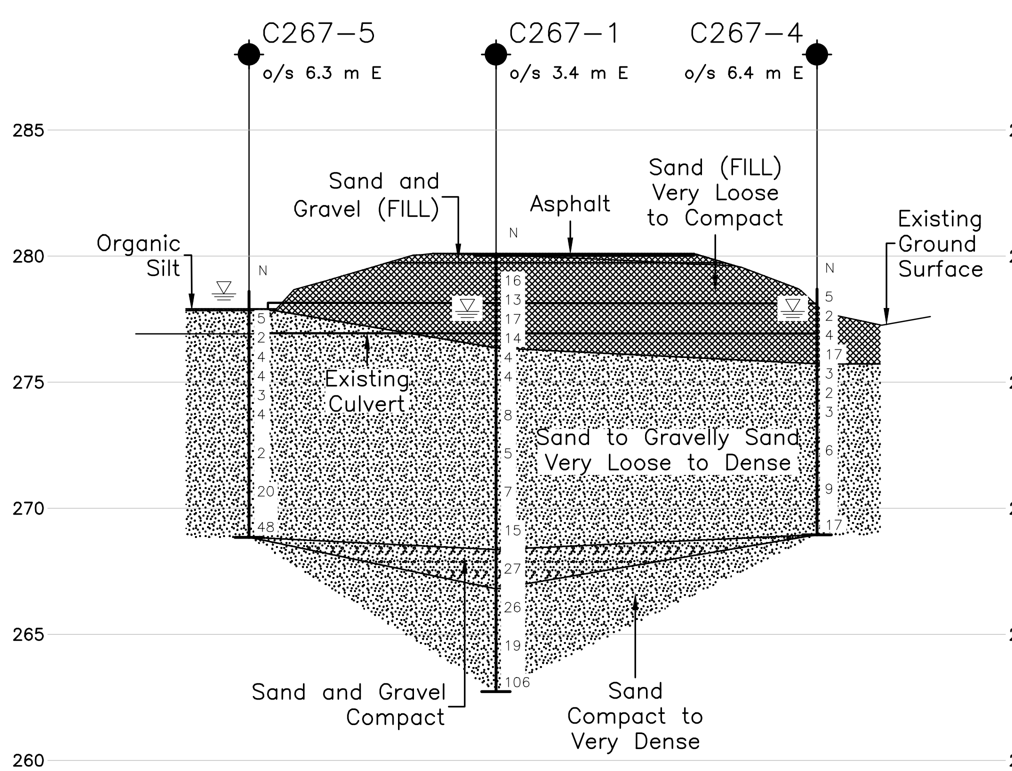
KEY PLAN
SCALE
10 0 10 20 km

LEGEND

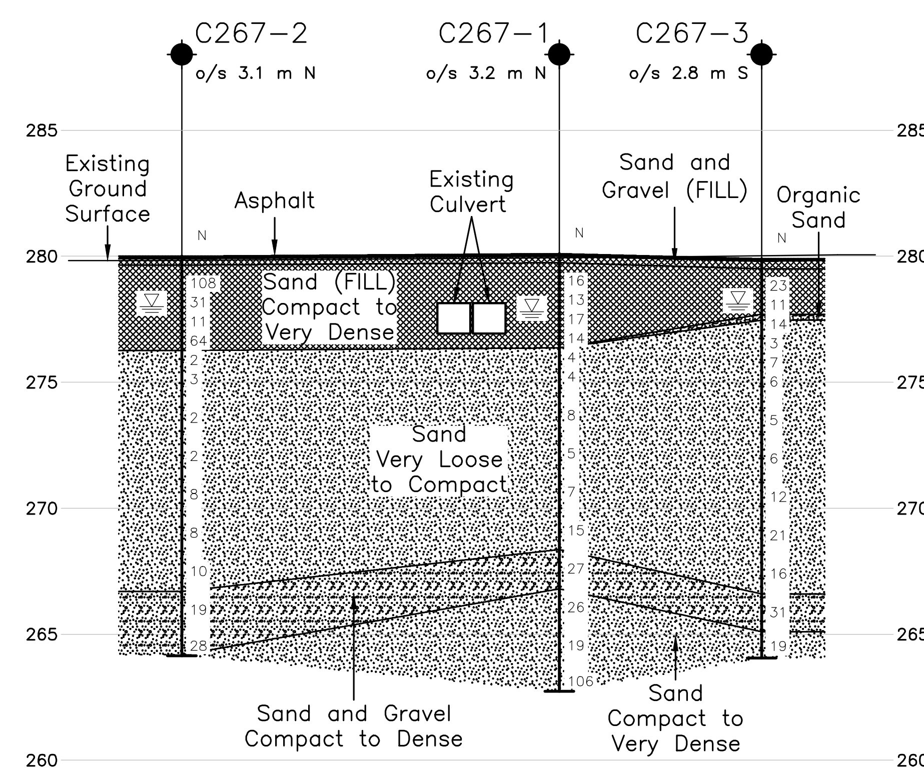
- Borehole – Current Investigation
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
C267-1	280.1	5330464.9	397300.4
C267-2	280.0	5330462.7	397285.6
C267-3	279.9	5330460.2	397309.2
C267-4	278.7	5330452.7	397305.1
C267-5	278.6	5330475.0	397301.9



