



May 4, 2016

FOUNDATION INVESTIGATION AND DESIGN REPORT

**HELEN LAKE CULVERT - SITE NO. 48C-190/C
HIGHWAY 11, NIPIGON, DISTRICT OF THUNDER BAY
UNSURVEYED TERRITORY
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6909-12-00 W.P. 6907-12-01**

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GEOCRES No.:52H-37

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REPORT





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PART A

DETAIL FOUNDATION INVESTIGATION REPORT
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HIGHWAY 11, NIPIGON, DISTRICT OF THUNDER BAY
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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 Helen Lake culvert (Site No. 48C-190/C). The Helen Lake culvert is located in the District of Thunder Bay, Unsurveyed Territory on Highway 11 at STA 12+037, approximately 5 km north of the Highway 11 and Highway 17 junction in Nipigon, Ontario. The key plan showing the general location of this section of Highway 11 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The Helen Lake culvert consists of a concrete box the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report. It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purposes of this report Highway 11 is oriented in a north-south direction for this section of roadway with the culvert perpendicular to the highway in a west-east orientation.

The topography on the west side of the highway consists of low-lying swampy terrain that forms the shoreline of Helen Lake. Dense tree cover is present beyond the highway right-of-way on the east side of the road. The creek water flows westerly across Highway 11 via the culvert and drains into Helen Lake. A creek channel has formed within the shoreline on the west side of the highway. Helen Lake in-turn drains southerly into Lake Superior via the Nipigon River.

At the culvert location, the highway grade is at Elevation 187.1 m and the existing culvert invert, based on drawings provided by MTO, is at Elevation 184.6 m and 184.2 m at the culvert inlet and outlet, respectively. The creek water level was measured by others on May 8, 2013 at Elevation 184.5 m at the culvert outlet. The creek water level was measured by Golder on December 10, 2015 at Elevations 184.3 m and 184.2 m at the culvert inlet and outlet, respectively. Surface conditions in the culvert inlet and outlet areas are shown on Photographs 1 to 4, attached.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between December 8 and 10, 2015, during which time three boreholes (Boreholes HL-1 to HL-3) were advanced at the approximate locations shown on Drawing 1. Boreholes HL-1 and HL-3 were advanced at the toe of the embankment slope near the culvert outlet/inlet, respectively, and Borehole HL-2 was advanced from the existing highway platform. Borehole HL-1 was advanced with a portable tripod rig using NW casing and wash boring techniques. Boreholes HL-2 and HL-3 were advanced with a CME 750 buggy-mounted drill rig using 108 mm inside diameter hollow stem augers. Both drills rigs were supplied and operated by RPM Drilling Ltd. of Thunder Bay, Ontario.

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 half weight hammer tripod from the stipulated Standard Penetration Test (SPT) height at Borehole HL-1 and by an automatic hammer at Borehole HL-2 and HL-3, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Sampled of the cohesive soils were obtained using



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76 mm O.D. thin walled Shelby Tubes (ASTM D1587) for relatively undisturbed samples. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573) using MTO Standard 'N' size vanes. The groundwater level in the open boreholes was 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 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 Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions and Atterberg limits were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the creek water at the inlet of the culvert was obtained on December 22, 2015, 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 as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to the highway centerline and existing culvert and converted into northing/easting coordinates on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MTO (drawing E4908811111.dwg). The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location 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) |
|-----------------|------------------------|-----------------------|------------------------------|--------------------|
| HL-1 | 5436693.5 | 212105.0 | 184.8 | 9.8 |
| HL-2 | 5436701.2 | 212118.5 | 187.1 | 12.8 |
| HL-3 | 5436718.1 | 212119.8 | 185.8 | 11.3 |

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)¹ mapping, the subsurface conditions in the vicinity of the Helen Lake culvert site generally consist of bedrock knobs, bordered by glaciolacustrine deposits comprised of sand, silt and clay and ground moraine deposits comprised of sand till.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)², the site is underlain by metasedimentary rocks comprised of wacke, arkose, argillite, slate, marble, chert, iron formations and minor metavolcanic rocks.

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52HSE



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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 detailed results of geotechnical laboratory testing are contained in Appendix B. The portable tripod used to advance Borehole HL-1 utilized a half weight hammer and the SPT 'N'-values presented on the Record of Borehole Sheet and presented below in Section 4 for this borehole have been adjusted to the inferred values that would be obtained using a standard weight hammer. The CME 750 drill rig used to advance Boreholes HL-2 and HL-3 utilized a full weight hammer and the SPT 'N'-values for these boreholes are uncorrected. The 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 profile 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.

In summary, the subsoil conditions encountered at the site consist of asphalt, granular fill and cobble and boulder fill (rip rap) underlain by deposits of topsoil/peat, sand and gravel, silt, clayey silt to silty clay, and silty sand. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

| Deposit/Layer Description | Boreholes | Deposit Thickness (m) | Deposit Surface Elevation (m) | N Values (blows)/ Shear Strength | Laboratory Testing |
|--|--------------|-----------------------|-------------------------------|--|--|
| | | | | Relative Density or Consistency | |
| Asphalt | HL-2 | 0.140 | 187.1 | n/a | n/a |
| (FILL) Sand and Gravel, trace to some silt; brown; moist | HL-2 | 1.9 | 187.0 | N = 16 – 23 Compact | w = 3% 1 – M (Fig. B1) |
| (FILL) Cobbles and Boulders (rip rap) | HL-3 | 0.6 | 185.8 | n/a | n/a |
| Topsoil/Peat; fibrous, black, wet | HL-1 to HL-3 | 0.2 – 0.3 | 185.2 – 184.8 | n/a | n/a |
| Sand and Gravel, trace silt; brown, wet | HL-1 | 0.2 | 184.5 | n/a | n/a |
| Silt ¹ , trace to some sand, trace organics (slightly plastic); brown to grey; wet | HL-1 to HL-3 | 2.4 – 3.7 | 185.0 – 184.3 | N = 0 (weight of hammer) – 8 Very Loose to Loose | w = 29% - 36% w _p = 25% - 28% w _i = 31% - 37% I _p = 5% - 10% 4 – MH (Fig. B2) 5 – AL (Fig. B3) |

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



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| Deposit/Layer Description | Boreholes | Deposit Thickness (m) | Deposit Surface Elevation (m) | N Values (blows)/ Shear Strength | Laboratory Testing |
|---|--------------|--|-------------------------------|---|---|
| | | | | Relative Density or Consistency | |
| Clayey Silt to Silty Clay ² , grey; wet | HL-1 to HL-3 | 5.9 – >7 (fully penetrated in HL-2 HL-1 and HL-3 terminated in this deposit) | 181.9 – 181.1 | N = 0 (weight of hammer) – 4 s _u = 19 – 43 S = 1 – 2 | w = 30% - 39% w _p = 19% - 25% w _l = 30% - 43% I _p = 12% - 17% 2 – MH (Fig. B4) 4 – AL (Fig. B5) |
| | | | | Soft to Firm | |
| Silty Sand ³ , trace gravel, grey; wet | HL-2 | >0.9 (terminated in this deposit) | 175.2 | N = 10 | n/a |
| | | | | Compact | |

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
 s_u = Undrained shear strength (kPa)
 S = Sensitivity
 M = Sieve analysis
 MH = Combined sieve and hydrometer analysis
 w = Natural moisture content (%)
 w_p = Plastic limit (%)
 w_l = Liquid limit (%)
 I_p = Plasticity index (%)
 AL = Atterberg limits test

Notes:

1. Approximately 5 mm to 25 mm peat laminations/seams were noted within the silt deposit.
2. Silt laminations were noted within the clayey silt to silty clay deposit.
3. Silty clay laminations were noted within the silty sand deposit.

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek water level was measured on December 10, 2015 at Elevation 184.3 m and 184.2 m at the culvert inlet and outlet, respectively. 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) |
|--------------|--------------------------------|---------------------------|
| HL-1 | 0.5 ¹ | 184.3 ¹ |
| HL-2 | dry | n/a |
| HL-3 | 5.5 | 180.3 |

Note:

¹ Borehole HL-1 was advanced using NW casing and wash boring techniques. As such, the water level may not be representative of in-situ groundwater conditions.



Analytical Testing of Creek Water

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 include pH, sulphate, chloride, resistivity and conductivity.

4.3 Supplemental Foundation Investigation (By Others)

MTO retained the services of DST Consulting Engineers Inc. (DST) to carry out a subsequent foundation investigation to supplement Golder's detailed design foundation investigation at the Helen Lake culvert site. The supplemental foundation investigation consisted of drilling one borehole (BH-1) located approximately 10 m north of the culvert. The approximate location of Borehole BH-1, based on the station and offset information provided by DST, is shown in plan on Drawing 1. A copy of DST's "Draft Supplementary Foundation Investigation Factual Report, Highway 11 – Helen Lake Culvert, 5.12 km North of Hwy 11/17, Unsurveyed Territory, District of Thunder Bay" (dated March 29, 2016), which was provided by Hatch on March 31, 2016, is included in Appendix C.

5.0 CLOSURE

Golder's field drilling program was carried out under the supervision of Mr. Randy Axford under the overall direction of Mr. Adam Core, P.Eng and 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 Principal of Golder, conducted an independent quality control review of this report.



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Report Signature Page

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PART B

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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 Helen Lake culvert. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during Golder's subsurface investigation. Where comments are made on construction, they are provided to highlight those aspects that could affect the future detail design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should 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 Helen Lake culvert is located in the District of Thunder Bay in Unsurveyed Territory on Highway 11 at STA 12+037, approximately 5 km north of the Highway 11 and Highway 17 junction in Nipigon, Ontario. The highway embankment is constructed of granular fill material and is about 2.9 m high (relative to the existing culvert invert) with approximately 1.1 m of soil cover over the culvert. The existing culvert consists of a concrete box, the details of which (i.e., width, height, length, etc.) are summarized in Table 1.

A box culvert, open footing culvert and pipe culvert are all considered feasible for replacement of the existing structure at this site, however from a foundation perspective a box type culvert sufficiently wide to handle the creek flow is preferred. An open footing culvert although feasible, presents additional challenges as it will extend the construction schedule and increase the excavation, dewatering and shoring requirements, when compared to a closed box culvert. A pipe culvert is also considered a feasible replacement alternative at this site, however provides less flow-through capacity compared to box a culvert or open footing culvert with a similar span, and if constructed from steel may have a shorter design life. A different culvert type may be preferred due to construction staging or other considerations such as fisheries requirements related to natural channel substrate. A comparison of culvert types based on advantages, disadvantages and risks/consequences is presented in Table 2.

As outlined in the request for proposal, and based on discussions with Hatch, we understand that the new culvert is to be comprised of a pre-cast, single-cell, concrete box approximately 3.6 m wide by 1.8 m high with the invert at Elevation 183.5 m at both the inlet and outlet ends. We understand there is no proposed embankment grade raise or widening in the area of the culvert as part of the Highway 11 reinstatement.

6.2 Geotechnical Resistance

For a 3.6 m wide replacement box culvert founded constructed on a granular bedding layer overlying the properly prepared silt subgrade at Elevation 182.9 m (taking into account the proposed invert Elevation, a 0.3 m thick concrete bottom slab and a 0.3 m thick bedding layer), a factored geotechnical axial resistance of 80 kPa at Ultimate Limit States (ULS) and a geotechnical reaction of 65 kPa at Serviceability Limit States (SLS), for 25 mm of settlement, may be used for design.

The existing culvert inferred to be founded on the silt deposit, which is noted to contain multiple peat seams/layers each between about 5 mm and 25 mm thick, and over time a similar structure founded on the site



stratum may experience some settlement due to compression and/or decomposition of the peat seams/layer. However, as there is no grade raise and/or widening being proposed at this site and the replacement culvert is of similar span dimensions and about 0.6 m higher compared to that of the existing culvert, there will be a slight reduction in the loading conditions and therefore further compression of the peat seams/layers is not anticipated. In addition, as the peat seams/layers are below the measured creek levels, and will likely be saturated, the risk of decomposition of the organic materials is considered to be relatively low.

