



July 28, 2016

DRAFT DETAIL FOUNDATION INVESTIGATION AND DESIGN REPORT

**SANDLINK CREEK CULVERT
SITE NO. 48E-128/C, HIGHWAY 625
DISTRICT OF THUNDER BAY, UNSURVEYED TERRITORY
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6306-14-00, W.P. 6309-14-01**

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DRAFT REPORT





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PART A

**DETAIL FOUNDATION INVESTIGATION REPORT
SANDLINK CREEK CULVERT – SITE NO. 48E-128/C
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Ltd. (Hatch), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Sandlink Creek culvert (Site No. 48E-128/C). The Sandlink Creek culvert is located in the District of Thunder Bay on Highway 625 at STA 10+041, approximately 8.8 km south of Highway 11. The key plan showing the general location of this section of Highway 625 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The Sandlink Creek culvert consists of a twin-cell, timber box, the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in this area is relatively flat with moderate to dense tree cover. Sandlink Lake, which is located to the east of the culvert site, drains westerly via Sandlink Creek. At the culvert location, the highway grade is at about Elevation 331.3 m and the existing culvert invert is at Elevations 328.5 m and 328.3 m, at the inlet (east end) and outlet (west end), respectively. The water level measured by others on May 27, 2014, ranged from Elevations 329.2 m and 329.0 m at the west and east side, respectively. Surface conditions at the culvert inlet and outlet areas are shown on Photographs 1 to 3 attached.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on December 13 and 14, 2014, during which time four Boreholes (SL-1 to SL-4) were advanced at the approximately the locations shown on Drawing 1. Subsequently, one additional borehole (SL-5) was advanced on February 11, 2016. Boreholes SL-1 to SL-4 were advanced using truck and track-mounted CME-55 drill rigs were supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec. Borehole SL-5 was advanced using portable equipment supplied and operated by Landcore Drilling of Chelmsford, Ontario.

Boreholes SL-1 and SL-4 were advanced at the toe of slope near the culvert inlet/outlet using 108 mm inside diameter hollow stem augers. Boreholes SL-2 and SL-3 were advanced from the existing highway platform using NW casing and wash boring techniques. Borehole SL-5 was advanced at the toe of slope near the proposed culvert inlet using NW casing and 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 an automatic hammer in Boreholes SL-1 to SL-4 and using a cathead hammer in Borehole SL-5, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Shear Strength Test) using MTO Standard 'N' size vanes. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis by a members 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 and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in



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Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, and Atterberg limits tests were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the creek water was obtained on December 9, 2014 using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters, including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline and existing culvert and converted into Northing/Easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing, provided by MTO in January 2015 (Drawing E4948626251.dwg). The MTM NAD83 (Zone 14) northing and easting coordinates, ground surface elevations referenced to geodetic datum and borehole depths at each borehole locations are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
SL-1	5509681.5	351930.4	329.2	8.5
SL-2	5509675.0	351941.2	331.5	11.6
SL-3	5509684.2	351943.6	331.2	11.6
SL-4	5509676.9	351952.2	330.6	8.5
SL-5	5509691.9	351948.8	329.6	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)¹ mapping, the subsoils in the vicinity of the Sandlink Creek culvert site generally consist of outwash plain deposits comprised primarily of sand.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)², the site is underlain by bedrock of the Archean Era, comprised of mafic to intermediate metavolcanic rocks consisting of basaltic and andesitic flows, tuffs and breccias, chert and iron formations with minor metasedimentary and intrusive rocks.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N'

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42ENE.

² Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.



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values and undrained shear strengths from field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic section on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for boreholes advanced through the embankment) overlying cohesionless deposits of sand to silty sand and sandy silt to silt, which are underlain by a cohesive deposit of clayey silt. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided in the following table and sections.

Deposit/Layer Description	Boreholes	Thickness (m)	Elevation (m)	N Values (blows) / Shear Strength (kPa)	Laboratory Testing
				Consistency or Relative Density	
Ice/Snow	SL-5	0.3	329.6	n/a	n/a
Asphalt	SL-2, SL-3	0.025	331.5 – 331.2	n/a	n/a
(FILL) Sand and gravel to sand, some silt, trace to some gravel, trace clay, brown, frozen to wet	SL-2, SL-3	2.6 – 2.1	331.4 – 331.1	N = 13 – 21 ¹	w = 13% – 28 % 2 - MH (Fig. B1)
				Compact	
Peat (Fibrous) , trace to some sand, trace gravel, black, wet	SL-5	1.9	329.3	N = 2 to 5	w = 104%
				Very Soft to Firm	
Silty Sand to Sand , trace gravel, trace clay, trace organics, brown, wet	SL-1, SL-3 and SL-4	1.4 – 2.3	330.6 – 329.1	N = 1 – 14	w = 20% – 30% 2 – M (Fig. B2)
				Very Loose to Compact	
Sandy Silt to Silt , trace to some clay, grey, wet	SL-1 to SL-5	4.3 – 6.5	329.2 – 326.8	N = 2 – 32	w = 26% – 29% 9 – MH (Fig. B3) 6 – AL – N.P.
				Very Loose to Dense	
Clayey Silt , trace sand, grey, wet	SL-1 to SL-5	0.6 – 2.9 (Boreholes terminated in this deposit)	322.8 – 322.0	N = 5 – 10 ² S _u = 72 – >100	w = 20% – 21% 4 – MH (Fig. B4) 4 – AL (Fig. B5) w _i = 27% – 29% w _p = 16% I _p = 11% – 14%
				Stiff to Very Stiff	



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Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
s_u = Undrained Shear Strength from in situ field 'N'-vane (kPa)
w = Natural Moisture Content (%)
MH = Combined Sieve and Hydrometer analysis
M = Sieve analysis for particle size
AL = Atterberg Limits Test
w_p = Plastic Limit (%)
w_l = Liquid Limit (%)
I_p = Plasticity Index (%)
N.P. = Non-plastic Atterberg Limits Test Result

Note:

¹ In the fill, two SPT 'N'-values of 50 blows and 61 blows per 0.3 m of penetration were noted, however these are likely indicative of the frozen state of the material and are not representative.

² In the clayey silt deposit, two SPT 'N'-values of 34 blows and 16 blows per 0.3 m of penetration were noted; however, these values are likely due to the presence of silt seams within the deposit.

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek ice level was measured at Elevation 328.9 m on December 13, 2014. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
SL-1	2.6	326.6
SL -2	0.9	330.6 ¹
SL -3	2.3	328.9 ¹
SL -4	3.9	326.7
SL-5	0.6	329.0 ¹

1. Boreholes SL-2, SL-3 and SL-5 were advanced using NW casing and wash boring. As such, water levels may not be representative of in-situ groundwater conditions.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Cody Walter, Mr. Mathew Riopelle and Mr. Shane Albert, under the overall direction of Mr. David Muldowney, P.Eng. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Mr. David Muldowney, P.Eng., provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., the Designated MTO Foundations Contact and Senior Consultant with Golder, conducted an independent quality control review of this report.



Report Signature Page

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PART B

**DETAIL FOUNDATION DESIGN REPORT
SANDLINK CREEK CULVERT – SITE NO. 48E-128/C
HIGHWAY 625, DISTRICT OF THUNDER BAY
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides detail foundation design recommendations for the proposed replacement of the Sandlink Creek culvert. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to carry out the design of the culvert structure. The foundation investigation report and the discussion and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The design-build contractor must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. 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 General

The existing Sandlink Creek Culvert is located on Highway 625 at STA 10+041, located approximately 8.8 km south of the Highway 11 junction. The highway embankment is constructed of granular fill material and is approximately 3.0 m high. The existing culvert consists of a twin-cell timber box, the details of which (i.e., width, height, length, etc.) are summarized in Table 1.