A-A' 1 CULVERT CENTERLINE PROFILE
HORIZONTAL SCALE
3 0 3 6 m
3 0 3 6 m
VERTICAL SCALE



B-B' 1 HIGHWAY CENTERLINE PROFILE
HORIZONTAL SCALE
3 0 3 6 m
3 0 3 6 m
VERTICAL SCALE

NOTES

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

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

REFERENCE

Base plans provided in digital format by CALLON DIETZ LTD. drawing file no. gwp521001400c.dwg, received AUGUST 14, 2019.

NO.	DATE	BY	REVISION

Geocres No. 32D-30

HWY. 66	PROJECT NO. 1896349	DIST.
SUBM'D.	CHKD. TB	DATE: 2/18/2020	SITE:
DRAWN: TR	CHKD. AB	APPD. JMAC	DWG. 1

PLOT DATE: February 20, 2020
FILENAME: S:\Clients\MTO\Hwy65&66\99_PROJ\1896349_AECOM_Hwy65-66-566\40_PROD\0014_R14_MCV267\1896349-0014-BG-0001.dwg

Photograph 1: East Approach at Culvert Location, Facing West (May 2019)

Photograph 2: Embankment South Slope at Culvert Location, Facing west (May 2019)

Photograph 3: Embankment North Slope (October 2018)

Photograph 4: Internal View of Culvert facing south (October 2018)

APPENDIX A

Record of Boreholes

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	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
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

3. 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.
4. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

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

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

Field Moisture Condition

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

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
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	$(\sigma_1 - \sigma_3)/2$ 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

RECORD OF BOREHOLE No C267-1

 METRIC

PROJECT 1896349

G.W.P. 5210-14-00

DIST ___ HWY 66

DATUM GEODETIC

LOCATION N 5330464.9; E 397300.4 NAD83 MTM ZONE 12 (LAT. 48.106347; LONG. -79.757784)

BOREHOLE TYPE 76 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring

DATE May 4, 2019

ORIGINATED BY MR

COMPILED BY TR

CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
280.1	GROUND SURFACE									
0.0	ASPHALT (100 mm)									
279.7 / 0.4	Sand and gravel (FILL) Asphalt coated particles from 0.16 m to 0.23 m depth									
	Sand, trace gravel, trace silt (FILL) Compact Brown to grey Moist to wet	1	SS	16						
		2	SS	13						
					∇ (approx. El. 277.9)					
	- Several gravel sizes in Sample 3	3	SS	17						
		4	SS	14		~20	1	95	(4)	
276.4 / 3.7	SAND, trace gravel, trace silt Very loose to compact Grey/brown Wet	5	SS	4						
		6	SS	4		~23	0	95	5	0
		7	SS	8						
		8	SS	5						
		9	SS	7		~20	0	99	(1)	
		10	SS	15						
268.4 / 11.7	SAND and GRAVEL									

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No C267-1

 METRIC

PROJECT 1896349
G.W.P. 5210-14-00
LOCATION N 5330464.9; E 397300.4 NAD83 MTM ZONE 12 (LAT. 48.106347; LONG. -79.757784)
ORIGINATED BY MR
DIST HWY 66
BOREHOLE TYPE 76 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring
COMPILED BY TR
DATUM GEODETIC
DATE May 4, 2019
CHECKED BY AB

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	SAND and GRAVEL Compact Grey/brown Wet	11	SS	27	268						
266.8 13.3	SAND, trace gravel, trace silt Compact to very dense Grey/brown Wet	12	SS	26	267, 266						
		13	SS	19	265	o (~18)		4	93	(3)	
		14	SS	106	264, 263						
262.7 17.4	END OF BOREHOLE NOTE: 1. Water level at a depth of 2.3 m below ground surface (Elev. 277.8 m) upon completion of drilling.										

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; 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; REMARKS & GRAIN SIZE DISTRIBUTION (%).