Consideration could be given to sub-excavating the 2.4 m to 3.7 m silt deposit which contains organics and peat lenses and replacing it, or a portion of it, with compacted engineered fill; however, there is a risk that long-term, post-construction settlements of underlying compressible clayey silt to silty clay deposit could occur due to the additional loading from the replacement fill. While a slight increase in the geotechnical resistances would be expected for the condition of founding the box culvert on the replacement granular backfill, a greater potential would then exist for settlement of the granular fill/culvert due to compression of the underlying cohesive deposit as noted. If sub-excavation of the silt deposit is considered, then additional laboratory consolidation testing and settlement analysis should be performed to determine the potential magnitude and time rate of settlement.

The geotechnical resistance/reaction provided above 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 its Commentary.

The structural engineer should give consideration to the sequence and staging of construction when utilizing the geotechnical axial resistance at SLS in the design of the culvert as the loading conditions on the foundation soils below the culvert and the associated settlements at the culvert location will be governed by the magnitude of the loading impeded by the overlying and adjacent embankment fill. The geotechnical axial resistance at SLS should be reviewed by the Foundations Engineer if a grade raise and/or widening is incorporated into the design.

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 (i.e., bedding layer) is $\tan \delta = 0.45$.

6.3 Stability, Settlement and Horizontal Strain

6.3.1 Stability

Limit equilibrium slope stability analysis was carried out for the re-constructed highway embankment using the commercially available program GeoStudio 2007 (Version 7.23), produced by Geo-Slope International Ltd., employing the Morgenstern-Price method of analysis. For the analyses, the Factor of Safety (FoS) of numerous



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potential surfaces was computed to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure.

The associated strengths and unit weights of the embankment and subsurface strata materials employed for the slope stability analysis are summarized below.

| Soil Deposit | Bulk Unit Weight (kN/m ³) | Effective Friction Angle (°) | Undrained Shear Strength (kPa) |
|--|--|---------------------------------|-----------------------------------|
| New Granular Embankment Fill (compacted) | 21 | 35 | - |
| Silt (very loose to loose) | 18 | 28 | |
| Clayey Silt to Silty Clay (soft to firm) | 17 | - | 25 |
| Silty Sand (compact) | 19 | 30 | - |

The results of the analysis indicate that a FoS greater than 1.3 is achieved for the approximately 2.3 m high re-constructed granular fill embankment at side slopes of 2H:1V or flatter. This analysis assumes that there is no grade raise or widening at the culvert site.

6.3.2 Settlement and Horizontal Strain

Given that an embankment grade raise or widening is not proposed as part of the culvert replacement and highway embankment re-construction, 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 the permanent embankment geometry is not changing from the current (existing) geometry. As a result, culvert construction concurrent with the embankment construction can be carried out without the need for any foundation mitigation measures or provisions for a culvert camber.

6.4 Lateral Earth Pressures

The lateral earth pressures acting on the side walls 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 culvert. 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



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for a thickness of at least 300 mm. Backfill should be placed in a maximum of 200 mm loose lift thickness. Weep holes should be installed to provide positive drainage of the granular backfill.

- For restrained culvert walls, granular fill should be placed in a zone with the width not less than the depth of front penetration, which at this site is equal to at least 2.4 m (OPSD 3090.100 – Foundation Frost Penetration Depths) behind the back of the walls (see Figure C6.20(a) of the Commentary to the CHBDC). The pressures are based on the proposed embankment fill material and the following parameters (unfactored) may be used:

| Fill Type | Internal Angle of Friction (ϕ) | Unit Weight (γ , kN/m ³) | Coefficients of Lateral Earth Pressure | | |
|----------------------------|---------------------------------------|--|--|----------------|----------------|
| | | | Active, K_a | At-Rest, K_o | Passive, K_p |
| Granular 'A' | 35° | 22 | 0.27 | 0.43 | 3.69 |
| Granular 'B' Type II | 35° | 21 | 0.27 | 0.43 | 3.69 |
| Granular 'B' Type I or III | 32° | 21 | 0.31 | 0.47 | 3.25 |

6.5 Culvert Construction Considerations

6.5.1 Construction Staging and Temporary Roadway Protection

We understand that staged construction is being considered at this site for replacement of the culvert. Based on the preliminary General Arrangement drawing provided by Hatch, we understand that the creek flows will be diverted via a temporary diversion pipe to be installed approximately 10.5 m north of the existing/replacement culvert. The sketches of the proposed staging operation provided by Hatch indicate staging considerations generally as follows:

- Stage 1: install temporary roadway protection along the highway centerline; divert traffic to the west side of the road; and install the temporary diversion pipe on east side.
- Stage 2: divert traffic to the east side of the road; install the temporary diversion pipe on west side; and remove/replace the west portion of the existing culvert with the new culvert portion.
- Stage 3: divert traffic to the west side of the road; replace the east portion of the existing culvert with the new culvert section; and remove the east portion of the temporary diversion pipe.
- Stage 4: divert traffic to the east side of the road; and removed west portion of the temporary diversion pipe.

The temporary excavation for the culvert replacement will be made through the existing embankment granular fill and peat layer and into the very loose to loose native silt deposit. 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 fill is considered to be Type 3 soil above the groundwater table and Type 4 soil below; whereas the silt deposit is considered to be Type 4 soil. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are formed no steeper than 1 Horizontal to 1 Vertical (1H:1V). In Type 4 soils, the side slopes should be formed no steeper than 3H:1V.



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Temporary protection support systems will be required along the highway to facilitate construction staging and maintain traffic during culvert replacement work. 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 roadway.

The temporary support systems may be designed using the following parameters:

| Soil Type | Unit Weight (γ , kN/m ³) | Internal Angle of Friction (ϕ , degrees) | Cohesion (c_u , kPa) | Coefficient of Earth Pressure | | |
|---|---|---|----------------------------|-------------------------------|------------------|------------------|
| | | | | Active K_a | At Rest K_o | Passive K_p |
| Existing Granular Fill (compact) | 20 | 32 | - | 0.31 | 0.47 | 3.25 |
| Peat/Topsoil (very loose) | 12 | 27 | 1 | 0.38 | 0.55 | 2.64 |
| Silt (very loose to loose) | 18 | 28 | - | 0.36 | 0.53 | 2.77 |
| Clayey Silt to Silty Clay (soft to firm) | 17 | 27 | 20 | 0.38 | 0.55 | 2.66 |
| Silty Sand (compact) | 18 | 30 | - | 0.33 | 0.50 | 3.00 |

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 earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

The silt and clayey silt to silty clay deposits are sensitive to disturbance from vibration and/or driving, which should be considered in the design and installation of the temporary support systems. Design of the temporary support system should also 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 Below Culvert

Prior to placement of any bedding material, granular fill or concrete working slab if required, all organics (including peat, topsoil and mixed organic soil materials) and any disturbed 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. Following inspection, the sub-excavated area should be backfilled in a



timely manner with granular material meeting the requirements of an OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III that is placed and compacted in accordance with OPSS.PROV 501 (Compacting). The use of Granular 'B' Type II is recommended in wet ground conditions or below water.

6.5.3 Culvert Bedding

The sub-excavation backfill, 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. Given the potential presence of groundwater/surface water, we do not recommend that Granular B Type I or III, nor any materials from the Group II list in OPSS 422, 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 95 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 fine concrete aggregate meeting the grading requirements specified in OPSS.PROV 1002 (Aggregates – Concrete) should be provided similar to that presented on OPSS 803.010 (Backfill and Cover for Concrete Culverts).

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.

6.5.4 Backfill

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 as per OPSS 422 (Precast Reinforced Concrete Box Culverts).

Given that the native silt at this site is classified as highly frost susceptibility, a frost taper should be constructed with a similar geometry deposit to that provided in Section B-B (Frost Penetration Line Below Top of Culvert) of OPSS 803.010 (Backfill and Cover for Concrete Culverts) with the backfill extending a minimum of 2.4 m horizontally from the culvert walls as indicated above in Section 6.4 "Lateral Earth Pressures".

Backfill placement for reconstruction of the roadway embankments over and along the culvert should be carried out as per OPSS 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and new fill along the cut faces.



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.

6.5.5 Subgrade Protection

The native silt subgrade will be susceptible to disturbance from construction traffic and/or ponded water. To limit the effect of this disturbance, a 300 mm thick granular bedding layer should be placed in a timely manner, once the foundation subgrade has been inspected and approved. Consideration should be given to include an NSSP in the contract to address subgrade protection at this site. An example NSSPs for subgrade protection to be included in the Contract is presented in Appendix D.

6.5.6 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 concrete cut-off wall or a clay seal 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 of 1 m, thick 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 equal to the frost penetration depth on either side of the culvert inlet opening. If a geosynthetic clay liner (GCL) is utilized in lieu of the clay seal, the GCL should be constructed within the embankment slope to allow for a minimum 0.3 m thick granular (embankment) fill cover to be placed over the GCL to provide for protection from the requisite overlying erosion protection material.

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. Similarly, rip rap should be provided over the full extent of the clay seal or GCL.

6.5.7 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, some groundwater flow or seepage into the excavation can be expected due to the relatively permeable nature of the adjacent embankment fill. 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.



Although a pre-cast concrete box culvert can be placed in wet conditions, given the presence of the relatively permeable embankment fill, it is anticipated that dewatering within the excavation will be required to allow for preparation of the subgrade soils and proper placement and compaction of the bedding material. 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, which should be considered in the design and installation of the dewatering system.

Dewatering of all excavations should be carried out in accordance with OPSS 517 (Dewatering). It is recommended that an NSSP be included in the Contract to address dewatering for the culvert site; a sample NSSP is included in Appendix D.

Provided that the creek flow is diverted and the dewatering system is installed to a suitable depth to mitigate groundwater inflows, pumping volumes are not anticipated to exceed 50 m³/day. However, an application for a Permit to Take Water (PTTW) should be submitted in the event that the pumping volumes exceed this amount.

6.5.8 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 (pH, sulphate, chloride, resistivity and conductivity) tested is intended to allow the design engineer to assess the potential for the creek/lake water to cause deterioration of concrete and corrosion to steel.

For a potential sulphate attack on concrete, the results of the water analysis were compared to Table 3 in CSA A23.1-09, indicate that the relative degree of sulphate attack is low (i.e. less than the moderate range). However, given that the location of the culvert location is on Highway 11 and will be exposed to de-icing salts, it is recommended that C-1 class exposure concrete be considered for construction of the culvert.

The resistivity results indicate that the creek water has a moderate corrosiveness potential based on the Transportation Research Board Guidelines (Transportation Research Board, National Research Council, 1998). It should be noted that the creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events and the water chemistry could be variable.

These recommendations are provided as guidance only; the structural designer should assess the results of the laboratory testing and potential for concrete deterioration and corrosion into consideration when selecting the materials for the replacement culvert.

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., Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review of this report.



FOUNDATION REPORT HELEN LAKE CULVERT - SITE NO. 48C-190/C

Report Signature Page

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

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

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

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52HSE

Transportation Research Board, National Research Council, 1998, "Service Life of Drainage Pipe", National Cooperative Highway Research Program (NCHRP) Synthesis 254.

ASTM International:

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

ASTM D1587 Standard Practice for Thin-Walled Tube Sampling for Soils for Geotechnical Purposes

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 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 208.010 Benching of Earth Slopes

OPSD 803.010 Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m



FOUNDATION REPORT HELEN LAKE CULVERT - SITE NO. 48C-190/C

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

OPSD 3090.100 Foundation, Frost Penetration Depths for Northern Ontario

Ontario Water Resource Act:

Regulation 903 Wells (as amended)



FOUNDATION REPORT HELEN LAKE CULVERT - SITE NO. 48C-190/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) | East End of Culvert (m) | West End of Culvert (m) |
| Hwy 11 STA 12+037 | 48C-190/C | 2.9 | Concrete Box | 3.65 m wide x 1.25 m high | 25.2 | 184.6 | 184.2 |

- Notes:
1. Embankment height is relative to existing ground surface at the centreline of the roadway and the existing culvert invert.
 2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (Drawing E490881111.dwg).