As part of the preliminary design phase of the project, alternative types of culverts were considered for replacement of the existing structure, as reported in the "Preliminary Foundation Investigation and Design Report, Sandlink Creek Culvert – Site 48E-128.C, Highway 625 District of Thunder Bay, Unsurveyed Territory, G.W.P. 6309-14-00, GEOCRE 42E-18, dated May 14, 2015." by Golder Associates Ltd.

Based on the General Arrangement (GA) drawing provided by Hatch on December 15, 2015, the existing culvert is to be replaced with a 5.4 m wide by 2.7 m high by 22.5 m long pre-cast concrete box on a new alignment approximately 6 m north (to STA 10+047) of the existing structure to allow for approximately 1 m of separation between the existing culvert and the proposed culvert. The proposed culvert inverts are at Elevations 328.2 m and 328.0 m at the inlet end and outlet end, respectively. We understand that there is no proposed embankment grade raise at the proposed culvert location.

6.2 Geotechnical Resistances

For the box culvert replacement, it is recommended that any organic materials encountered below the culvert footprint be sub-excavated and replaced with Granular 'B' Type II. The factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical reaction at Serviceability Limit States (for 25 mm of settlement) for a 5.4 m wide box culvert founded on a properly prepared subgrade/granular bedding layer overlying the native very loose to compact sand to silty sand deposit or the loose to very dense sandy silt to silt deposit at Elevation 327.8 m and 327.7 m (taking into account the culvert invert, a 0.3 m thick concrete box culvert bottom, a 75 mm levelling course, and a 0.3 m thick granular bedding layer) may be taken as 250 kPa and 100 kPa, respectively.



The geotechnical resistance/reaction provided are based on loading applied perpendicular to the base of the culvert; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC 2006) and it's Commentary.

The loading on the foundation soils below the culvert and the associated settlement at the culvert location will be governed by the thickness/height of the overlying and adjacent embankment fill. As such, it is recommended that the structural engineer exercise caution when utilizing the values for the geotechnical reaction at SLS in the design of the culvert and that consideration be given to the sequence and staging of the construction. We understand that there will not be a grade raise.

6.2.1 Frost Protection

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

6.2.2 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces/sliding resistance between the base of the box culvert and granular bedding material should be calculated in accordance with Section 6.7.5 of the CHBDC. For a pre-cast concrete box culvert founded on a compacted granular fill (Bedding/Levelling layer), the coefficient of friction ($\tan \delta$) between the base of the box segments and the bedding fill may be taken as 0.45.

6.3 Stability, Settlement and Horizontal Strain

For the subsurface conditions present at this site and given the proposed embankments height up to about 3.0 m above the existing ground surface, the granular fill embankments at this site will be stable at side slopes of 2 Horizontal to 1 Vertical (2H:1V) or flatter. This assumes that there is no grade raise or platform widening at the culvert site. Additionally, the existing native soils will not experience additional load, and therefore, settlement of the culvert is estimated to be less than 25 mm.

Horizontal strain is not expected to occur as we understand that the permanent embankment geometry is not changing from the current (existing) geometry. As a results, culvert construction concurrent with the embankment reconstruction can be carried out without the need for any foundation mitigation measures of culvert camber.

6.4 Lateral Earth Pressures

The lateral earth pressures acting on the side walls (or head/wing walls if required) of the culvert will depend on the type and method of placement of backfill materials, the nature of 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 culverts and any wing or head walls. It should be noted that these design recommendations and parameters are applicable to level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III should be used as backfill behind the culvert walls, and on top of the culvert for a thickness of up to 300 mm. Backfill should be placed in maximum 200 mm loose lift thickness and compacted. Weep holes should be installed to provide positive drainage of the granular backfill.
- Granular fill may be placed in a zone with the width equal or greater than the equivalent depth of frost penetration (as per OPSD 3090.100 (Foundation Frost Penetration Depths for Northern Ontario), which for this site is 2.6 m behind the back of the walls for a restrained wall (see Figure C6.20(a) of the Commentary to the CHBDC), or within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5 H:1V) extending up and back from the rear face of the base of the walls for an unrestrained wall (see Figure C6.20(b) of the Commentary to the CHBDC). The lateral earth pressures acting against the culvert walls and wing/head walls are based on the proposed backfill material against the walls and the following parameters (unfactored) may be used:

Fill Type	Internal Angle of Friction (ϕ)	Unit Weight	Coefficients of Static Lateral Earth Pressure		
			At-Rest, K_o	Active, K_a	Passive, K_p
Granular 'A'	35°	22 kN/m ³	0.43	0.27	3.69
Granular 'B' Type II	35°	21 kN/m ³	0.43	0.27	3.69
Granular 'B' Type I or III	32°	21 kN/m ³	0.47	0.30	3.26

If the structures allow for lateral yielding, active earth pressures may be used in the design of the structure(s). If the structures do not allow lateral yielding, at-rest earth pressures should be assumed for design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as presented in Table C6.6 of the Commentary to the CHBDC.

6.5 Construction Considerations

6.5.1 Construction Staging and Temporary Roadway Protection

The temporary excavation for the culvert replacement will be made through the existing embankment granular fill and into native soils, which are comprised of very loose to dense sand to silty sand and sandy silt to silt. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). The granular fills and native soils are considered to be Type 3 soil above the groundwater table and Type 4 soil below. Temporary open-cut excavations in Type 3 soils



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should remain stable if side slopes are formed no steeper than 1H:1V. In Type 4 soils, the side slopes should be formed no steeper than 3H:1V.

Based on the GA drawing provided by Hatch, a temporary protection support system is being proposed along the highway centreline to facilitate construction staging and maintain traffic during culvert replacement work. At this site, the temporary support systems could consist of either driven sheet-piling or soldier piles and lagging where H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. Support to the system could be in the form of struts and walers and rakers or anchors. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways.

The support system may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Undrained Shear Strength	Coefficient of Earth Pressure		
	(γ , kN/m ³)	(ϕ , degrees)	(kPa)	Active, K_a	At Rest, K_o	Passive, K_p
Existing Sand to Sand and Gravel - Fill (Compact)	20	32	-	0.47	0.30	3.26
Peat (Very Loose to Loose)	12	27	1	0.38	0.55	2.66
Silty Sand to Sand (Very Loose to Compact)	19	28	-	0.36	0.53	2.77
Silt to Sandy Silt (Very Loose to Dense)	18	28	-	0.36	0.53	2.77
Clayey Silt (Stiff to Very Stiff)	17	27	50	0.38	0.55	2.66

The temporary shoring design should be assessed for both the drained (ϕ) and undrained (c_u) cases, based on the more conservative earth pressure conditions. Further, the total passive resistance of the temporary protection system below the base of the excavation should be calculated based on the values of K_p given above and then reduced by an appropriate factor of safety that considered the allowable wall movement as extrapolated from Figure C6.16 of the CHBDC (2006) to account for the fact that a large strain would be required for full mobilization of the passive resistance.

The silt to sandy silt and clayey silt deposits are potentially sensitive to disturbance from vibration and/or driving of piles, which should be considered in the design and installation of the temporary protection systems. Design of the temporary excavation and roadway support system should include an evaluation of base stability ('base heave' or soil squeezing stability) and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006).