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

RECORD OF BOREHOLE No C267-2

METRIC

PROJECT 1896349

G.W.P. 5210-14-00

DIST ______ HWY 66

DATUM GEODETIC

LOCATION N 5330462.7; E 397285.6 NAD83 MTM ZONE 12 (LAT. 48.106329; LONG. -79.757983)

BOREHOLE TYPE 76 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring

DATE May 4, 2019

ORIGINATED BY MR

COMPILED BY TR

CHECKED BY AB

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
280.0	GROUND SURFACE								
0.0	ASPHALT (100 mm)								
279.6 / 0.4	Sand and gravel (FILL) Asphalt coated particles from 0.12 m to 0.20 m depth								
	Sand, trace to some gravel, trace asphalt (FILL) Compact to very dense Brown Frozen to wet	1	SS	108					
		2	SS	31	∇				
		3	SS	11					
277.0 / 3.0	Sandy gravel (FILL) Very dense Brown Wet	4	SS	64					
276.3 / 3.7	SAND, trace gravel, trace silt Very loose to loose Grey/brown Wet	5	SS	2		4	93	(3)	
		6	SS	3					
		7	SS	2		0	96	(4)	
		8	SS	2					
		9	SS	8					
		10	SS	8		0	98	(2)	

Elevation scale: 279, 278, 277, 276, 275, 274, 273, 272, 271, 270, 269

Column headings: 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

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No C267-2

 METRIC

PROJECT 1896349

G.W.P. 5210-14-00

LOCATION N 5330462.7; E 397285.6 NAD83 MTM ZONE 12 (LAT. 48.106329; LONG. -79.757983)

ORIGINATED BY MR

DIST HWY 66

BOREHOLE TYPE 76 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring

COMPILED BY TR

DATUM GEODETIC

DATE May 4, 2019

CHECKED BY AB

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED)	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
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND, trace gravel, trace silt Very loose to loose Grey/brown Wet		11	SS	10						
							267				
266.7 13.3	SAND and GRAVEL Compact Grey/brown Wet										
			12	SS	19		266		○		46 52 (2)
							265				
			13	SS	28						
264.1 15.9	END OF BOREHOLE NOTE: 1. Water level at a depth of 2.0 m below ground surface (Elev. 278.0 m) upon completion of drilling.										

SUD-MTO 001 S:\CLIENTS\MTO\HWY65&66\02_DATA\GINT\1896349.GPJ GAL-MISS.GDT 19-12-11 TR

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

GOLDER

RECORD OF BOREHOLE No C267-3

 METRIC

PROJECT 1896349

G.W.P. 5210-14-00

DIST HWY 66

DATUM GEODETIC

LOCATION N 5330460.2; E 397309.2 NAD83 MTM ZONE 12 (LAT. 48.106303; LONG. -79.757667)

BOREHOLE TYPE 76 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring

DATE May 5, 2019

ORIGINATED BY MR

COMPILED BY TR

CHECKED BY AB

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
279.9	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
	Sand and gravel (FILL)										
279.5 0.4	Asphalt coated particles from 0.16 m to 0.28 m depth										
	Sand, some gravel (FILL) Compact Brown Moist to wet	1	SS	23							
		2	SS	11	∇ (approx. 278.1)						
277.7	Organic SAND, some gravel, some silt Dark brown Frozen	3 A / 3 B	SS	14		≈23	OC=5.9%	20	66	(14)	
277.5 2.4	SAND, trace gravel, trace silt Very loose to compact Grey/brown Wet	4	SS	3							
		5	SS	7							
		6	SS	6		≈20		2	96	(2)	
		7	SS	5							
		8	SS	6							
		9	SS	12		≈20		0	94	(6)	
		10	SS	21							

Elevation scale: 279, 278, 277, 276, 275, 274, 273, 272, 271, 270, 269, 268

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No C267-3

 METRIC

PROJECT 1896349

G.W.P. 5210-14-00

LOCATION N 5330460.2; E 397309.2 NAD83 MTM ZONE 12 (LAT. 48.106303; LONG. -79.757667)

ORIGINATED BY MR

DIST HWY 66

BOREHOLE TYPE 76 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring

COMPILED BY TR

DATUM GEODETIC

DATE May 5, 2019

CHECKED BY AB

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED)	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
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND, trace gravel, trace silt Very loose to compact Grey/brown Wet		11	SS	16		267				
266.6 13.3	SAND and GRAVEL Dense Grey/brown Wet		12	SS	31		266				
265.1 14.8	SAND, trace to some gravel Compact Grey/brown Wet		13	SS	19		265				
264.0 15.9	END OF BOREHOLE NOTE: 1. Water level at a depth of 1.8 m below ground surface (Elev. 278.1 m) upon completion of drilling.										