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



FOUNDATION REPORT HELEN LAKE CULVERT - SITE NO. 48C-190/C

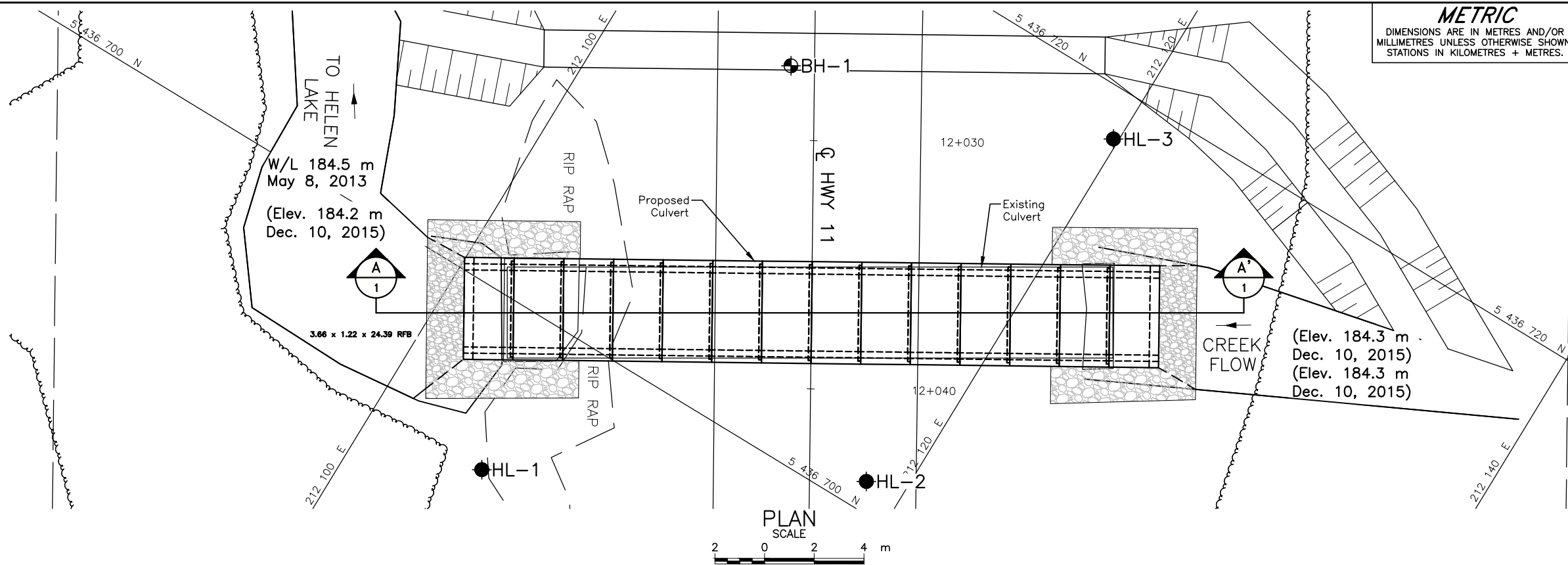
Table 2: Comparison of Foundation Alternatives

| Option | Advantages | Disadvantages | Risks/Consequences |
|----------------------|--|--|---|
| Pre-Cast Box Culvert | <ul style="list-style-type: none"> Minimizes depth of excavation, protection system and dewatering requirements compared to the open footing option. Allows faster construction resulting in shorter duration for dewatering and surface water pumping. More tolerant of total and differential settlement if the highway embankment is raised or widened at the culvert site or if heave/settlement occurs resulting from freeze/thaw of the subgrade. Backfill/bedding under the culvert may be placed underwater (i.e. Granular 'B' Type II) minimizing or eliminating water pumping requirements. | <ul style="list-style-type: none"> May not satisfy fisheries requirements related to natural channel substrate, if applicable. Cut-off wall (or clay blanket) required at inlet to mitigate potential scour under culvert. Transportation to and on-site lifting of large pre-cast sections will be required. May require water diversion of a relatively wide creek channel. | <ul style="list-style-type: none"> Some risk of disturbance of the native silt deposit during construction; can be mitigated with use a tremie concrete working slab or a Granular 'B' Type II working pad/bedding. Low risk related to settlement performance as box segments can accommodate total and differential settlement (if required). |
| Open Footing Culvert | <ul style="list-style-type: none"> May be feasible to construct the culvert on pre-cast footing sections, to accelerate construction schedule and reduce time for dewatering (pumping) of surface water. Existing culvert can likely be used for water diversion while new footings are being constructed adjacent to the existing culvert depending on the width of the new culvert. Readily suitable for construction using concrete or metal sections. Would likely satisfy fisheries requirements related to natural channel substrate, if applicable. | <ul style="list-style-type: none"> Excavation depths are greater than for a concrete box or pipe culvert option, resulting in increased excavation support and dewatering requirements, and additional spoil material to be disposed off-site whether the footings are pre-cast or cast-in-place. Constructing footings in the dry will take longer due to requirements for installation of a groundwater and surface water control system, dewatering and surface water pumping, and excavation in a confined space, and would require a tremie concrete plug to allow for subsequent dewatering and footing construction. Less tolerant of total and differential settlement if the highway embankment is raised or widened at the culvert site. Concrete or metal arch sections supported on concrete open (strip) footings may not allow for adequate soil cover to be placed including the roadway pavement structure and the long-term performance of such structures is not known. More onerous excavation/protection/construction operations on footing would be founded within a soft to firm clayey silt/silty clay stratum (below frost) penetration depth requiring penetration through the overlying very loose/loose silt stratum | <ul style="list-style-type: none"> High risk of disturbance of the native silt deposit during construction; can be mitigated with use of a tremie concrete working slab or Granular 'B' Type II pad. May require greater depth of dewatering/ dewaterin for footing construction. Culvert joints may be required to accommodate total and differential settlement (if required). |



FOUNDATION REPORT HELEN LAKE CULVERT - SITE NO. 48C-190/C

| Option | Advantages | Disadvantages | Risks/Consequences |
|-----------------|---|---|---|
| Pipe Culvert(s) | <ul style="list-style-type: none">■ Allows for faster construction resulting in shorter duration for dewatering and surface water pumping compared to an open footing culvert.■ More tolerant of total and differential settlement if the highway embankment is raised or widened.■ Backfill under the culvert may be placed underwater (i.e. Granular 'B' Type II) minimizing or eliminating water pumping requirements. | <ul style="list-style-type: none">■ Reduced flow-through capacity compared to box culvert and open footing options with a similar span - additional flow capacity may have to be provided by multiple pipes.■ Cut-off wall (or clay seal/blanket) may be required at inlet to mitigate potential scour under culvert(s).■ Difficult to compact backfill materials to level of culvert springline.■ CSP does not have as long a design life compared to concrete options. | <ul style="list-style-type: none">■ Some risk of disturbance of the native silt deposit during construction; can be mitigated with use of a tremie concrete working slab or Granular 'B' Type II working pad.■ Limited risk related to settlement performance. |

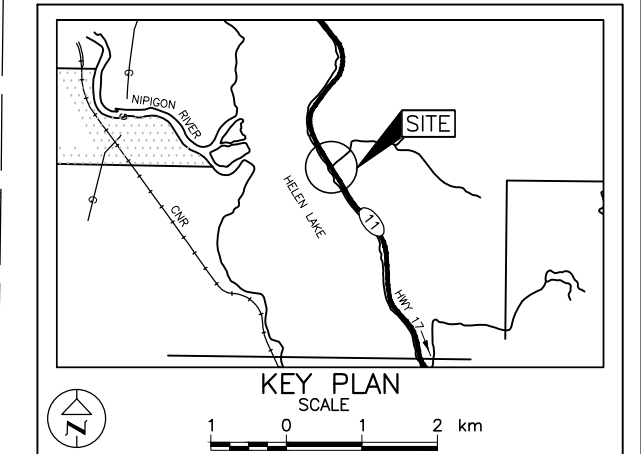


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DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.6909-12-00

HIGHWAY 11
HELEN LAKE CULVERT STA 12+037
BOREHOLE LOCATIONS AND
SOIL STRATA

SHEET



LEGEND

Borehole - Golder 2015
 Borehole - By Others
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 |
| HL-1 | 184.8 | 5436693.5 | 212105.0 |
| HL-2 | 187.1 | 5436701.2 | 212118.5 |
| HL-3 | 185.8 | 5436718.1 | 212119.8 |
| BH-1 | 187.2 | 5436713.9 | 212107.2 |

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.

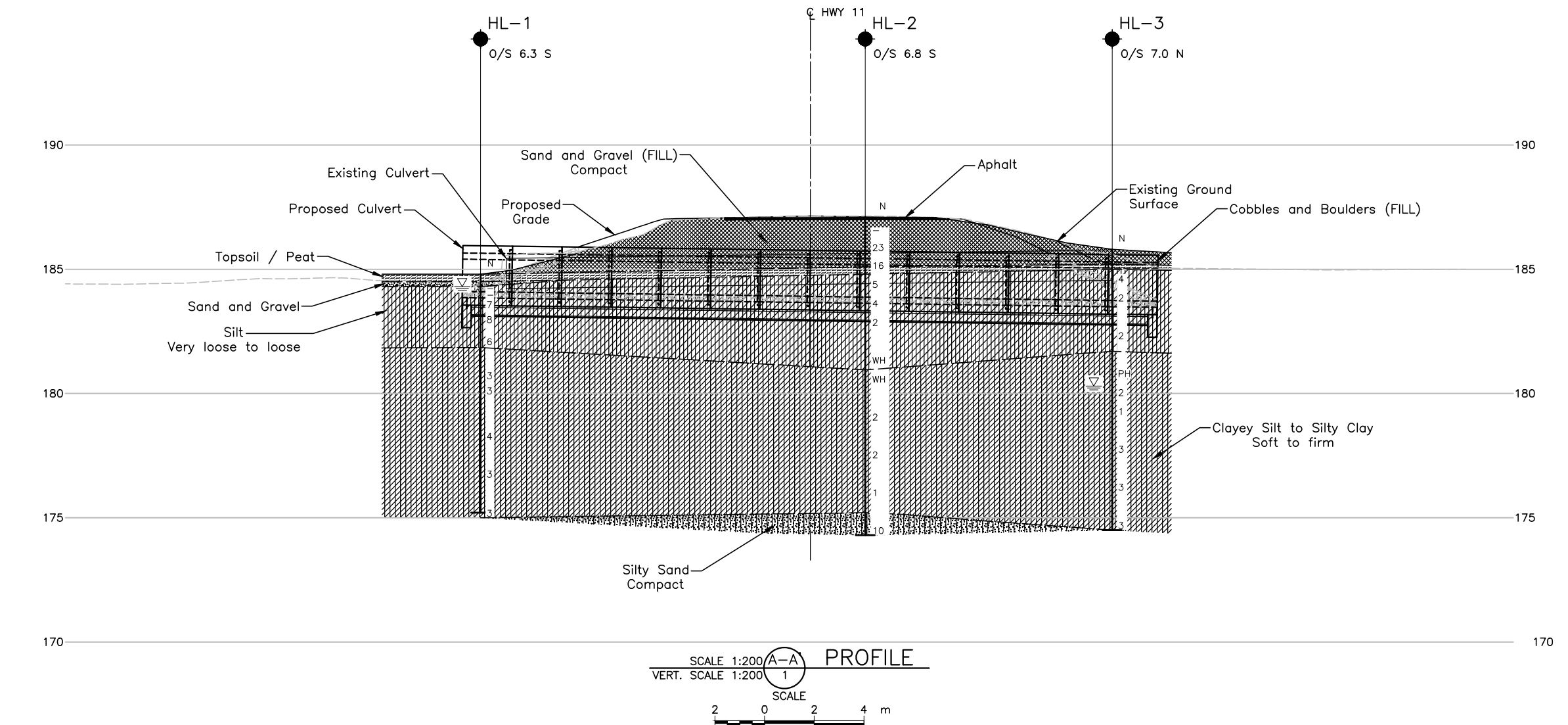
REFERENCE

Base plans provided in digital format by MTO, drawing file no. E4908811111.dwg received Dec. 11, 2015.
Culvert General Arrangement plan provided by Hach, drawing file no. ST-358767-HELEN LAKE CULVERT-01-GENERAL ARRANGEMENT.dwg received Mar. 30, 2016.