6.5.2 Excavation and Replacement Fill Below Culvert

Prior to placement of any bedding material, granular fill or concrete, all organics (including peat, topsoil and mixed organic soil materials) and any softened soils, should be sub-excavated from below the plan limits of the proposed works.

The culvert subgrade should be inspected following sub-excavation to ensure that all organics and other unsuitable materials have been removed, in accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts). Following inspection, the sub-excavated area should be backfilled with granular material meeting the requirements of an OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I or II that is placed and compacted in accordance with OPSS.PROV 501 (Compacting). The use of Granular 'B' Type II fill is recommended in wet conditions or below the water and placement should be in accordance with OPSS.PROV 209 (Embankments over Swamps).

6.5.3 Culvert Bedding and Backfill

The bedding, levelling pad and granular backfill requirements for a pre-cast box culvert should be accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts). Given the potential for surface water flow and some groundwater seepage through the native soils during excavation to the invert and bedding level, it is recommended that a minimum 300 mm thick layer of OPSS.PROV 1010 (Aggregates) Granular 'B' Type II material be used for bedding purposes. We do not recommend that Granular 'B' Type I or III be used for bedding purposes. As the native soil below the bedding is generally fine grained, it is recommended that a non-woven geotextile be placed between the native soil and the bottom of the bedding. The geotextile should be the specifications for OPSS 1860 (Geotextiles) Class II, and have a fabric opening size (FOS) not greater than 212 µm. The bedding should be placed in maximum 200 mm thick loose lifts and compacted to at least 98 per cent of the standard Proctor maximum dry density (SPMDD) of the materials as specified in OPSS.PROV 501 (Compacting). In addition, a 75 mm thick uncompacted levelling pad consisting of OPSS.PROV 1010 (Aggregates) Granular 'A' or concrete fine aggregate meeting the grading requirements specified in OPSS.PROV 1002 (Aggregates – Concrete) should be provided with a similar geometry to that shown on OPSD 803.010 (Backfill and Cover for Concrete Culverts) for culvert construction in dry conditions.

Backfill behind the culvert walls should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III. The granular backfill 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.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

As the existing granular embankment fill material and native sand deposit are considered low frost-susceptible (based on MTO Pavement Design and Rehabilitation Manual, 2013), and extends to depths below the estimated depth of frost penetration, a frost taper is not required at this site.



6.5.4 Subgrade Protection

The native soils (silt to sandy silt) will be susceptible to disturbance from construction traffic and/or ponded water. To limit the effect of this disturbance a 300 mm granular bedding layer should be placed in a timely manner. The foundation subgrade should be inspected and approved immediately prior to placement of the bedding layer. Consideration should be given to include an NSSP in the contract to address subgrade protection at this site. An example NSSP for subgrade protection to be included in the Contract is presented in Appendix C.

6.5.5 Erosion Protection

Provision should be made for scour and erosion protection at the culvert location. In order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream end of the culvert. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should be a minimum thickness of 1 m, if constructed of natural clay or soil bentonite mix. The clay seal should extend from a depth of 1 m below the scour level to a minimum vertical height equivalent to the high water level. The seal should also extend a minimum horizontal distance of 2 m on either side of the culvert inlet opening.

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

6.5.6 Control of Groundwater and Surface Water

Excavation along the culvert alignment will be required to remove organic and overburden soils prior to placement of backfill, bedding material and the culvert structure. As a result of the excavation, groundwater flow into the excavation can be expected due to the relatively permeable nature of the native soils. Therefore, control of groundwater will be necessary to allow for construction to be carried out in dry conditions, where required. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

Based on the GA drawing provided by Hatch, we understand that the creek flows will be diverted through one of the cells of the existing culvert. A temporary sheet-pile cut-off wall or cofferdam will be required to divert the creek water to the temporary bypass.

Groundwater control will be required for the box culvert as the foundation excavation to the founding level is expected to extend below the groundwater level. Temporary shoring and groundwater control could be in the form of a sheet-pile cut off wall or cofferdam advanced to an appropriate depth to control groundwater inflow from the creek and to prevent base heaving of the foundation subgrade.



The subsurface soils at this site are potentially sensitive to disturbance from vibration and/or driving of piles, which should be considered in the design and installation of the unwatering system.

Dewatering of all excavations should be carried out in accordance with OPSS 517 (Dewatering). An NSSP should be included in the Contract to address unwatering at this site; a sample NSSP is included in Appendix C.

Provided that the creek water flow is diverted and the unwatering system is installed to a suitable depth to mitigate groundwater inflows, pumping volumes of construction dewatering are not anticipated to exceed 50 m³/day. However, an application under the Environmental Activity Section Registry (EASR) of the Ontario Ministry of the Environment and Climate Change (MOECC) should be submitted in the event that the pumping volumes exceed this amount. Under the EASR, a permit to take water is not required for water taking for construction sites dewatering volumes less than 400,000 L/day.

6.5.7 Analytical Testing for Construction Materials

The results of an analytical test on a sample of creek water taken at the culvert site are presented in Table B1 in Appendix B. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

7.0 CLOSURE

This Detail Foundation Design Report was prepared by Mr. Adam Core, P.Eng., and the technical aspects were reviewed by Mr. David Muldowney P.Eng. Mr. Jorge M. A. Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant with Golder, conducted an independent quality control review of this report.



Report Signature Page

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Designated MTO Foundations Contact, Senior

AC/DAM/JMAC/kp

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n:\active\2014\1190 sudbury\1191\1411523 - hmm 26 culverts thunder bay\reporting\1 - detail design\d4 - sandlink creek\draft\1411523 rpt d4 16jul28 sandlink creek.docx



REFERENCES

Canadian Standards Association (CSA), 2006. Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06. CSA Special Publication, S6.1 06.

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Occupational Health and Safety Act and Regulation for Construction Projects, January 2006.

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.

Ministry of Transportation, “MTO Pavement Design and Rehabilitation Manual”. MTO Materials Engineering and Research Office, Second Edition 2013.

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42ENE.

ASTM International:

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

ASTM D2573 Standard Test Method for Field Vane Shear Test in Cohesive Soil

Ontario Provincial Standard Specifications (OPSS)

OPSS 422 Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut

OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation

OPSS 1205 Material Specification for Clay Seal

OPSS 1860 Material Specification for Geotextiles

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 209 Construction Specifications for Embankments Over Swamps and Compressible Soils

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS.PROV 1002 Material Specification for Aggregates - Concrete

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

Ontario Provincial Standard Drawings (OPSD)

OPSD 803.010 Backfill and Cover for Concrete Culverts

OPSD 810.010 Rip-Rap Treatments for Sewer and Culvert Outlets

OPSD 3090.100 Foundation Frost Penetration Depths for Northern Ontario

Ontario Water Resource Act:

Regulation 903 Wells (as amended)