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

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

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GOLDER

RECORD OF BOREHOLE No C267-4

 METRIC

PROJECT 1896349
G.W.P. 5210-14-00
DIST ____ HWY 66
DATUM GEODETIC

LOCATION N 5330452.7; E 397305.1 NAD83 MTM ZONE 12 (LAT. 48.106236; LONG. -79.757723)
BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring
DATE May 31, 2019

ORIGINATED BY YS
COMPILED BY TR
CHECKED BY AB

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT (kN/m³)	GR	SA	SI	CL
278.7	GROUND SURFACE											
0.0	Sand, some gravel, trace rootlets, trace organics (FILL) Very loose to compact Brown Moist to wet	1	SS	5								
		2	SS	2	▽	278						
		3	SS	4		277						
		4	SS	17		276						
275.7 3.0	SAND to gravelly SAND, trace silt Very loose to compact Brown Wet	5	SS	3			○ (~20)		8	88	4	0
		6	SS	2		275						
		7	SS	3		274						
		8	SS	6		273	○ (~17)		22	75	(3)	
		9	SS	9		272, 271						
		10	SS	17		270						
268.9 9.8	END OF BOREHOLE					269						

NOTE:

1. Water level at a depth of 0.9 m below ground surface (Elev. 277.8 m) upon completion of drilling.

Legend: 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; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

GOLDER

RECORD OF BOREHOLE No C267-5

 METRIC

PROJECT 1896349
G.W.P. 5210-14-00
DIST ____ HWY 66
DATUM GEODETIC

LOCATION N 5330475.0; E 397301.9 NAD83 MTM ZONE 12 (LAT. 48.106437; LONG. -79.757761)
BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring
DATE May 15, 2019

ORIGINATED BY MR
COMPILED BY TR
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
278.6	GROUND SURFACE											
0.0	Topsoil (FILL)				∇							
278.3 / 0.3	Sand and gravel (FILL) Brown					278						
277.9 / 0.8	Organic SILT Black Wet	1	SS	5								
	SAND, trace gravel, trace silt Very loose to dense Grey/brown Wet	2	SS	2		277						
		3	SS	4		276	~20		0	99	(1)	
		4	SS	4		275						
		5	SS	3								
		6	SS	4		274						
						273						
		7	SS	2		272	~19		0	96	(4)	
						271						
		8	SS	20		270						
268.8		9	SS	48		269						
9.8	END OF BOREHOLE											

NOTE:

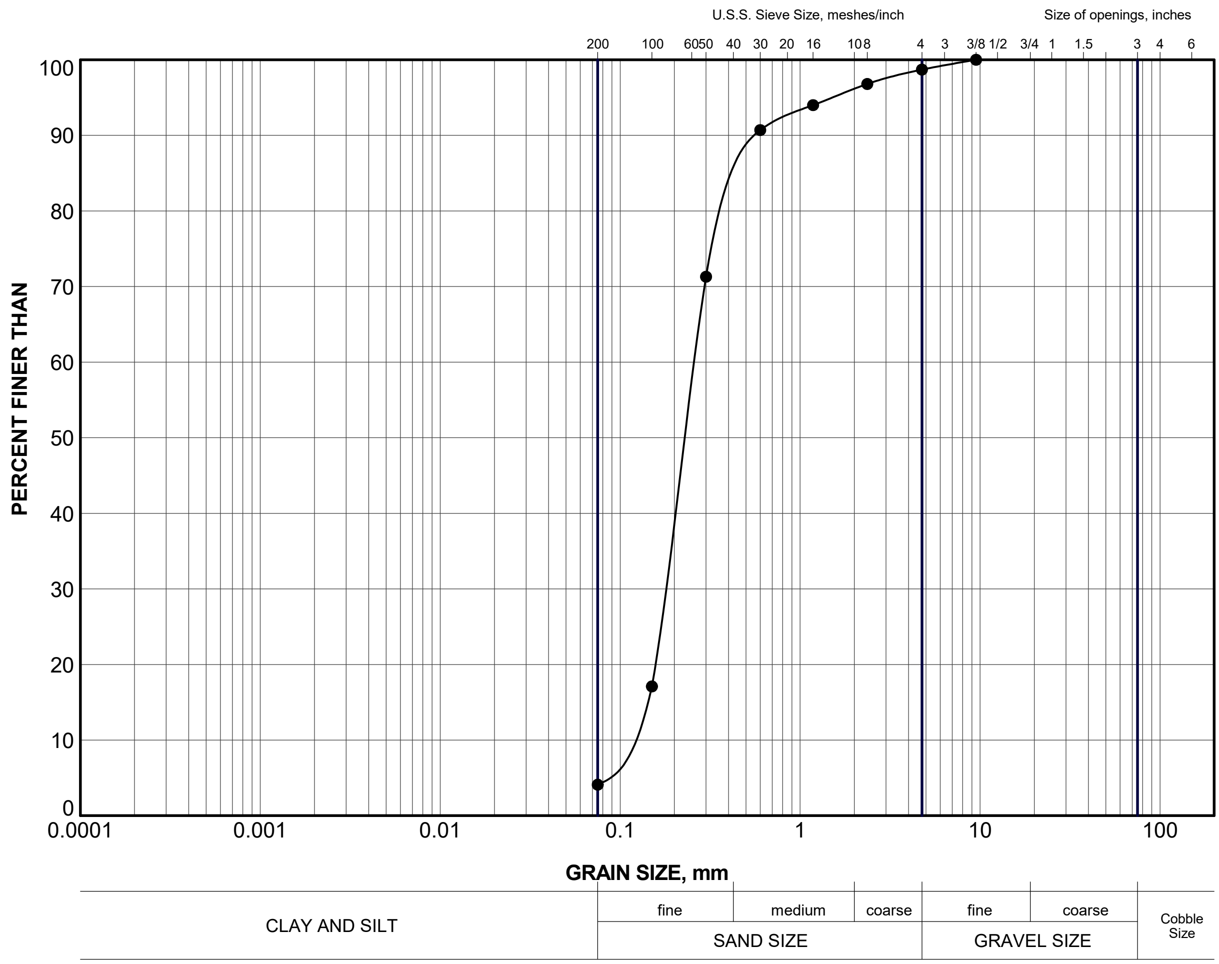
1. Water level at a depth of 0.1 m below ground surface (Elev. 278.5 m) upon completion of drilling.