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| DRAWN: JJL | CHKD. DAM | APPD. JMAC |
| | | SITE: 48C-190/C |
| | | DWG. 1 |





PHOTOGRAPHS

**Photograph 1: Helen Lake Culvert
Looking East at Inlet (December 2015)**



**Photograph 2: Helen Lake Culvert
Looking West at Helen Lake and Outlet (December 2015)**





PHOTOGRAPHS

**Photograph 3: Helen Lake Culvert
Looking South at Inlet (December 2015)**



**Photograph 4: Helen Lake Culvert
Looking North at Inlet (December 2015)**





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 | | 1533879 | | RECORD OF BOREHOLE No HL-1 | | | | 1 OF 1 METRIC | | | | | | | | | |
|---------------|--|------------|---------|-----------------------------------|------------|----------------------------|-----------------|---|--|-----|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| G.W.P. | | 6909-12-00 | | LOCATION | | N 5436693.5; E 212105.0 | | ORIGINATED BY | | RA | | | | | | | |
| DIST | | HWY 11 | | BOREHOLE TYPE | | NW Casing and Wash Boring | | COMPILED BY | | AC | | | | | | | |
| DATUM | | GEODETIC | | DATE | | December 9 and 10, 2015 | | 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 kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | |
| 184.8 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 0.0 | TOPSOIL (300 mm) | | | | | | | | | | | | | | | | |
| 184.5 | | | | | | | | | | | | | | | | | |
| 0.5 | SAND and GRAVEL, trace silt Brown Wet | | 1 | AS | - | | | | | | | | | | | | |
| | SILT, trace to some sand, trace organics Loose Brown to grey Moist | | 2 | AS | - | | | | | | | | | | | | |
| | Two 10 mm thick peat layer seams below 1.4 m depth. | | 3 | SS | 7 | | | | | | | | | | | | 0 6 80 14 |
| | | | 4 | SS | 8 | | | | | | | | | | | | |
| | | | 5 | SS | 6 | | | | | | | | | | | | |
| 181.9 | | | | | | | | | | | | | | | | | |
| 2.9 | SILTY CLAY Firm Grey Wet | | | | | | | | | | | | | | | | |
| | No recovery in Sample 6. | | 6 | SS | 3 | | | | | | | | | | | | |
| | | | 7 | SS | 3 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 4 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | 9 | SS | 3 | | | | | | | | | | | | 0 0 77 23 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | 10 | SS | 3 | | | | | | | | | | | | |
| 175.0 | | | | | | | | | | | | | | | | | |
| 9.8 | END OF BOREHOLE | | | | | | | | | | | | | | | | |
| | Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 184.3 m) upon completion of drilling. 2. Split spoon samples obtained by drilling with a 1/2 weight hammer; SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer. | | | | | | | | | | | | | | | | |

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 18/03/16 DATA INPUT:


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

| PROJECT 1533879 | | | RECORD OF BOREHOLE No HL-2 | | | 1 OF 2 METRIC | | | | | | | | | | | | |
|-------------------|--|------------|--|------|------------|--|-----------------|--------------------|---|----------|----------------|-------------|-------------------|---|---------------------------------------|----|----|------------|
| G.W.P. 6909-12-00 | | | LOCATION N 5436701.2; E 212118.5 | | | ORIGINATED BY RA | | | | | | | | | | | | |
| DIST _____ HWY 11 | | | BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers | | | COMPILED BY AC | | | | | | | | | | | | |
| DATUM GEODETIC | | | DATE December 8, 2015 | | | 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 (%) | | | | | |
| | | | | | | | | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 | W _p | W | W _L | γ | GR | SA | SI | CL |
| 187.1 | GROUND SURFACE | | | | | | | | | | | | | | | | | |
| 0.0 | ASPHALT (140 mm) | | | | | | 187 | | | | | | | | | | | |
| 0.1 | Sand and gravel, trace to some silt (FILL) Compact Brown Moist | | 1 | AS | - | | | | | | | | | | | | | 47 44 (9) |
| | | | 2 | SS | 23 | | 186 | | | | | | | | | | | |
| | | | 3 | SS | 16 | | | | | | | | | | | | | |
| 185.1 | PEAT (Fibrous) Black Wet | | | | | | 185 | | | | | | | | | | | |
| 184.8 | SILT, trace to some sand, trace organics Very loose to loose Brown to grey Moist to wet | | 4 | SS | 5 | | | | | | | | | | | | | 0 10 78 12 |
| 2.3 | Three 25 mm thick peat layers below 3.0 m depth. | | 5 | SS | 4 | | 184 | | | | | | | | | | | |
| | | | 6 | SS | 2 | | 183 | | | | | | | | | | | |
| | | | | | | | 182 | | | | | | | | | | | |
| | | | 7 | SS | WH | | | | | | | | | | | | | 0 1 84 15 |
| 181.1 | SILTY CLAY Soft to firm Grey Wet | | 8 | SS | WH | | 181 | | | | | | | | | | | |
| 6.0 | | | | | | | 180 | | 2 | | | | | | | | | |
| | | | 9 | SS | 2 | | 179 | | | | | | | | | | | |
| | | | | | | | 178 | | 2 | | | | | | | | | |
| | | | 10 | SS | 2 | | | | | | | | | | | | | |
| | | | | | | | 177 | | 1 | | | | | | | | | |
| | | | 11 | SS | 1 | | 176 | | | | | | | | | | | |
| | | | | | | | | | 2 | | | | | | | | | |
| 175.2 | | | | | | | | | | | | | | | | | | |

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 18/03/16 DATA INPUT:

Continued Next Page

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

| PROJECT 1533879 | | RECORD OF BOREHOLE No HL-2 | | | | 2 OF 2 METRIC | | | | | | | | | | | | |
|-------------------|---|---|--------|------|----------------------------|----------------------|---|--------------------|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---|--|--|--|
| G.W.P. 6909-12-00 | | LOCATION N 5436701.2; E 212118.5 | | | | ORIGINATED BY RA | | | | | | | | | | | | |
| DIST _____ HWY 11 | | BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers | | | | COMPILED BY AC | | | | | | | | | | | | |
| DATUM GEODETIC | | DATE December 8, 2015 | | | | 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 kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | | | "N" VALUES | SHEAR STRENGTH kPa | | | | | | | | | | |
| | --- CONTINUED FROM PREVIOUS PAGE --- | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | | | | | WATER CONTENT (%) 20 40 60 | | | | | | |
| 11.9 | SILTY SAND, trace gravel Compact Grey Wet |  | 12 | SS | 10 | | 175 | | | | | | | | | | | |
| 174.3 12.8 | Silty clay laminations throughout. END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling. | | | | | | | | | | | | | | | | | |

| PROJECT 1533879 | | | RECORD OF BOREHOLE No HL-3 | | | 1 OF 2 METRIC | | | | | | | | | | | | | | | |
|-------------------|---|------------|--|------|------------|--|-----------------|--------------------|---|----------------|---|----------------|-------------------|--|---------------------------------------|---|--|--|--|--|--|
| G.W.P. 6909-12-00 | | | LOCATION N 5436718.1; E 212119.8 | | | ORIGINATED BY RA | | | | | | | | | | | | | | | |
| DIST _____ HWY 11 | | | BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers | | | COMPILED BY AC | | | | | | | | | | | | | | | |
| DATUM GEODETIC | | | DATE December 8 and 9, 2015 | | | 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 | 20 40 60 80 100 | W _p | W | W _L | 20 40 60 | | | | | | | | |
| 185.8 | GROUND SURFACE | | | | | | | | | | | | | | | | | | | | |
| 0.0 | COBBLES AND BOULDERS (FILL) | | | | | | | | | | | | | | | | | | | | |
| 185.2 | | | | | | | | | | | | | | | | | | | | | |
| 0.8 | PEAT (Fibrous) Black Wet SILT, trace sand, trace organics Very loose Brown to grey Moist Two 5 mm thick peat laminations between 1.5 m and 4.1 m depth. | | 1 | SS | 4 | | 185 | | | | | | | | | | | | | | |
| | | | 2 | SS | 2 | | 184 | | | | | | | | | | | | | | |
| | | | | | | | 183 | | | | | | | | | | | | | | |
| | | | 3 | SS | 2 | | 182 | | | | | | | | | | | | | | |
| | | | | | | | 181 | | | | | | | | | | | | | | |
| 181.5 | CLAYEY SILT to SILTY CLAY, trace sand Soft to firm Grey Wet Silt laminations to 5.2 m depth. | | 4 | TO | PH | | 181 | | | | | | | | | | | | | | |
| 4.3 | | | 5 | SS | 2 | | 180 | | | | | | | | | | | | | | |
| | | | 6 | SS | 1 | | 179 | | | | | | | | | | | | | | |
| | | | | | | | 178 | | | | | | | | | | | | | | |
| | | | 7 | SS | 3 | | 177 | | | | | | | | | | | | | | |
| | | | | | | | 176 | | | | | | | | | | | | | | |
| | | | 8 | SS | 3 | | 175 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | 9 | SS | 3 | | | | | | | | | | | | | | | | |
| 174.5 | | | | | | | | | | | | | | | | | | | | | |
| 11.3 | | | | | | | | | | | | | | | | | | | | | |

Continued Next Page

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

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 18/03/16 DATA INPUT:



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

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 18/03/16 DATA INPUT:



APPENDIX B

Laboratory Test Results



FOUNDATION REPORT HELEN LAKE CULVERT - SITE NO. 48C-190/C

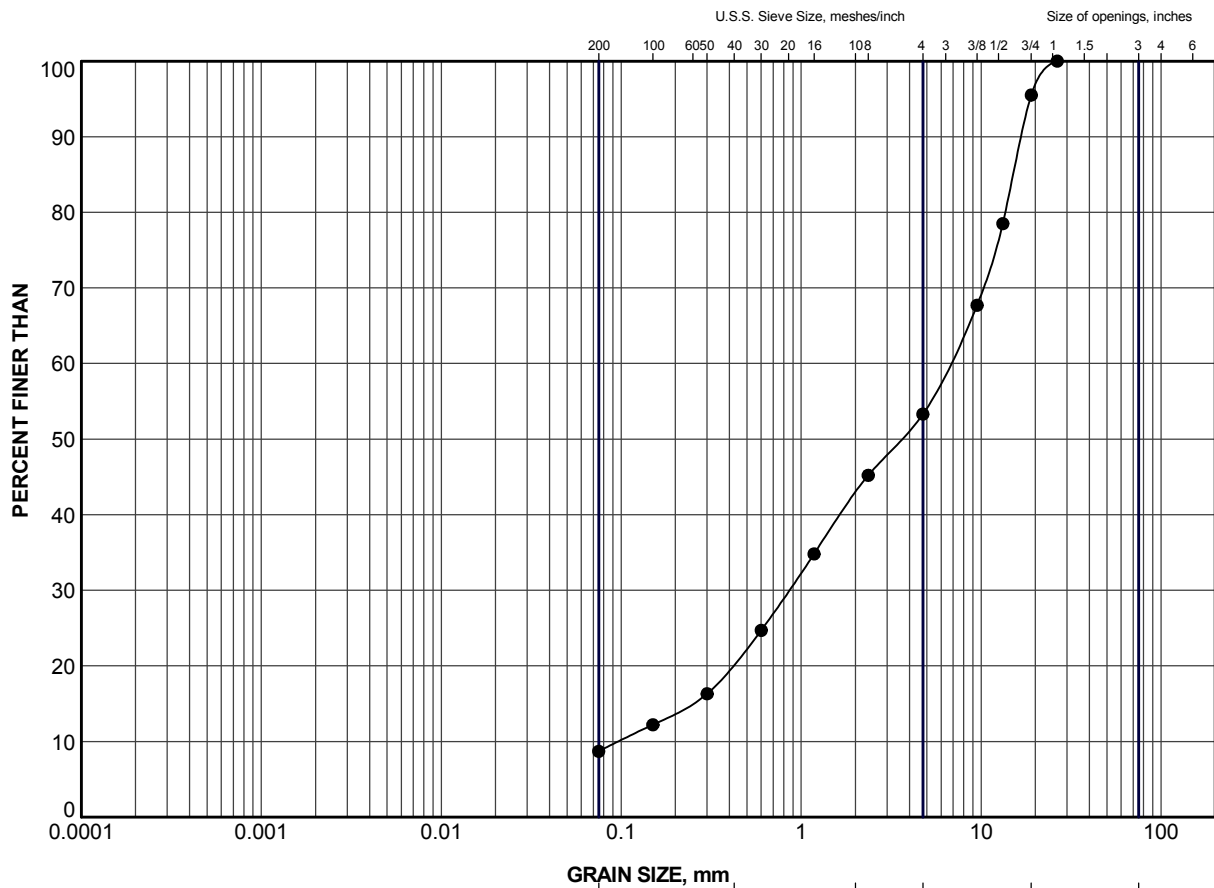
Table B1: Summary of Analytical Testing of Creek Water Sample near Helen Lake

| Parameter | Units | Result |
|-------------------|---------|--------------|
| Chloride (CL) | mg/L | 2.4 |
| Sulphate (SO4) | mg/L | Not Detected |
| Conductivity (EC) | µmho/cm | 330 |
| Resistivity | ohm-cm | 3,000 |
| pH | n/a | 8.14 |