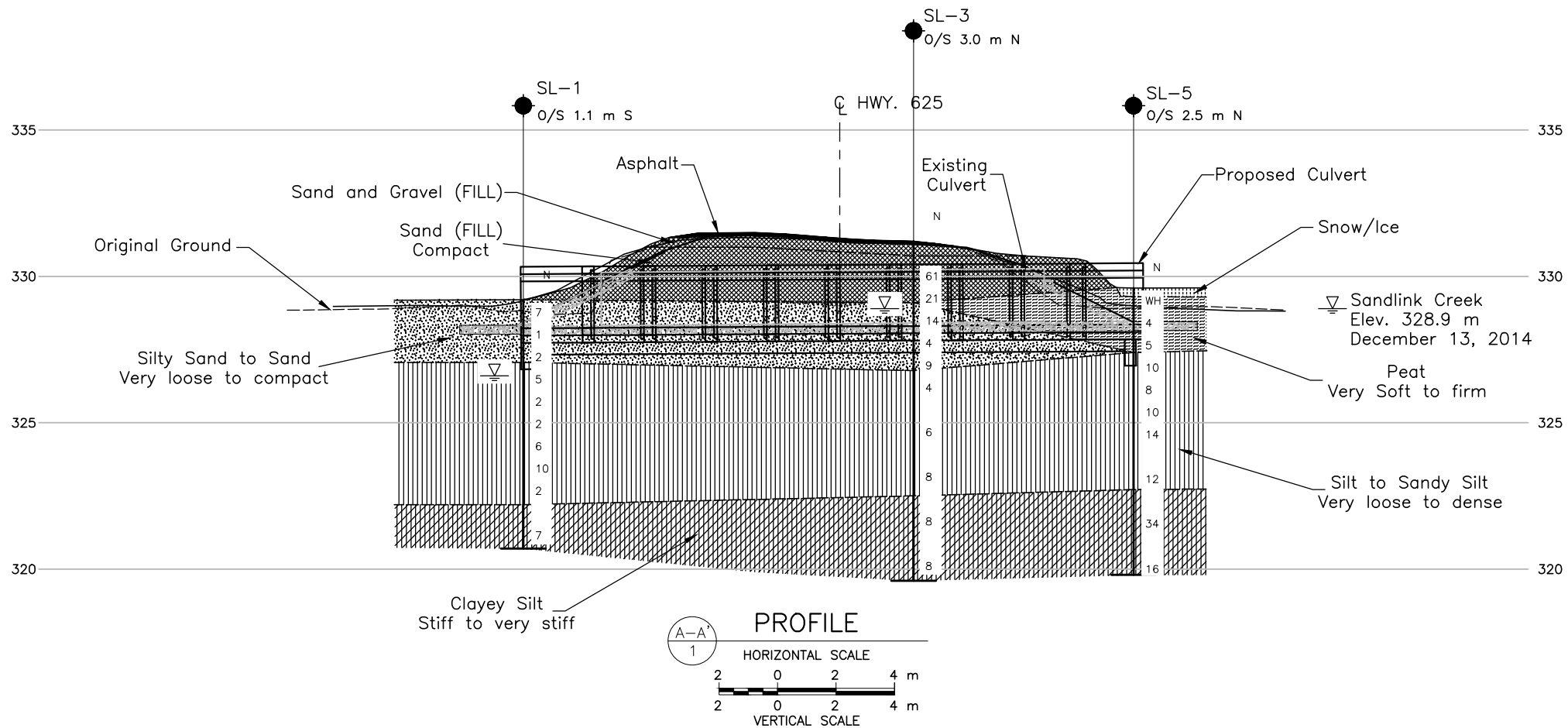
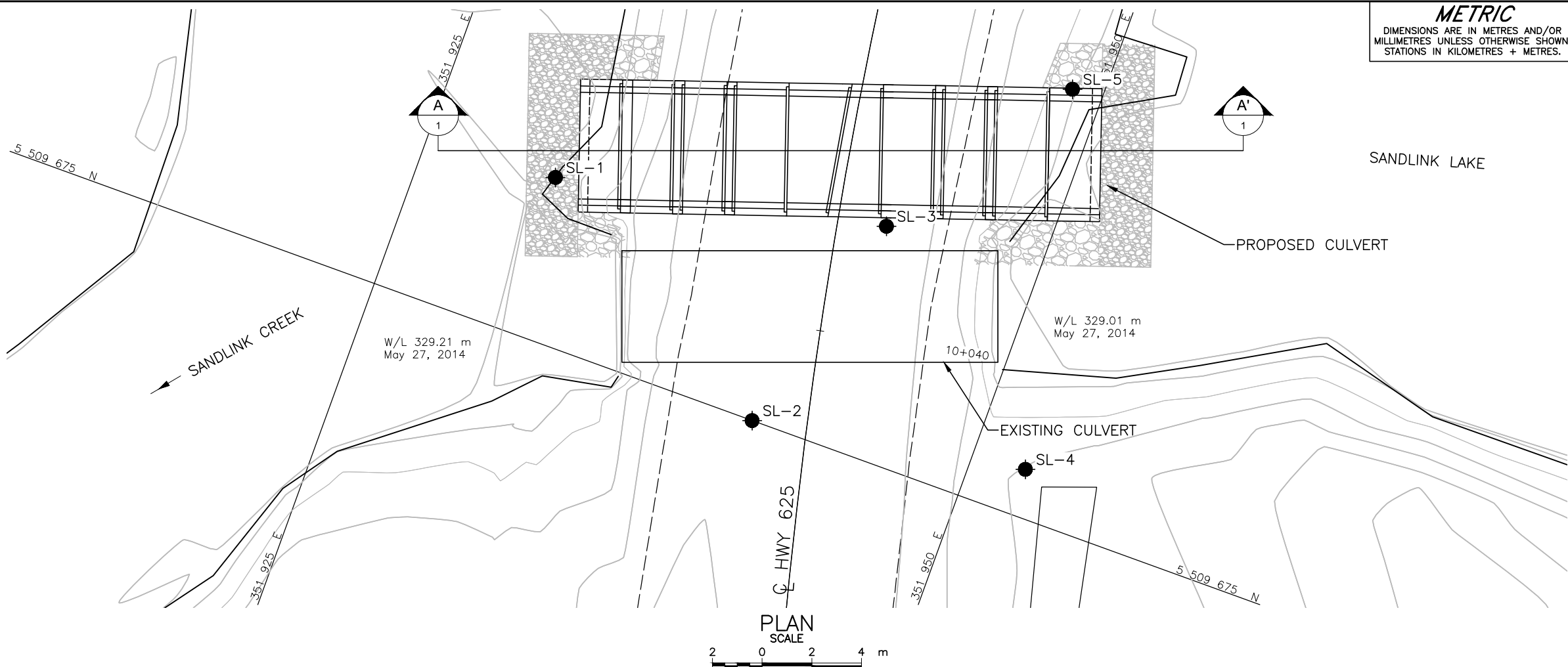
DRAFT DETAIL FOUNDATION REPORT SANDLINK CREEK CULVERT, SITE NO. 48E-128/C

Table 1: Summary Details of Existing Culvert

Culvert Location	Site #	Approximate Height of Embankment ¹ (m)	Existing Culvert			Approximate Invert Elevation ²	
			Type	Approximate Dimension ²	Approximate Length (m)	West End of Culvert (m)	East End of Culvert (m)
Hwy 625 STA 10+041	48E-128/C	3.0	Twin Timber Box	1.8 m high by 4.5 m wide (total)	15	328.3	328.5

- Notes:
1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the culvert.
 2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (Drawing E4948626251.dwg).