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
REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

APPENDIX B

Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C267-1	4	276.8

PROJECT

HIGHWAY 66
STATION 10+172
TOWNSHIP OF MCVITTIE CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

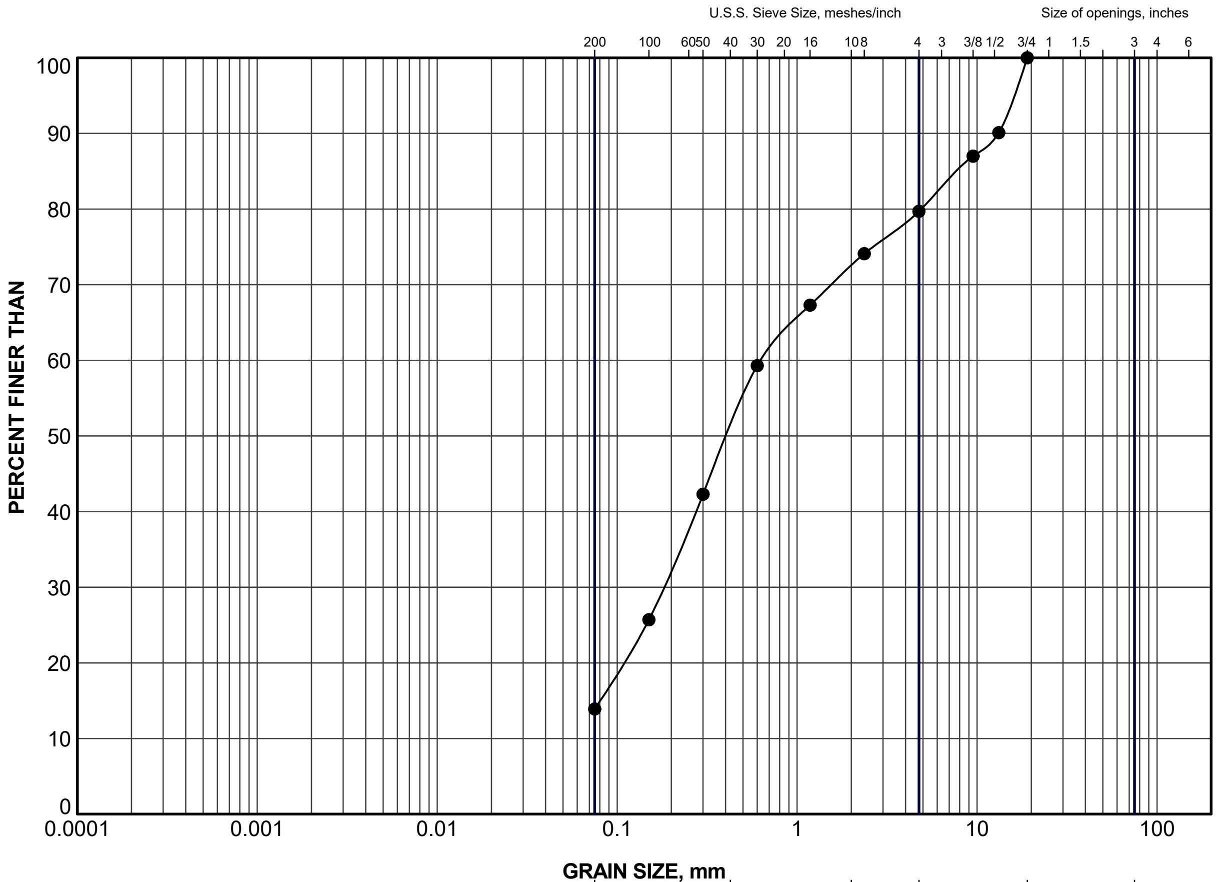
Sand (FILL)

GOLDER

SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Nov 2019	SCALE N/A	REV.
CHECK	AB	Nov 2019		
APPR	JMAC	Nov 2019	FIGURE B-1	