Notes:

1. Sample obtained on December 22, 2015.
2. Analytical testing carried out by Maxxam Analytics.

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



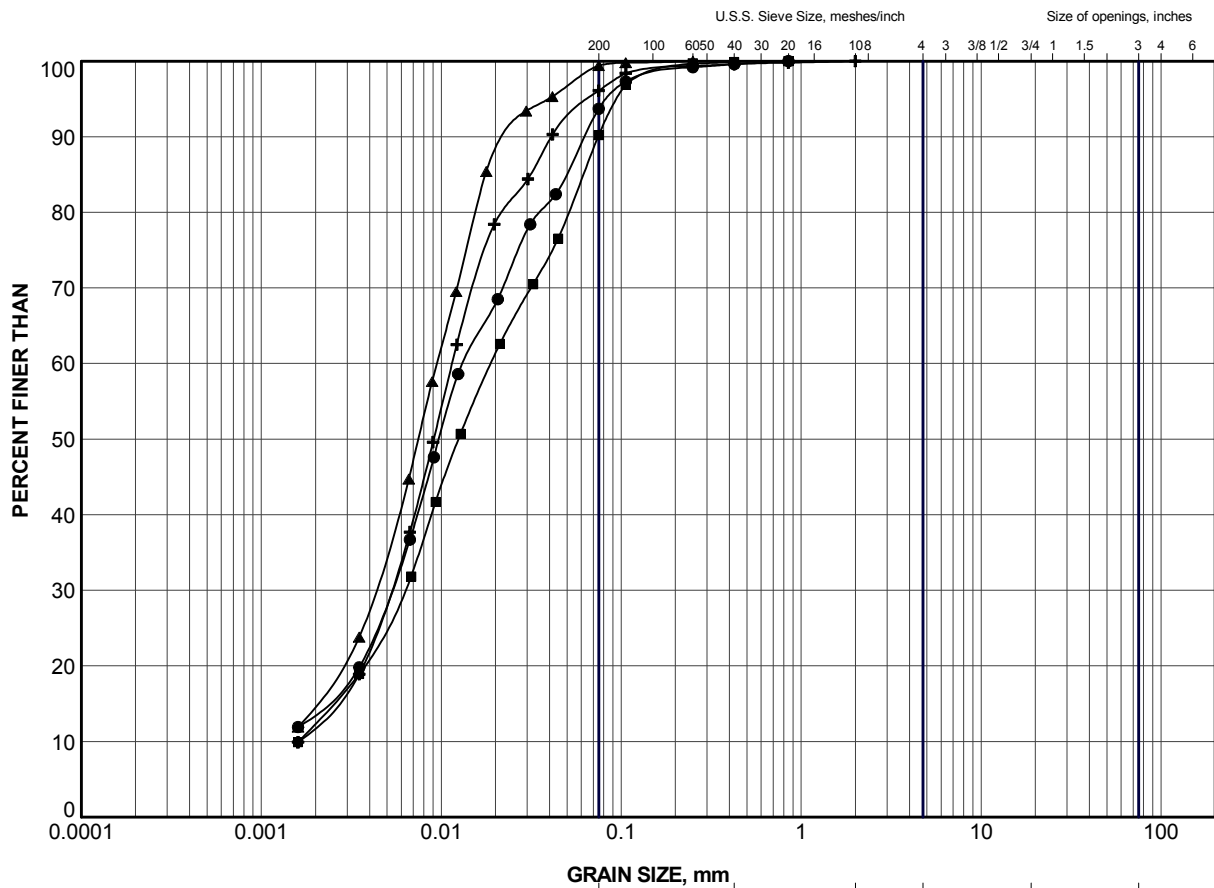
| GRAIN SIZE, mm | | | | | | |
|----------------|-----------|--------|--------|-------------|--------|-------------|
| CLAY AND SILT | fine | medium | coarse | fine | coarse | Cobble Size |
| | SAND SIZE | | | GRAVEL SIZE | | |

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ● | HL-2 | 1 | 186.7 |

| | | | | | |
|---|------|----------|-----------|----------------------|------|
| PROJECT | | | | | |
| HIGHWAY 11 HELEN LAKE CULVERT STA 13+037 | | | | | |
| TITLE | | | | | |
| GRAIN SIZE DISTRIBUTION SAND and GRAVEL (FILL) | | | | | |
| PROJECT No. | | 1533879 | | FILE No. 1533879.GPJ | |
| DRAWN | JJL | Jan 2016 | SCALE | N/A | REV. |
| CHECK | DAM | Jan 2016 | FIGURE B1 | | |
| APPR | JMAC | Jan 2016 | | | |




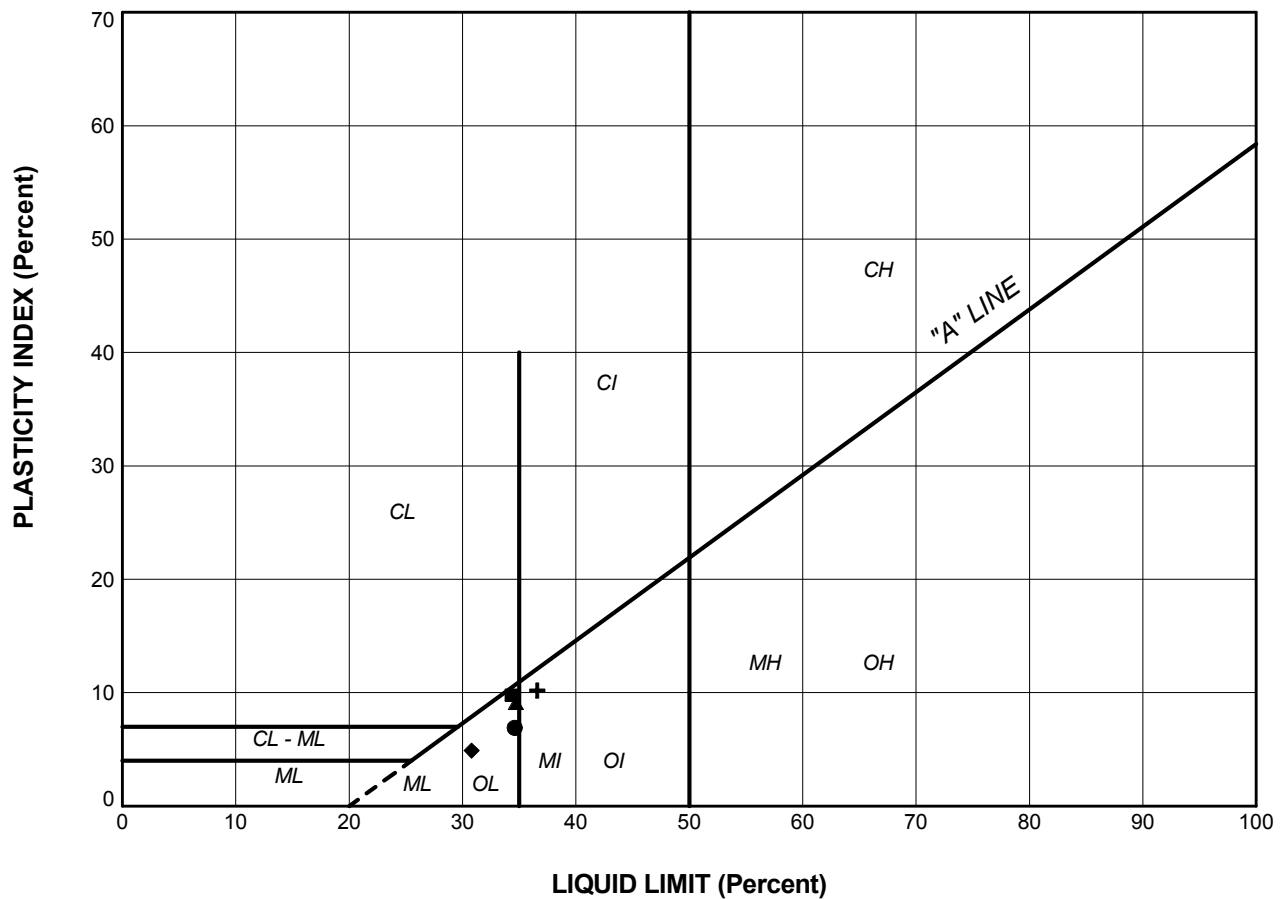


| GRAIN SIZE, mm | | | | | | |
|----------------|-----------|--------|--------|-------------|--------|-------------|
| CLAY AND SILT | fine | medium | coarse | fine | coarse | Cobble Size |
| | SAND SIZE | | | GRAVEL SIZE | | |

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ● | HL-1 | 3 | 183.7 |
| ■ | HL-2 | 4 | 184.5 |
| ▲ | HL-2 | 7 | 181.5 |
| + | HL-3 | 3 | 182.4 |

| | | | | | | | | | | | |
|--|------|----------|------------------|-----|------|---|--|--|-------------|--|--|
| PROJECT | | | | | | HIGHWAY 11 HELEN LAKE CULVERT STA 13+037 | | | | | |
| TITLE | | | | | | GRAIN SIZE DISTRIBUTION SILT | | | | | |
| PROJECT No. | | | 1533879 | | | FILE No. | | | 1533879.GPJ | | |
| DRAWN | JJL | Mar 2016 | SCALE | N/A | REV. | | | | | | |
| CHECK | DAM | Mar 2016 | | | | | | | | | |
| APPR | JMAC | Mar 2016 | | | | | | | | | |
|  Golder Associates SUDBURY, ONTARIO | | | FIGURE B2 | | | | | | | | |