Prepared by: AC
Checked by: DAM
Reviewed by: JMAC

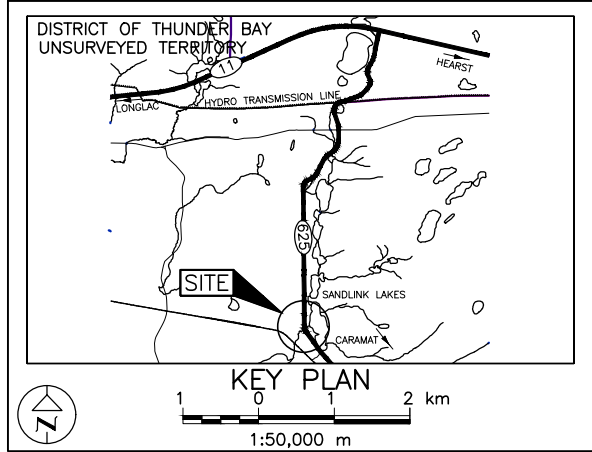


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 6306-14-00

HIGHWAY 625
SANDLINK CREEK CULVERT STA 10+047
BOREHOLE LOCATIONS AND SOIL
STRATA

SHEET



LEGEND

- Borehole
- 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			
No.	ELEVATION	NORTHING	EASTING
SL-1	329.2	5509681.5	351930.4
SL-2	331.5	5509675.0	351941.2
SL-3	331.2	5509684.2	351943.6
SL-4	330.6	5509676.9	351952.2
SL-5	329.6	5509691.9	351948.8

NOTES

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

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file no. E494862651, dated JUNE 2014, received JAN 27 2015. Proposed culvert plan and profile drawing file no. ST-343032-SANDLINK CREEK CULVERT-01-GA-BOX.dwg, received JUL 5, 2016.

DRAFT

NO.	DATE	BY	REVISION
Geocres No.,			
HWY. 625		PROJECT NO. 1411523	DIST. .
SUBM'D. AC	CHKD. .	DATE: 7/20/2016	SITE: 48E-128/C
DRAWN: JUL	CHKD. DAM	APPD. JMAC	DWG. 1



PHOTOGRAPHS

**Photograph 1: Sandlink Creek Culvert
East Side - Inlet (Taken from MTO, OSIM_08-22-2012)**



**Photograph 2: Sandlink Creek Culvert
West Side - Outlet (Taken from MTO, OSIM_08-22-2012)**





PHOTOGRAPHS

**Photograph 3: Sandlink Creek Culvert
East Side - Inlet (Golder – December 14, 2014)**





APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
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 = $\tan \delta$
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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. 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.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; 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

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
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	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT 1411523		RECORD OF BOREHOLE No SL-1				1 OF 1 METRIC											
G.W.P. 6309-14-00		LOCATION N 5509681.5; E 351930.4				ORIGINATED BY CW											
DIST _____ HWY 625		BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers				COMPILED BY SEMP											
DATUM GEODETIC		DATE December 13, 2014				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
329.2	GROUND SURFACE							20	40	60	80	100					
0.0	SILTY SAND to SAND, trace gravel, trace organics (rootlets, wood) Very loose to loose Brown Wet		1	SS	7												
			2	SS	1												4 90 (6)
			3	SS	2												
327.1																	
2.1	SILT to Sandy SILT, trace sand, trace clay Very loose to compact Grey Wet		4	SS	5												
			5	SS	2											NP	0 25 75 0
			6	SS	2												
			7	SS	6												
			8	SS	10											NP	0 4 95 1
			9	SS	2												
322.0																	
7.2	CLAYEY SILT, trace sand Very stiff Grey Wet		10	SS	7												0 4 66 30
320.7																	
8.5	END OF BOREHOLE																
	Note: 1. Water level at a depth of 2.6 m below ground surface (Elev. 326.6 m) upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 20/07/16 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No SL-2				1 OF 1 METRIC							
G.W.P. 6309-14-00		LOCATION N 5509675.0; E 351941.2		ORIGINATED BY MR									
DIST _____ HWY 625		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY SEMP									
DATUM GEODETIC		DATE December 13 and 14, 2014		CHECKED BY DAM									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		γ	
								20 40 60 80 100	W _p W W _L	20 40 60	kN/m ³	GR SA SI CL	
331.5	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT (25 mm)												
331.0	Sand and gravel (FILL)												
0.5	Brown Frozen												
	Sand, some silt, trace clay, trace organics (FILL)		1	SS	50*							0 82 17 1	
	Compact Brown Frozen/wet		2	SS	13								
	*Sample 1 frozen.		3A	SS	32								
328.9	SILT, trace to some sand, trace clay		3B	SS	32								
2.6	Compact to dense Grey Wet		4	SS	32								
			5	SS	25								
			6	SS	18							NP 0 5 95 0	
			7	SS	15								
			8	SS	17							NP 0 8 90 2	
322.8	CLAYEY SILT, trace sand		9	SS	10								
8.7	Stiff to very stiff Grey Wet		10	SS	8							0 2 67 31	
319.9	END OF BOREHOLE												
11.6	Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 330.6 m) upon completion of drilling.												

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 2007/16 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No SL-3			1 OF 1 METRIC																								
G.W.P. 6309-14-00			LOCATION N 5509684.2; E 351943.6			ORIGINATED BY MR																								
DIST _____ HWY 625			BOREHOLE TYPE NW Casing, Wash Boring			COMPILED BY SEMP																								
DATUM GEODETIC			DATE December 13, 2014			CHECKED BY DAM																								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																									
331.2	GROUND SURFACE																													
0.0	ASPHALT (25 mm)																													
330.7	Sand and gravel (FILL)																													
0.5	Brown Frozen																													
	Sand, some silt, trace to some gravel, trace clay (FILL)		1	SS	61*																									
	Compact Dark brown Frozen / wet																													
	*Sample 1 frozen.		2	SS	21																									
329.1	SAND, some silt, trace to some gravel, trace clay, trace organics (wood, roots)																													
2.1	Loose to compact Dark brown Wet		3	SS	14																									
			4	SS	4																									
			5	SS	9																									
326.8	SILT, trace sand, trace clay																													
4.4	Loose Grey Wet		6	SS	4																									
			7	SS	6																									
			8	SS	8																									
322.5	CLAYEY SILT, trace sand																													
8.7	Stiff Grey Wet		9	SS	8																									
			10	SS	8																									
319.6	END OF BOREHOLE																													
11.6	Note: 1. Water level at a depth of 2.3 m below ground surface (Elev. 328.9 m) upon completion of drilling.																													

PROJECT 1411523		RECORD OF BOREHOLE No SL-4				1 OF 1 METRIC							
G.W.P. 6309-14-00		LOCATION N 5509676.9; E 351952.2				ORIGINATED BY CW							
DIST _____ HWY 625		BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers				COMPILED BY SEMP							
DATUM GEODETIC		DATE December 13 and 14, 2014				CHECKED BY DAM							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa				W _p W W _L	
330.6	GROUND SURFACE							20 40 60 80 100	20 40 60				
0.0	SILTY SAND to SAND, trace gravel, trace organics Very loose Dark brown Wet		1	SS	3		330						5 83 (12)
329.2			2	SS	3								
1.4	SILT, trace to some sand, trace clay Loose to compact Grey Wet		3	SS	10		329						0 4 92 4
			4	SS	21		328						
			5	SS	12		327						
			6	SS	6		326						
			7	SS	6		325						
			8	SS	16		324						
322.7			9a	SS	5		323						
7.9	CLAYEY SILT, trace sand Very stiff Grey Wet		9b										
322.1													
8.5	END OF BOREHOLE												
	Note: 1. Water level at a depth of 3.9 m below ground surface (Elev. 326.7 m) upon completion of drilling.												