SUD-MTO GSD GLDR_LDN.GDT



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C267-3	3A	277.5

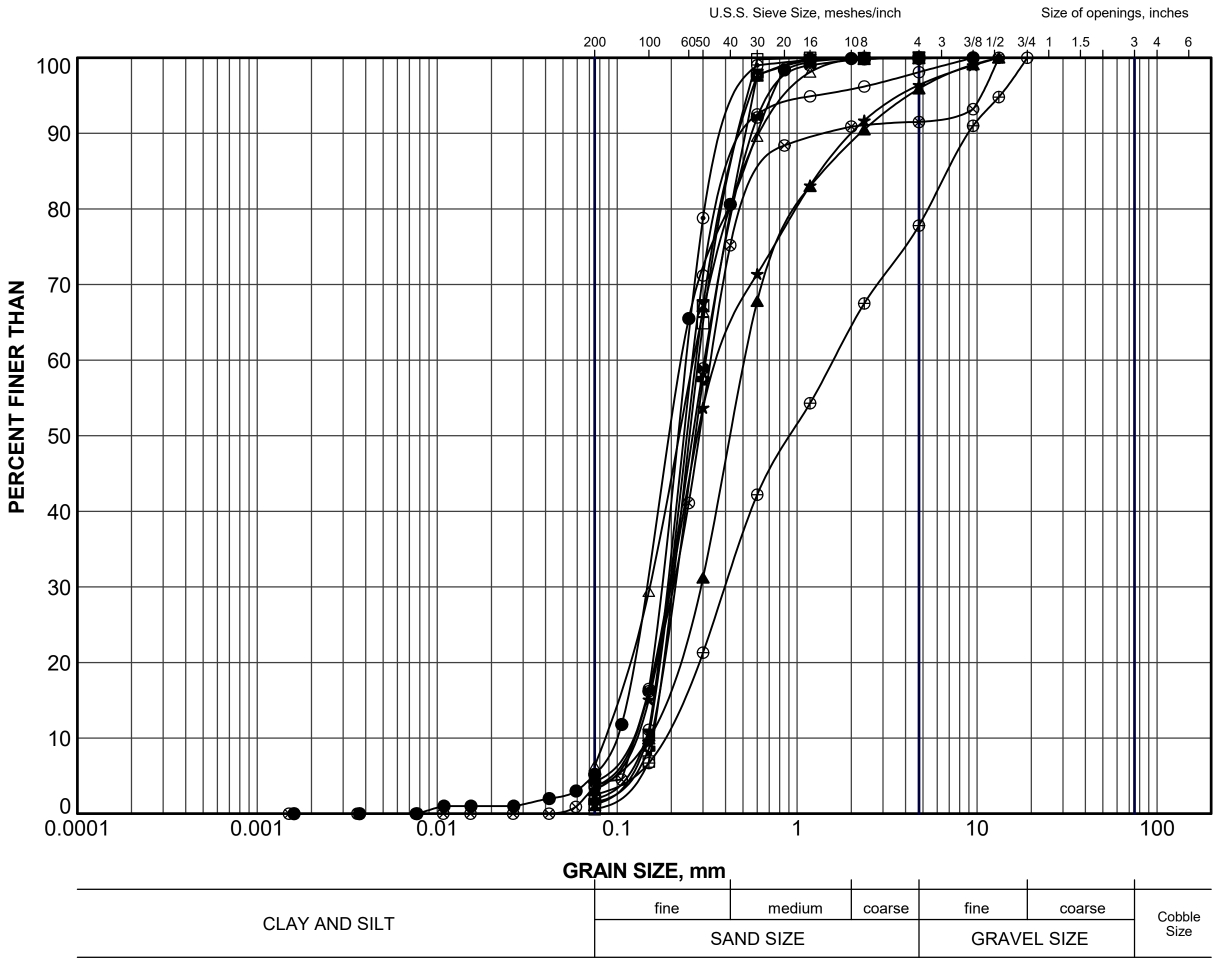
PROJECT
HIGHWAY 66
STATION 10+172
TOWNSHIP OF MCVITTIE CULVERT

TITLE
GRAIN SIZE DISTRIBUTION
ORGANIC SAND

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.	1896349.GPJ
DRAWN	TR	Dec 2019	SCALE N/A	REV.
CHECK	AB	Dec 2019		
APPR	JMAC	Dec 2019	**FIGURE B-2**	

SUD-MTO GSD GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C267-1	6	275.2
⌧	C267-1	9	270.7
▲	C267-1	13	264.6
★	C267-2	5	275.9
⊙	C267-2	7	273.6
✪	C267-2	10	269.0
○	C267-3	6	275.0
△	C267-3	9	270.5
⊗	C267-4	5	275.4
⊕	C267-4	8	272.3
□	C267-5	3	276.0
◕	C267-5	7	272.2