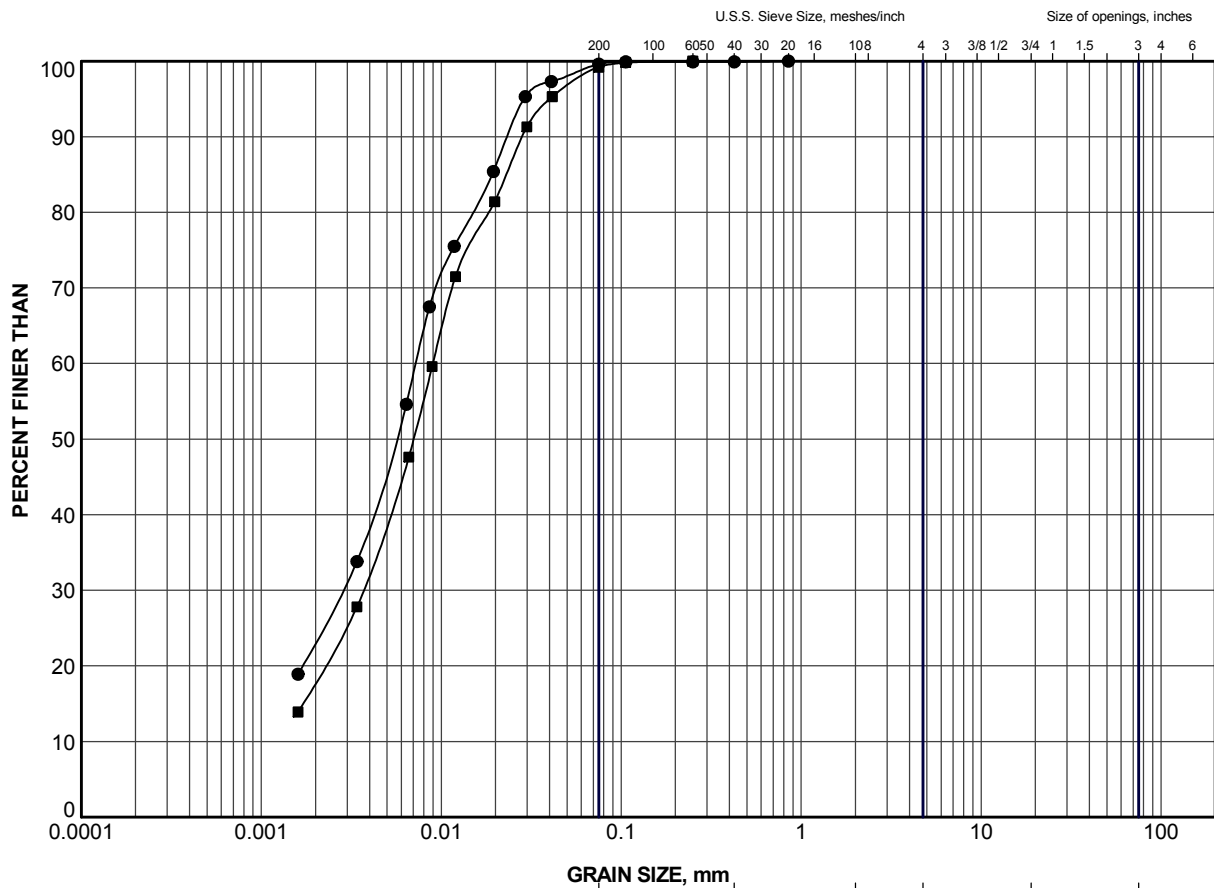


LEGEND

| SYMBOL | BOREHOLE | SAMPLE | LL(%) | PL(%) | PI |
|--------|----------|--------|-------|-------|------|
| ● | HL-1 | 3 | 34.6 | 27.7 | 6.9 |
| ■ | HL-1 | 5 | 34.3 | 24.5 | 9.8 |
| ▲ | HL-2 | 4 | 34.7 | 25.6 | 9.1 |
| + | HL-2 | 7 | 36.6 | 26.4 | 10.2 |
| ◆ | HL-3 | 3 | 30.8 | 25.9 | 4.9 |

| | | | | | |
|---|--|---------|--|----------|--|
| PROJECT | | | | | |
| HIGHWAY 11 HELEN LAKE CULVERT STA 13+037 | | | | | |
| TITLE | | | | | |
| PLASTICITY CHART SILT | | | | | |
| PROJECT No. | | 1533879 | | FILE No. | |
| DRAWN | | J.J.L. | | Mar 2016 | |
| CHECK | | DAM | | Mar 2016 | |
| APPR | | JMAC | | Mar 2016 | |
| SCALE | | N/A | | REV. | |
| FIGURE | | B3 | | | |





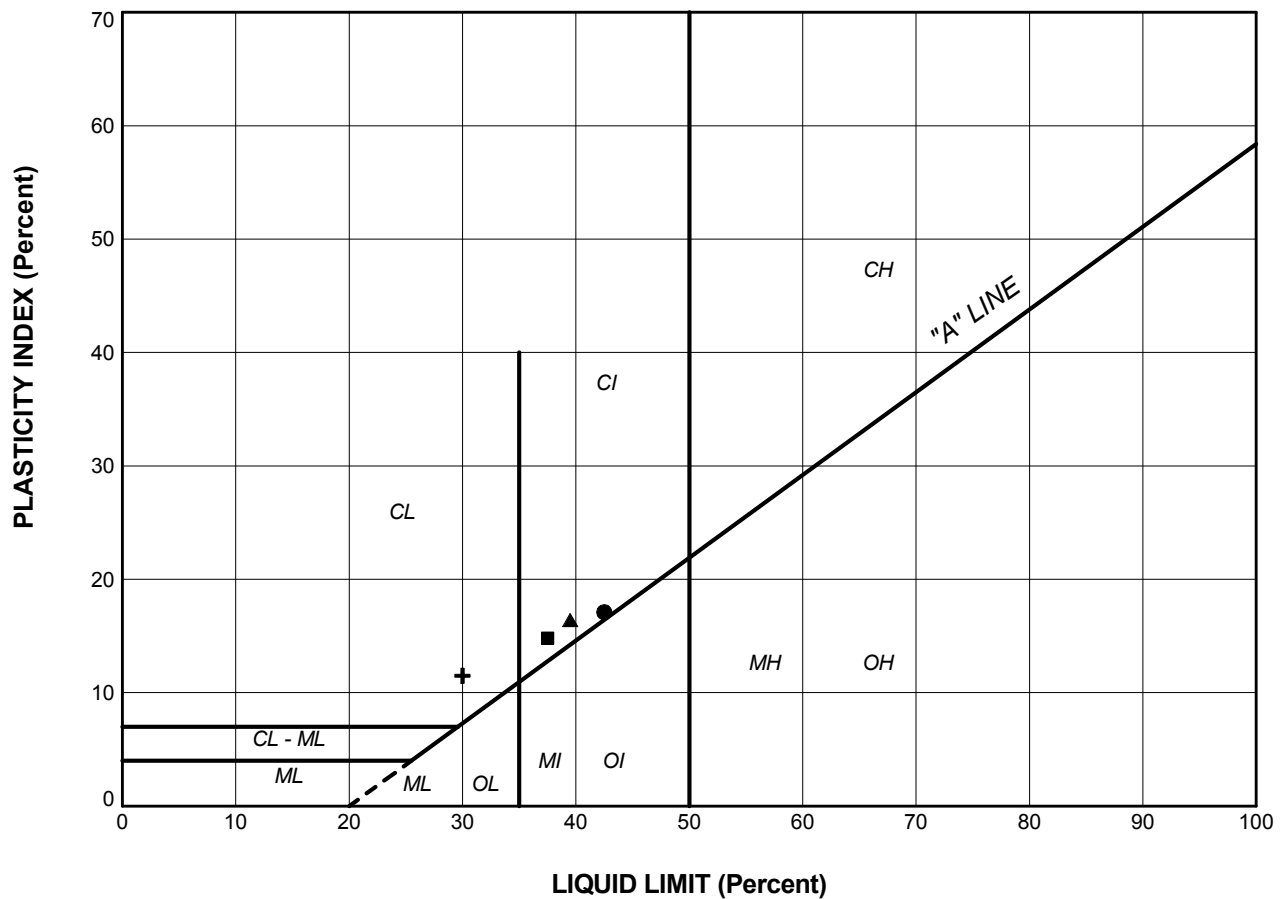
| CLAY AND SILT | GRAVEL SIZE, mm | | | | | Cobble Size |
|---------------|-----------------|--------|--------|-------------|--------|-------------|
| | fine | medium | coarse | fine | coarse | |
| | SAND SIZE | | | GRAVEL SIZE | | |

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|--------|----------|--------|----------|
| ● | HL-1 | 9 | 176.9 |
| ■ | HL-3 | 6 | 179.4 |

| | | | | | |
|---|------|----------|-----------|----------------------|------|
| PROJECT | | | | | |
| HIGHWAY 11 HELEN LAKE CULVERT STA 13+037 | | | | | |
| TITLE | | | | | |
| GRAIN SIZE DISTRIBUTION SILTY CLAY | | | | | |
| PROJECT No. | | 1533879 | | FILE No. 1533879.GPJ | |
| DRAWN | JJL | Mar 2016 | SCALE | N/A | REV. |
| CHECK | DAM | Mar 2016 | FIGURE B4 | | |
| APPR | JMAC | Mar 2016 | | | |





LEGEND

| SYMBOL | BOREHOLE | SAMPLE | LL(%) | PL(%) | PI |
|--------|----------|--------|-------|-------|------|
| ● | HL-1 | 9 | 42.5 | 25.4 | 17.1 |
| ■ | HL-2 | 10 | 37.5 | 22.7 | 14.8 |
| ▲ | HL-3 | 6 | 39.5 | 23.1 | 16.4 |
| + | HL-3 | 8 | 30.0 | 18.5 | 11.5 |

| | | | | | |
|---|--|---------|--|----------|--|
| PROJECT | | | | | |
| HIGHWAY 11 HELEN LAKE CULVERT STA 13+037 | | | | | |
| TITLE | | | | | |
| PLASTICITY CHART CLAYEY SILT to SILTY CLAY | | | | | |
| PROJECT No. | | 1533879 | | FILE No. | |
| DRAWN | | JJL | | Mar 2016 | |
| CHECK | | DAM | | Mar 2016 | |
| APPR | | JMAC | | Mar 2016 | |
| SCALE | | N/A | | REV. | |
| FIGURE | | B5 | | | |





APPENDIX C

Supplemental Foundation Investigation



DRAFT
SUPPLEMENTARY FOUNDATION INVESTIGATION FACTUAL
REPORT
HIGHWAY 11 – HELEN LAKE CULVERT
5.12 KM NORTH OF HWY 11/17
UNSURVEYED TERRITORY, DISTRICT OF THUNDER BAY
AGREEMENT NO.: 5013-E-0033
ASSIGNMENT #15
SITE NO.: 48C-190C
GEOCRES NO.
GWP 6909-12-00

MARCH 29, 2016
IN-NO-025963

PREPARED FOR:
Ministry of Transportation
Engineering Office, Geotechnical Section
Northeastern Region Office
447 Mckeown Avenue, Suite 301,
North Bay, ON P1B 9S9

DST CONSULTING ENGINEERS INC.
605 Hewitson Street, Thunder Bay, Ontario P7B 5V5
Phone: 1-807-623-2929 Fax: 1-807-623-1792

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**FOUNDATION INVESTIGATION REPORT
HIGHWAY 11 – HELEN LAKE CULVERT
5.12 KM NORTH OF HWY 11/17
UNSURVEYED TERRITORY,
DISTRICT OF THUNDER BAY
AGREEMENT NO.: 5013-E-0033
SITE NO.: 48C-190C
GEOCRES NO.
GWP 6909-12-00**

1. INTRODUCTION

DST Consulting Engineers Inc. (DST) has been retained by the Ministry of Transportation (MTO), Geotechnical Section, Northeastern Region to conduct a foundation investigation to support the design and construction of a temporary protection system for the proposed Helen Lake Culvert replacement. The existing culvert is located on Highway 11 approximately 5.12 km north of the Highway 11/17 junction in Nipigon. This work was carried out under Agreement No.: 5013-E-0033, Assignment #15.

This report addresses the field investigation, laboratory test program, and factual report on subsurface conditions encountered.

It is understood that prior to the stage replacement of the existing concrete culvert a temporary protection system will be implemented along the highway centreline. A temporary diversion pipe located 10.5 m north of the existing culvert has been proposed to facilitate dewatering during construction.

The site was recently investigated by Golder Associates. It is understood that the additional information obtained under this agreement will be used to supplement the recent investigations.

2. SITE DESCRIPTION

The site is located on Highway 11 approximately 5.12 km north of the Highway 11/17 junction in Nipigon (Latitude 49.061658, Longitude -88.268518), in unsurveyed territory, District of Thunder Bay. The surrounding area is vegetated and wooded with Helen Lake along the east.

Geological information is available from published *Ontario Geological Survey Map #52H/SE* by the *Ontario Ministry of Natural Resources* for the Frazer Lake Area. The map indicates that the local area landform is identified as Bedrock knob. Bedrock knob landscape is characterized by an irregular bedrock surface having complex multiple slopes of varying steepness. The covers of glacial deposits overlying the bedrock knobs is generally thin and discontinuous. Much of the glacial overburden consists of boulder, sand-rich till that was transported only in short distance by ice.

3. INVESTIGATION PROCEDURES AND LABORATORY TESTING

Site work was carried out on March 3rd, 2016 utilizing a CME 750 drill rig equipped for geotechnical drilling. One borehole was advanced at the proposed temporary pipe diversion location to a total depth of 25.4 m (10 m of hollow stem augering and 15.4 m of Dynamic Cone Penetration Test or DCPT).

The borehole was advanced at approximately (Sta.12+027) 0.95 m right of centreline to a depth of 25.4 m below the existing surface.

The ground surface elevations at the borehole locations were surveyed by DST personnel and referenced to benchmark 185.463 m in root of tree (10.892 RT of 11+991.594) as indicated on the drawings provided by the Ministry. Table 3.1 summarizes the detail of borehole location and depth.