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 20/07/16 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No SL-5				1 OF 1 METRIC								
G.W.P. 6309-14-00		LOCATION N 5509691.9; E 351948.8		ORIGINATED BY SA										
DIST _____ HWY 625		BOREHOLE TYPE NW Casing and Wash Boring		COMPILED BY AC										
DATUM GEODETIC		DATE February 11, 2016		CHECKED BY DAM										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
329.6	SNOW SURFACE							20 40 60 80 100	20 40 60					
0.0	ICE/SNOW							20 40 60 80 100	20 40 60					
329.3			1	SS	2									
0.3	PEAT (Fibrous), trace to some sand, trace gravel Very soft to firm Black Wet		2	SS	4									
			3	SS	5									
327.4														
2.2	SILT, trace to some clay, trace sand Loose to compact Grey Wet		4	SS	10									0 2 91 7
			5	SS	8									
			6	SS	10									
			7	SS	14									0 2 96 2
			8	SS	12									
322.7														
6.9	CLAYEY SILT, trace sand Grey Wet A 300 mm thick silt seam encountered at 7.9 m depth.		9	SS	34									
			10	SS	16									0 2 68 30
319.8														
9.8	END OF BOREHOLE Notes: 1. Water level at a depth of 0.6 m below ground surface (Elev. 329.0 m) upon completion of drilling.													

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 20/07/16 DATA INPUT:



APPENDIX B

Laboratory Test Results



DRAFT DETAIL FOUNDATION REPORT SANDLINK CREEK CULVERT, SITE NO. 48E-128/C

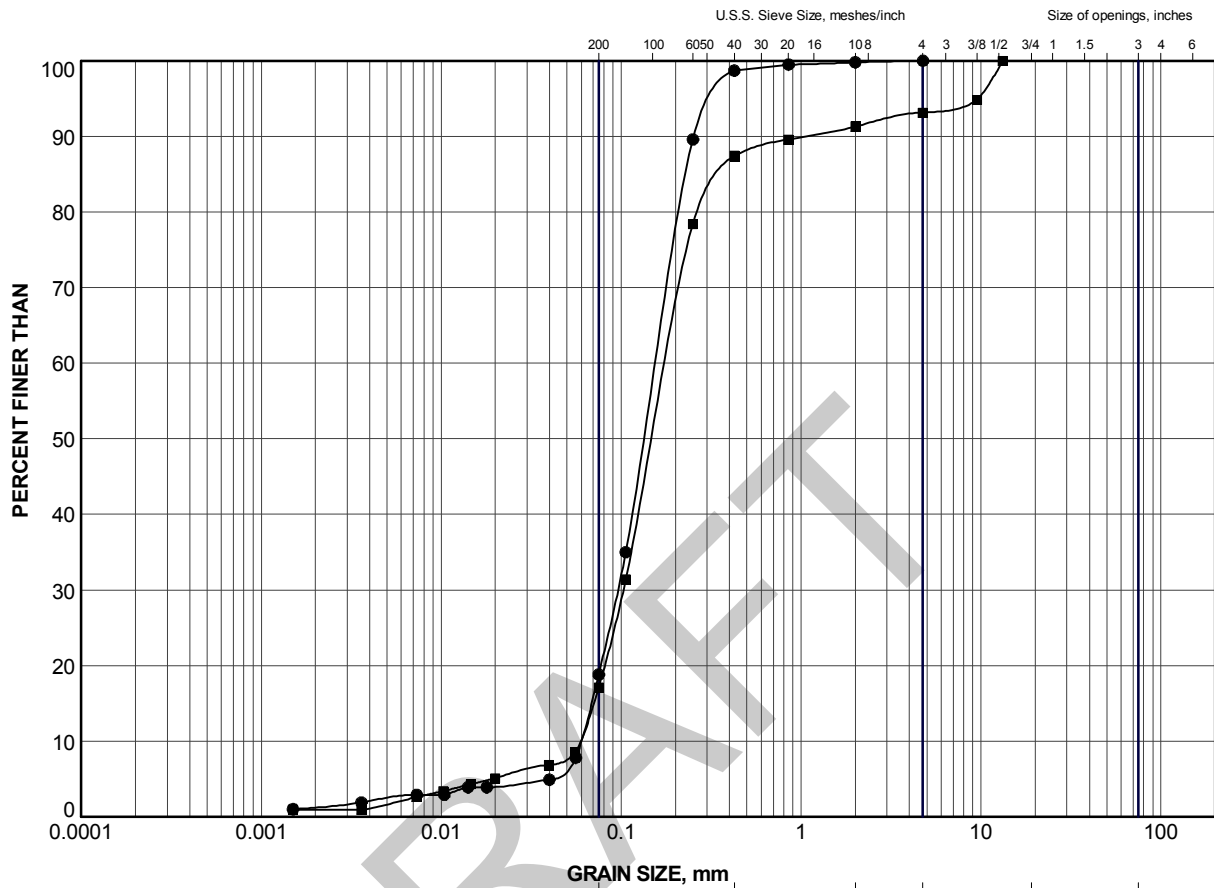
Table B1: Summary of Analytical Testing of Sandlink Creek Water Sample

Parameter	Units	Result
Chloride (CL)	mg/L	2.19
Sulphate (SO4)	mg/L	0.86
Conductivity (EC)	µS/cm	201
Resistivity	ohms*cm	4975
pH	n/a	7.77

Notes:

1. Sample obtained on December 9, 2014.
2. Analytical testing carried out by ALS Canada Ltd.


Prepared by: AC
Checked by: DAM
Reviewed by: JMAC

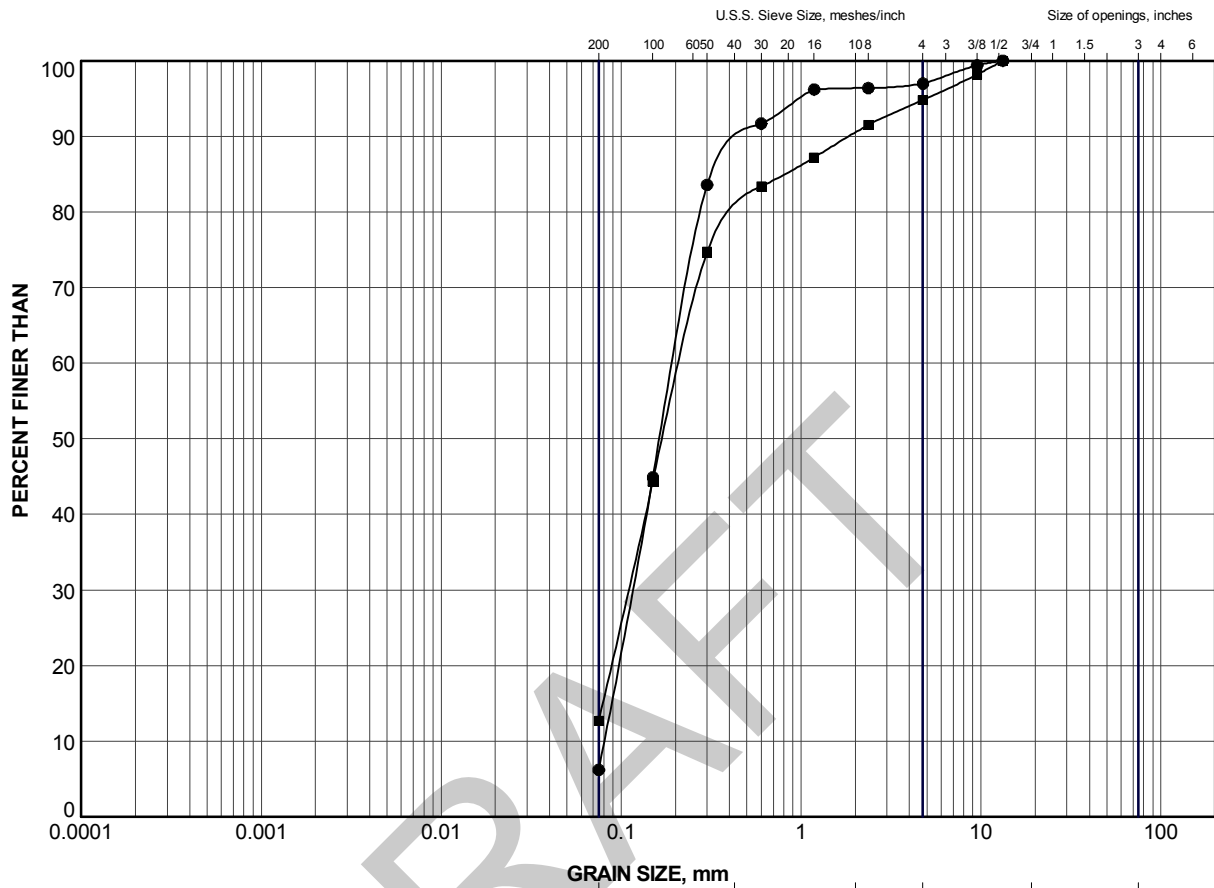


GRAVEL SIZE, mm							Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	SL-2	1	330.4
■	SL-3	2	329.4


PROJECT					
HIGHWAY 625 SANDLINK CREEK CULVERT STA 10+041					
TITLE					
GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	TB	Mar 2015	SCALE	N/A	REV.
CHECK	DAM	Mar 2015			
APPR	JMAC	Mar 2015			
 Golder Associates SUDBURY, ONTARIO			FIGURE B1		

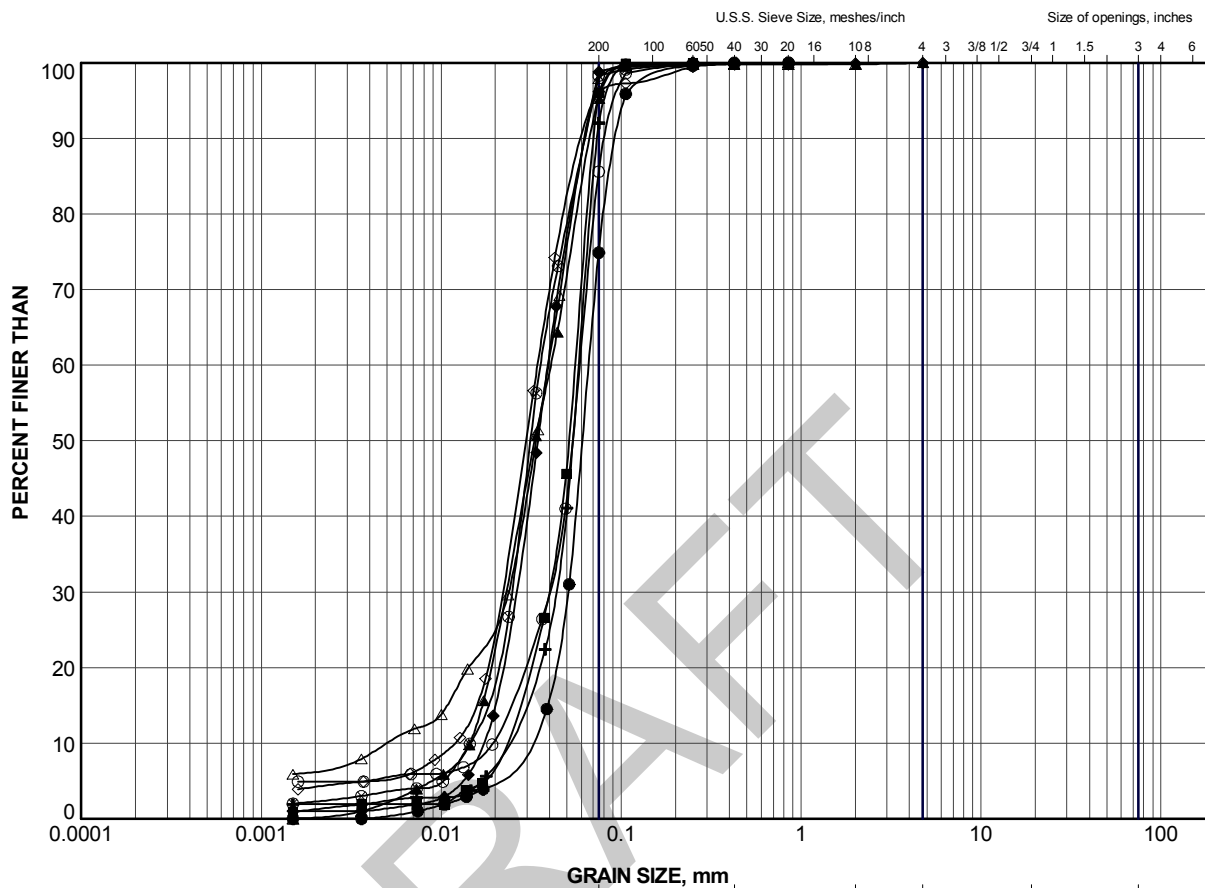


CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	SL-1	2	328.1
■	SL-4	1	330.3

PROJECT					HIGHWAY 625 SANDLINK CREEK CULVERT STA 10+041				
TITLE					GRAIN SIZE DISTRIBUTION SAND				
PROJECT No.			1411523		FILE No.			1411523.GPJ	
DRAWN	TB	Mar 2015	SCALE	N/A	REV.				
CHECK	DAM	Mar 2015							
APPR	JMAC	Mar 2015							
 Golder Associates SUDBURY, ONTARIO			FIGURE B2						



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	SL-1	5	325.8
■	SL-1	8	323.6
▲	SL-2	6	326.6
+	SL-2	8	323.6
◆	SL-3	7	324.8
◇	SL-4	3	328.8
○	SL-4	7	325.7
△	SL-5	4	327.0
⊗	SL-5	7	324.9