PROJECT

HIGHWAY 66
STATION 10+172
TOWNSHIP OF MCVITTIE CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

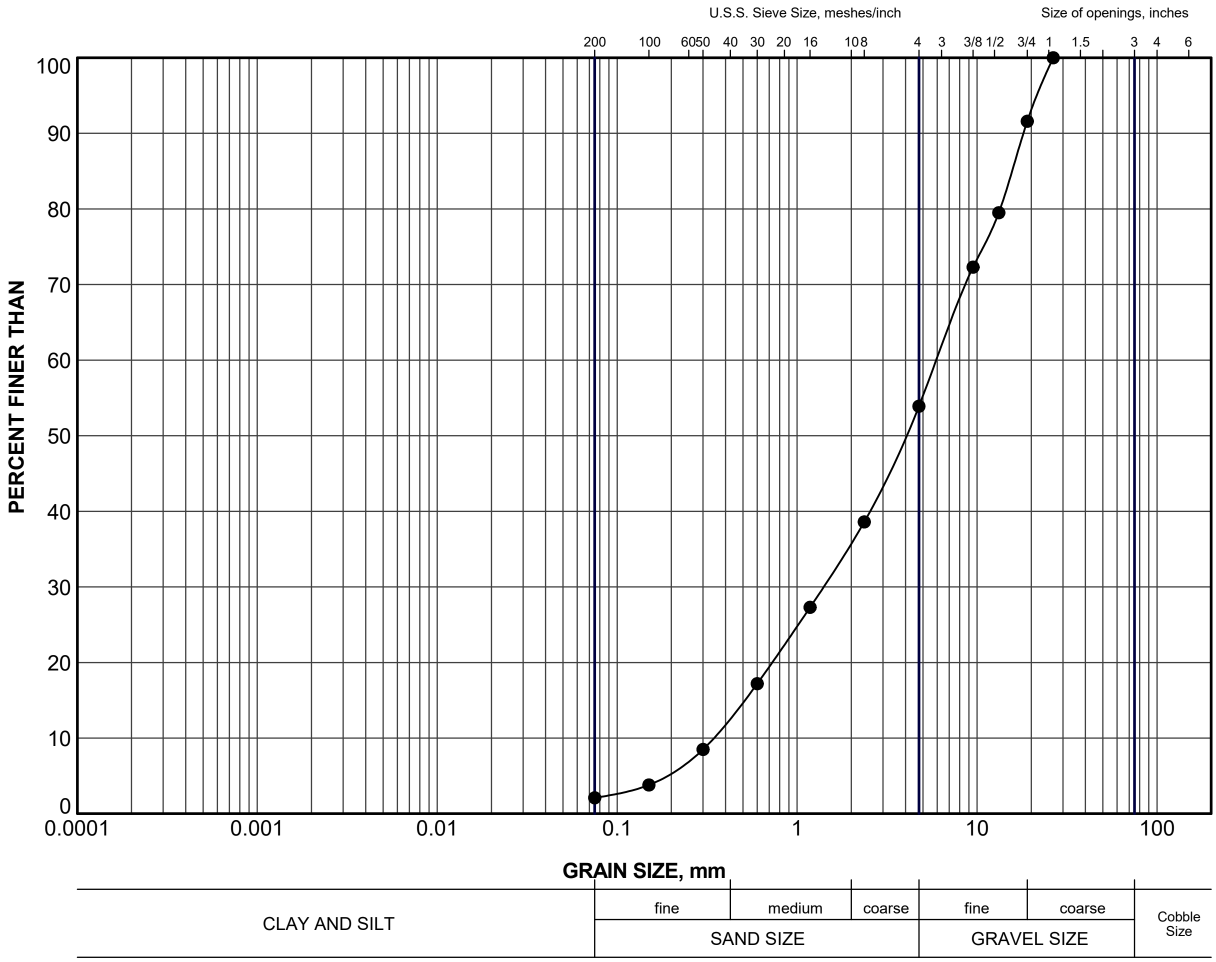
SAND to Gravelly SAND

GOLDER

SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No. 1896349.GPJ	
DRAWN	TR	Dec 2019	SCALE N/A	REV.
CHECK	AB	Dec 2019		
APPR	JMAC	Dec 2019	**FIGURE B-3**	

SUD-MTO GSD GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C267-2	12	266.0

PROJECT

HIGHWAY 66
STATION 10+172
TOWNSHIP OF MCVITTIE CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

SAND and GRAVEL

GOLDER

SUDBURY, ONTARIO

PROJECT No.		1896349
DRAWN	TR	Dec 2019
CHECK	AB	Dec 2019
APPR	JMAC	Dec 2019

FILE No. 1896349.GPJ

SCALE N/A REV.