All boreholes were abandoned using suitable abandonment barrier as described in Ontario Regulation 903 and its amendments. Boreholes were decommissioned by backfilling to the bottom of the road base with cuttings and bentonite chips. From the bottom of the road base, granular materials were replaced to the bottom of the asphalt and the asphalt was sealed with a cold patch.

The fieldwork was supervised on a full-time basis by DST personnel. Soil samples were obtained from the auger flights and from the split spoon sampler used for the standard penetration test (SPT). The SPT involves driving a 51 mm diameter thick-walled sampler into the soil under the energy of a 63.5 kg weight falling through 760 mm. The number of blows required to drive the sampler 305 mm is known as the Standard Penetration Test (SPT) blow count (N) which provides an indication of the condition or consistency of the soil. DCP Tests was also conducted in the field beyond 10 m, the test is performed by dropping a hammer from a certain fall height measuring penetration depth per blow, termination / refusal was met when penetration tests exceeded 100 blows per 0.3 m. In addition, in-situ vane shear testing were performed in cohesive soils at selected depths using an MTO vane. The soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further

analyses.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included moisture contents, particle size analyses and Atterberg Limits. A total of thirteen (13) moisture contents, three (3) particle size analyses, two hydrometer (2) and four (4) Atterberg limits have been carried out for this assignment. Laboratory test results are presented in the Borehole Logs and graphical plots attached Appendix C (Enclosures).

Table 3-1: Detail of Borehole Location

| Borehole ID | Station | Elevation (m) | Depth (m) | Offset (m) |
|-------------|----------|---------------|-----------|------------|
| BH 1 | 12 + 027 | 187.2 | 25.4 | 0.95 Rt |

4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are presented based on the information obtained during power auger drilling.

The generalized stratigraphy at the proposed diversion pipe location, based on the conditions encountered in the borehole, consists of asphalt at surface, underlain by sand fill with gravel which overlies another layer of asphalt. Below the second asphalt layer sand and gravel fill is encountered overlying silt which further overlies clay. Summary of the soil strata is provided in Table 4-1.

Table 4-1: Summary of soil strata at proposed diversion pipe

| Layer | Depth (m) | Elevation (m) | Soil Properties |
|-----------------|------------|----------------|--|
| Asphalt | 0.0 to 0.2 | 187.2 to 187.0 | |
| Fill - Sand | 0.2 to 0.5 | 187.0 to 186.7 | Unit Weight ($\gamma = 21 \text{ kN/m}^3$) Internal Angle of Friction ($\phi = 32 \text{ Degrees}$) |
| Asphalt | 0.5 to 0.6 | 186.7 to 186.6 | |
| Fill - Granular | 0.6 to 2.3 | 186.6 to 184.9 | Unit Weight ($\gamma = 21 \text{ kN/m}^3$) Internal Angle of Friction ($\phi = 32 \text{ Degrees}$) |
| Silt | 2.3 to 7.6 | 184.9 to 179.6 | Unit Weight ($\gamma = 19 \text{ kN/m}^3$) Internal Angle of Friction ($\phi = 30 \text{ Degrees}$) |
| Clay | 7.6 to 10 | 179.6 to 177.2 | Unit Weight ($\gamma = 18 \text{ kN/m}^3$) Undrained Shear Strength (30 - 40 kPa) |

4.1 Asphalt

Asphalt was encountered at surface with a thickness of approximately 200 mm.

4.2 Fill - Sand

Sand fill with gravel and trace fines was encountered below the asphalt at the depth from 0.2 m to 0.5 m (Elev. 187.0 m to 186.5 m) with a thickness of 0.3 m.

Laboratory tests conducted on the selected sample indicate a moisture content of 2 %. Particle size analyses carried out on the selected sample are summarized in Table 4-2.

Table 4-2: Summary of Sieve Analysis- Fill - Sand

| Laboratory Results – Sieve Analysis | |
|-------------------------------------|----|
| Gravel % | 28 |
| Sand % | 67 |
| Fines % | 5 |

4.3 Asphalt

A second layer of asphalt was encountered below the sand fill at depth 0.5 m to 0.6 m (Elev. 186.7 m to 186.6 m) with a thickness of approximately 0.1 m.

4.4 Fill- Granular

Granular fill consisting of various portions of Sand and gravel with some to trace fines, and occasional cobbles was encountered below the second layer of asphalt at depth 0.6 m to 2.3 m (Elev. 186.6 m to 184.9 m) with a thickness of 1.7 m.

The SPT 'N' values vary from 99 to 100+, indicating a very dense condition. The high SPT blow count recorded may be the result of the presence of large cobbles or the frozen layer encountered within the granular fill material and therefore, may not be representative of actual condition. The moisture contents of selected sample tested was 4 %. The laboratory test results are summarized in Table 4-3.

Table 4-3: Summary of Sieve Analysis- Fill – Granular

| Laboratory Results – Sieve Analysis | |
|-------------------------------------|----------|
| Gravel % | 17 to 47 |
| Sand % | 45 to 70 |
| Fines % | 8 to 13 |

4.5 Silt

Silt with some clay and some to trace sand was encountered underlying the granular fill at the depth from 2.3 m to 7.6 m (Elev. 184.9 m to 179.6 m) with a thickness of 5.3 m. Trace rootlets and wood chips was encountered within the silt layer.

No SPTs could be carried out as SPT spoon sank with weight of hammer. Atterberg limits tests carried out on selected samples indicate that the silt is medium plastic. Field vane tests completed show shear strength between 24 to 36 kPa indicating a soft to firm consistency. The moisture contents of selected samples tested range from 20 to 39 %. The laboratory test results are summarized in Table 4-4 and 4-5.

Table 4-4: Summary of Hydrometer Tests - Silt

| Laboratory Results – Hydrometer Tests | |
|---------------------------------------|----------|
| Gravel % | 0 |
| Sand % | 1 to 11 |
| Silt % | 75 to 81 |
| Clay % | 13 to 18 |

Table 4-5: Summary of Atterberg Limits- Silt

| Laboratory Results – Atterberg Limits | |
|---------------------------------------|----------|
| Liquid Limit % | 32 to 34 |
| Plastic Limit % | 25 |
| Plastic Index % | 7 to 9 |

4.6 Clay

Clay was encountered below the silt at the depths from 7.6 m to 10 m (Elev. 179.6 m to 177.2 m), with a thickness of 2.4 m.

No SPTs could be carried out as SPT spoon sank with weight of hammer. Atterberg Limits

tests carried out on samples from boreholes indicate that the clay has a medium plasticity. Field vane tests completed show shear strengths of 30 and 42 kPa indicating a firm consistency. The moisture contents of selected samples tested ranged from 36 to 39 %. The laboratory test results are summarized in following Tables 4-6.

Table 4-6: Summary of Atterberg Limits- Clay

| Laboratory Results – Atterberg Limits | |
|---------------------------------------|----------|
| Liquid Limit % | 33 to 39 |
| Plastic Limit % | 23 to 25 |
| Plastic Index % | 10 to 14 |

4.7 Dynamic Cone Penetration Test

Dynamic cone was advanced beyond the 10 m sampled depth to a depth of 25.4 m (Elev. 177.2 m to 161.8 m). DCPT values obtained range from 1 to 120 with the final 1.5 m ranging from 90 to 120 blows per 0.3 m penetration respectively.

4.8 Groundwater

Groundwater level in the borehole was measured upon completion of borehole drilling and prior to backfilling of the borehole. This information is included on the Borehole Logs in Appendix C and summarized in Table 4-7. The groundwater levels can be expected to vary with the season and precipitation events.

Table 4-7: Groundwater depth

| Borehole | Groundwater Depth (m) | Groundwater Elev. (m) |
|----------|-----------------------|-----------------------|
| Borehole | 9.0 | 178.2 |

5. MISCELLANEOUS

Site work was carried out on March 3rd, 2016 utilizing a CME 750 all-terrain drill rig operated by DST. Fieldwork was supervised on a full time basis by DST personnel. Soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis. Interpretation of the data and preparation of the report was completed by Selorm Danku, P.Eng and reviewed by Dr. Karim, P.Eng. who is the designated principal contact for MTO projects.

6. LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

Prepared by:

Reviewed by:

DRAFT

DRAFT

Selorm Danku P. Eng
Geotechnical Engineer

Dr. ASM Masud Karim, P.Eng.
Senior Associate - Regional Manager
Infrastructure Client Group

APPENDIX 'A'
LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

GEOTECHNICAL STUDIES

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that DST Consulting Engineers be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

Appendix B

DESCRIPTION OF TERMS

EXPLANATION OF TERMS USED IN REPORT

SPT 'N' VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE OF THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51 mm O.D. SPLIT BARREL SAMPLES TO PENETRATE 0.3 m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76 m. FOR PENETRATION OF LESS THAN 0.3 m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST (DCPT): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51 mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3 m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

TEXTURAL CLASSIFICATION OF SOILS

| BOULDERS | COBBLES | GRAVEL | SAND | SILT | CLAY |
|---------------------|--------------|---------------|------------------|-------------------|--------------------|
| GREATER THAN 200 mm | 75 TO 200 mm | 4.75 TO 75 mm | 0.075 TO 4.75 mm | 0.002 TO 0.075 mm | LESS THAN 0.002 mm |

COARSE GRAIN SOIL DESCRIPTION (50% GREATER THAN 0.075 mm)

| TERMINOLOGY | TRACE OR OCCASIONAL | SOME | WITH | ADJECTIVE (e.g. SILTY OR SANDY) | AND (e.g. SAND AND SILT) |
|-------------|---------------------|-----------|-----------|---------------------------------|--------------------------|
| | LESS THAN 10% | 10 TO 20% | 20 TO 30% | 30 TO 40% | 40 TO 60% |

CONSISTENCY*: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (C_u) AND SPT 'N' VALUES AS FOLLOWS

| C_u (kPa) | 0 – 12 | 12 – 25 | 25 – 50 | 50 – 100 | 100 – 200 | > 200 |
|-------------------|-----------|---------|---------|----------|------------|-------|
| N (BLOWS / 0.3 m) | <2 | 2 - 4 | 4 - 8 | 8 - 15 | 15 - 30 | >30 |
| | VERY SOFT | SOFT | FIRM | STIFF | VERY STIFF | HARD |

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS ON DENSENESS AS INDICATED BY SPT 'N' VALUES AS FOLLOWS

| N (BLOWS / 0.3 m) | 0 – 5 | 5 – 10 | 10 – 30 | 30 – 50 | > 50 |
|-------------------|------------|--------|---------|---------|------------|
| | VERY LOOSE | LOOSE | COMPACT | DENSE | VERY DENSE |

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100 mm+ IN LENGTH EXPRESSED AS A PERCENTAGE OF THE LENGTH OF THE CORING RUN.

THE **ROCK QUALITY DESIGNATION (R.Q.D)** FOR MODIFIED RECOVERY IS:

| R.Q.D (%) | 0 – 25 | 25 – 50 | 50 – 75 | 75 – 90 | 90 – 100 |
|-----------|-----------|---------|---------|---------|-----------|
| | VERY POOR | POOR | FAIR | GOOD | EXCELLENT |

LEGEND OF RECORDS FOR BOREHOLES: SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

| | | | |
|---|--|---|-------------------------------------|
| SS | SPLIT SPOON SAMPLE | WS | WASH SAMPLE |
| TW | THIN WALL SHELBY TUBE SAMPLE | AS | AUGER (GRAB) SAMPLE |
| PH | SAMPLER ADVANCED BY HYDRAULIC PRESSURE | TP | THIN WALL PISTON SAMPLE |
| WH | SAMPLER ADVANCED BY SELF STATIC WEIGHT | PM | SAMPLER ADVANCED BY MANUAL PRESSURE |
| SC | SOIL CORE | RC | ROCK CORE |
|  | WATER LEVEL | $SENSITIVITY = \frac{UNDISTURBED\ SHEAR\ STRENGTH}{REMOVED\ SHEAR\ STRENGTH}$ | |

*HIERARCHY OF SOIL STRENGTH PREDICTION: 1) LABORATORY TRIAXIAL TESTING. 2) FIELD INSITU VANE TESTING. 3) LABORATORY VANE TESTING. 4) SPT VALUES. 5) POCKET PENETROMETER.