PROJECT

HIGHWAY 625
SANDLINK CREEK CULVERT STA 10+047

TITLE

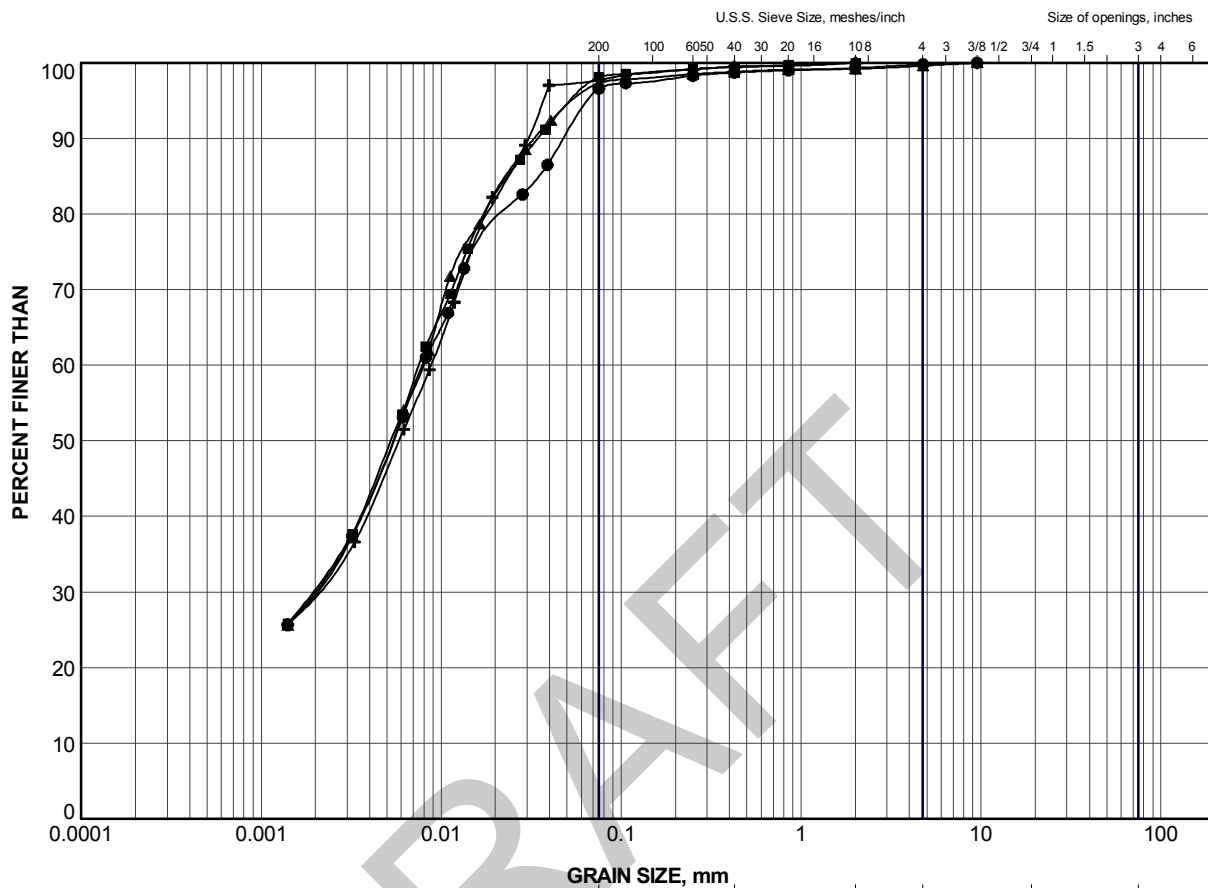
GRAIN SIZE DISTRIBUTION


SILT to SANDY SILT



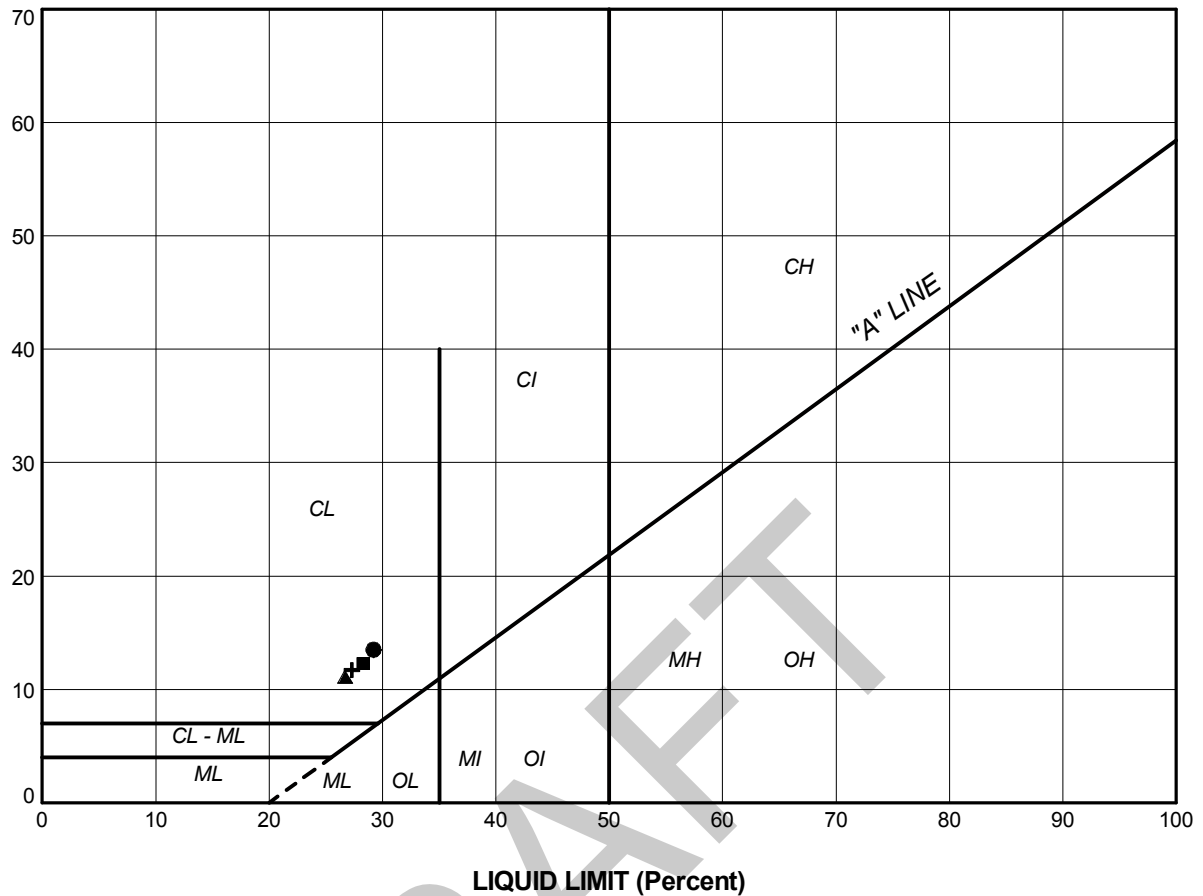
Golder Associates
SUDBURY, ONTARIO

PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016	FIGURE B3		
APPR	JMAC	Mar 2016			



PROJECT					
HIGHWAY 625 SANDLINK CREEK CULVERT STA 10+041					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	TB	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016			
APPR	JMAC	Mar 2016			
 Golder Associates SUDBURY, ONTARIO			FIGURE B4		

PLASTICITY INDEX (Percent)



SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	SL-1	10	29.2	15.7	13.5
■	SL-2	9	28.3	16.0	12.3
▲	SL-3	10	26.7	15.6	11.1
+	SL-5	10	27.3	15.6	11.7

PROJECT					
HIGHWAY 625 SANDLINK CREEK CULVERT STA 10+041					
TITLE					
PLASTICITY CHART CLAYEY SILT					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016	FIGURE B5		
APPR	JMAC	Mar 2016			





APPENDIX C

Non-Standard Special Provisions

UNWATERING OF STRUCTURE EXCAVATION - Item No.

Non-Standard Special Provision

Construction of the culvert will require excavations to extend below the groundwater level and the adjacent creek water level at both ends of the culvert. The embankment sand fill, peat and silt to sandy silt deposits if encountered within the excavation area, as may be present below the groundwater table will slough, run, boil or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate excavation protection and unwatering system to enable construction and prevent disturbance to the founding soils.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

SUBGRADE PROTECTION – Item No.

Non-Standard Special Provision

Scope of Work

The silt to sandy silt subgrade at this site is susceptible to disturbance and loosening from construction traffic and ponded water. Any loosened or disturbed soils below the plan limits of the proposed works should be sub-excavated and replaced with compacted engineered fill. A 300 mm thick protection layer, or bedding layer, comprised of Granular A or Granular B Type II material should be placed in a timely manner after inspection and approval of the subgrade condition. The subgrade should be inspected and approved immediately before placing the bedding layer to confirm the subgrade conditions are suitable for the construction of the culvert.

Basis of Payment

Payment at the lump sum contract price for the above tender item includes full compensation for all labour, equipment and material for completion of the work.

END OF SECTION

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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