FIGURE B-4

SUD-MTO GSD GLDR_LDN.GDT

BV Labs Job #: B9D3975
Report Date: 2019/06/03

Golder Associates Ltd
Client Project #: 1896349(2100)
Site Location: HWY 66
Sampler Initials: MR

RESULTS OF ANALYSES OF SOIL

BV Labs ID		JTI432			JTI433	JTI434	JTI435	JTI436		
Sampling Date		2019/05/03 10:45			2019/05/04 14:47	2019/05/08 12:39	2019/05/11 16:36	2019/05/14 08:49		
COC Number		127611			127611	127611	127611	127611		
	UNITS	**C236-1 Lab-Dup**	**RDL**	**QC Batch**	**C267-1**	**C228-1**	**C227-1**	**C256-1**	**RDL**	**QC Batch**
CONVENTIONALS										
Sulphide	ug/g				<0.30	<0.30	<0.30	<0.30	0.30	6150574
Calculated Parameters										
Resistivity	ohm-cm				23000	12000	2500	22000		6129977
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g				<20	29	250	<20	20	6133046
Conductivity	umho/cm				43	84	405	46	2	6135430
Available (CaCl2) pH	pH				7.74	6.56	7.00	6.30		6133358
Soluble (20:1) Sulphate (SO4)	ug/g				<20	<20	<20	<20	20	6133048
Physical Testing										
Moisture-Subcontracted	%	15	0.30	6150575	21	20	20	20	0.30	6150575

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

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

APPENDIX C

Non-Standard Special Provisions and Notice to Contractor

<u>DEWATERING SYSTEM</u> - Item No.
<u>TEMPORARY FLOW PASSAGE SYSTEM</u> - Item No.

Special Provision No. 517F01 July 2017

Amendment to OPSS 517, November 2016

Design Storm Return Period and Preconstruction Survey Distance

517.01 SCOPE

Section 517.01 of OPSS 517 is deleted in its entirety and replaced with the following:

This specification covers the requirements for the design, operation, and removal of a dewatering or temporary flow passage system or both to control water during construction, and the control of the water prior to discharge to the natural environment and sewer systems.

517.04 DESIGN AND SUBMISSION REQUIREMENTS

517.04.01 Design Requirements

Subsection 517.04.01 of OPSS 517 is amended by deleting the first paragraph in its entirety and replacing it with the following:

A dewatering or temporary flow passage system or both shall be designed to control water at the locations specified in the Contract Documents and at any other location where a system is necessary to complete the work. The design of the system shall be sufficient to permit the work at each location to be carried out as specified in the Contract Documents.

Subsection 517.04.01 of OPSS 517 is further amended by deleting the second last paragraph in its entirety and replacing it with the following:

Temporary flow passage systems shall be designed, as a minimum, for a 2 year design storm return period and groundwater discharge, except for the work specified in Table A. For the work specified in Table A, the temporary flow passage system shall be designed, as a minimum, for the design storm return period specified in Table A and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

Intensity-Duration Factor (IDF) curve location, site specific minimum return period, return period flow estimates, and other information is provided in Table A. The IDF information can be accessed through the MTO IDF Curve Look up Tool on the Drainage and Hydrology page of MTO's website. The return period flow estimates do not include flow volumes from groundwater discharge. The Owner specifically excludes these flow estimates from the warranty in the Reliance on Contract Documents subsection of OPSS 100, MTO General Conditions of Contract.

Table A

IDF Curve Location	Latitude: 48.106316			Longitude: -79.757824		
Temporary Flow Passage Systems						
Site Name / Station Reference	Minimum Return Period (Years)	Return Period Flow Estimates (m^3/s)				Design Engineer Requirements (Note 1)
		2 Year	5 Year	10 Year	25 Year	
Highway 66, Station 10+172, Township of McVittie Culvert Replacement	***	****	****	****	****	Yes
Dewatering Systems						
Site Name / Station Reference	Preconstruction Survey Distance (Note 2) (m)					Design Engineer Requirements (Note 1)
Highway 66, Station 10+172, Township of McVittie Culvert Replacement	N/A					Yes

Note:

1. "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.
2. "N/A" indicates a preconstruction survey is not required.

NOTES TO DESIGNER:

Designer Fill-in for Table A:

* Enter the latitude and longitude co-ordinates of the IDF Curve as obtained using the MTO IDF Curve Look up Tool. Create additional tables, as necessary, if more than one (1) IDF curve was used on the contract (i.e. on a very long contract there may be two IDF curves used to better represent rainfall events for two (2) different sections of the contract).

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

*** For temporary flow passage system item locations, fill-in the minimum design storm return period for the site based on MTO Drainage Design Standard TW-1.

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

***** Insert "Yes" when recommended by the Foundation Engineer. Insert "No" otherwise.

****** Fill-in the required distance for preconstruction survey if recommended by the Foundation Engineer. Fill-in "N/A" if not recommended.

WARRANT: Always with these tender items.

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