Appendix C
ENCLOSURES

RECORD OF BOREHOLE No BH-1

1 OF 2

METRIC

W.P. IN-NO-025963 LOCATION Helen Lake Culvert ORIGINATED BY PR
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY SD
DATUM Geodetic DATE 2016 03 03 CHECKED BY MK

| 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 | | | | | | |
| 187.2 | GROUND SURFACE | | | | | | | 20 40 60 80 100 | | | | | | |
| 187.0 | ASPHALT | | AS1 | AS | | | 187 | 50 100 150 200 250 | | | | | | 28 67 (5) |
| 0.2 | FILL - sand with gravel, trace silt | | | | | | | | | | | | | 17 70 (13) |
| 186.7 | ASPHALT | | | | | | 186 | | | | | | | Frozen |
| 186.6 | FILL - sand some gravel, some silt, occasional cobble (large cobble), brown, very dense | | SS2 | SS | 99 | | | | | | | | | 47 45 (8) |
| 0.6 | -sand and gravel, trace silt | | SS3 | SS | +100 | | | | | | | | | |
| 184.9 | SILT - some clay, rootlets, grey, compact to loose | | SS4 | SS | 22 | | 185 | | | | | | | Wet |
| 2.3 | | | | | | | | | | | | | | |
| | | | SS5 | SS | 9 | | 184 | | | | | | | 0 11 75 13 |
| | - trace rootlets and wood pockets at 3.8 m | | SS6 | SS | 0 | | | | | | | | | Spoon sank with weight of hammer |
| | | | | | | | 183 | | | | | | | |
| | | | SS7 | SS | 0 | | | | | | | | | Spoon sank with weight of hammer |
| | | | | | | | 182 | | | | | | | |
| | | | SS8 | SS | 0 | | | | | | | | | Spoon sank with weight of hammer |
| | | | | | | | | | | | | | | |
| | | | SS9 | SS | 0 | | 181 | | | | | | | Spoon sank with weight of hammer |
| | | | | | | | | | | | | | | |
| | | | SS10 | SS | 0 | | 180 | | | | | | | Spoon sank with weight of hammer |
| 179.6 | CLAY - grey, firm | | | | | | | | | | | | | 0 1 81 18 |
| 7.6 | | | SS11 | SS | 0 | | 179 | | | | | | | Spoon sank with weight of hammer |
| | | | | | | | | | | | | | | |
| | | | SS12 | SS | 0 | | | | | | | | | |
| | Water table at 9.0 m | | | | | | 178 | | | | | | | Spoon sank with weight of hammer |
| | | | SS13 | SS | 0 | | | | | | | | | |
| 177.2 | END OF BOREHOLE at 10.0 m - DPCT TO 25.4 m | | | | | | 177 | | | | | | | |
| 10.0 | | | | | | | | | | | | | | |
| | | | | | | | 176 | | | | | | | |
| | | | | | | | 175 | | | | | | | |
| | | | | | | | 174 | | | | | | | |
| | | | | | | | 173 | | | | | | | |

Continued Next Page


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

RECORD OF BOREHOLE No BH-1

2 OF 2

METRIC

W.P. IN-NO-025963 LOCATION Helen Lake Culvert ORIGINATED BY PR
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Auger - 80 mm ID COMPILED BY SD
 DATUM Geodetic DATE 2016 03 03 CHECKED BY MK

| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT  20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE □ QUICK TRIAXIAL × LAB VANE 50 100 150 200 250 | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|----------------|------------|--------|------|----------------------------|-----------------|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | | | | | | | | |
| | GROUND SURFACE | | | | | | | | | | | |
| | | | | | | 172 | | | | | | |
| | | | | | | 171 | | | | | | |
| | | | | | | 170 | | | | | | |
| | | | | | | 169 | | | | | | |
| | | | | | | 168 | | | | | | |
| | | | | | | 167 | | | | | | |
| | | | | | | 166 | | | | | | |
| | | | | | | 165 | | | | | | |
| | | | | | | 164 | | | | | | |
| | | | | | | 163 | | | | | | |
| | | | | | | 162 | | | | | | |

ON MOT-HIGH VANES IN-NO-025963 BH LOGS.GPJ DST_MIN.GDT 17/3/16

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

ENCLOSURE 2

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

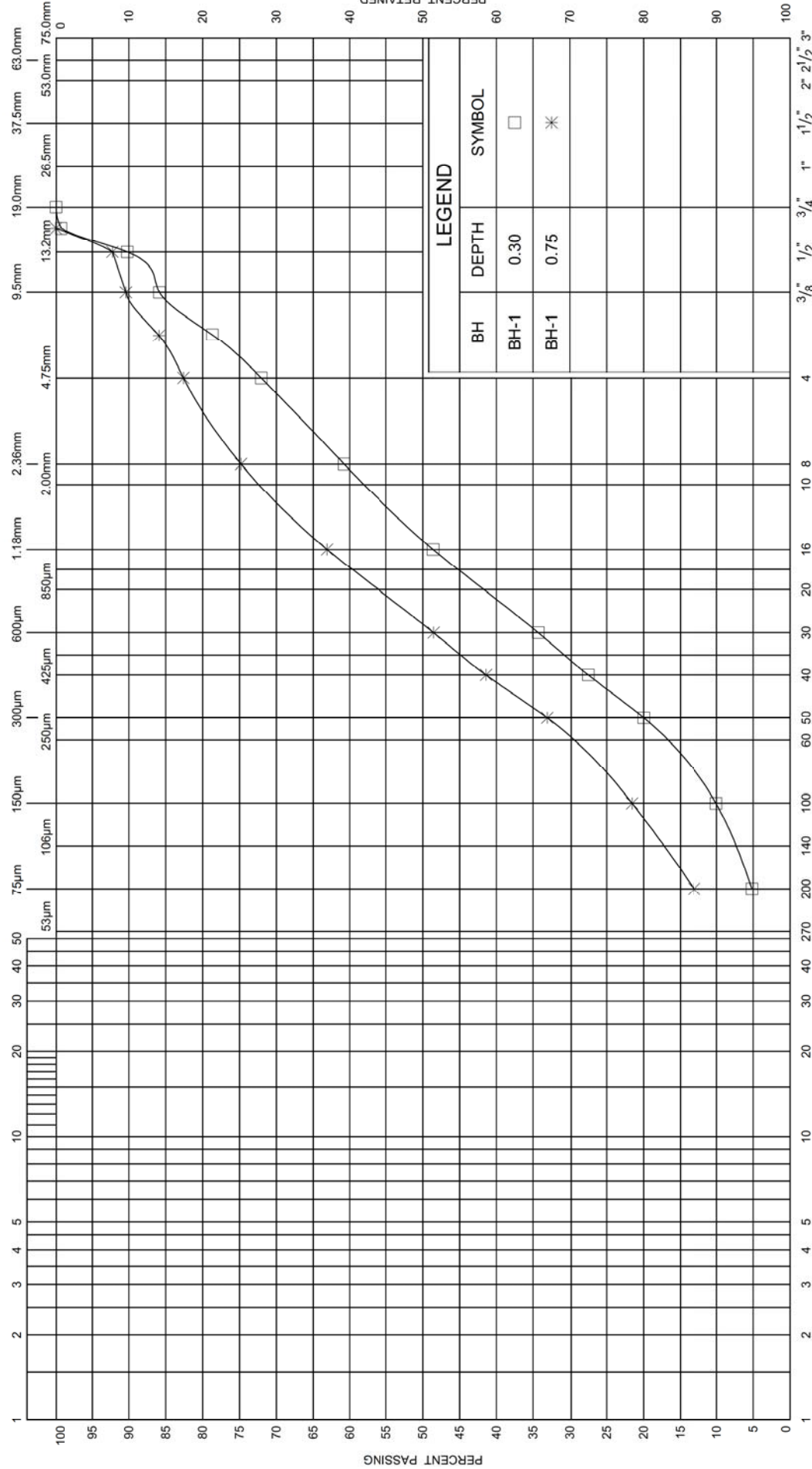
Medium

Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS



MINISTRY SIEVE DESIGNATION (Imperial)

GRAIN SIZE DISTRIBUTION
SAND

ENCLOSURE 3

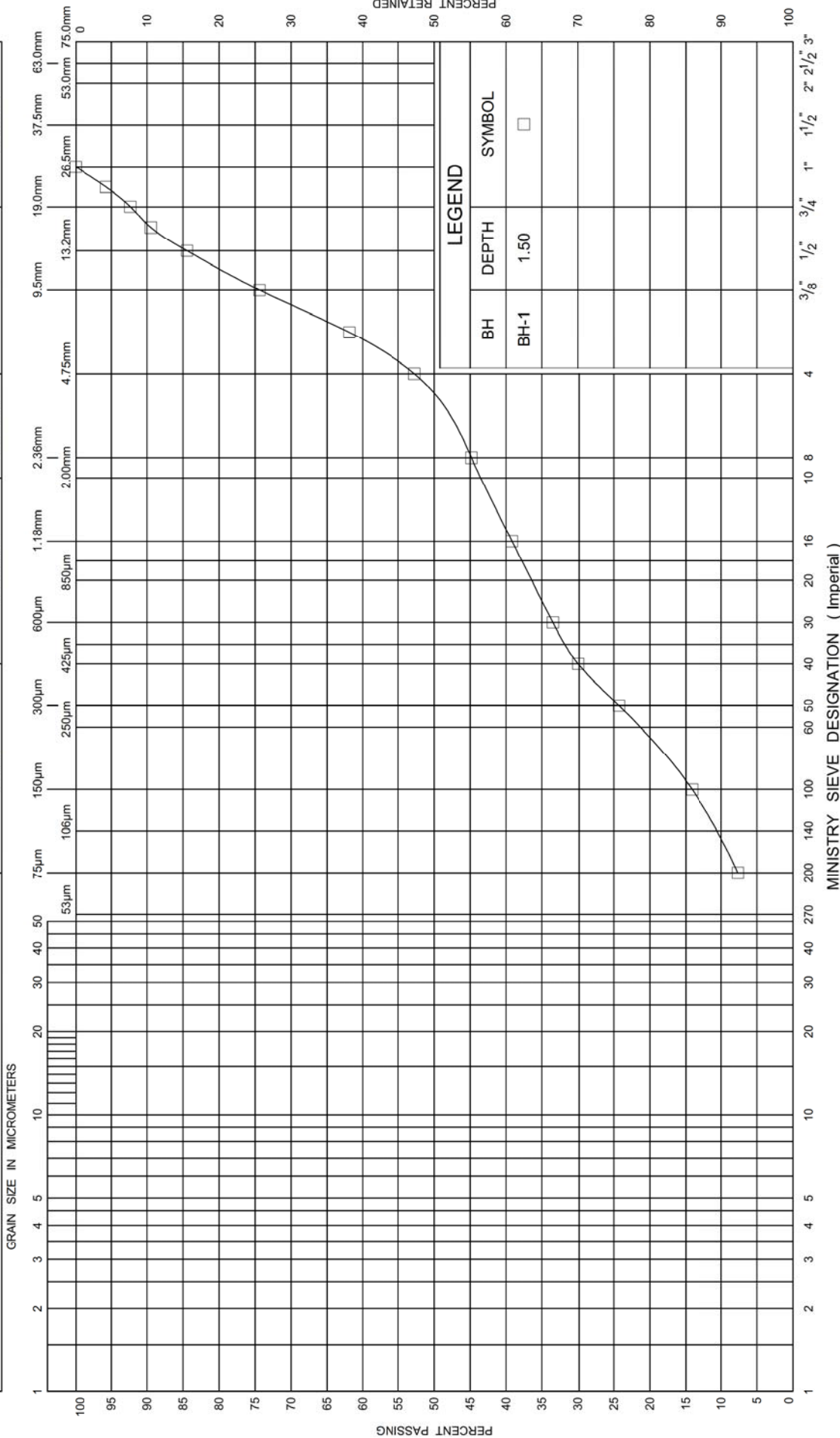
GWP 6909-12-00

HWY 11 - LAKE HELEN



UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | | SAND | | | GRAVEL | |
|-------------|--|------|--------|--------|--------|--------|
| | | Fine | Medium | Coarse | Fine | Coarse |



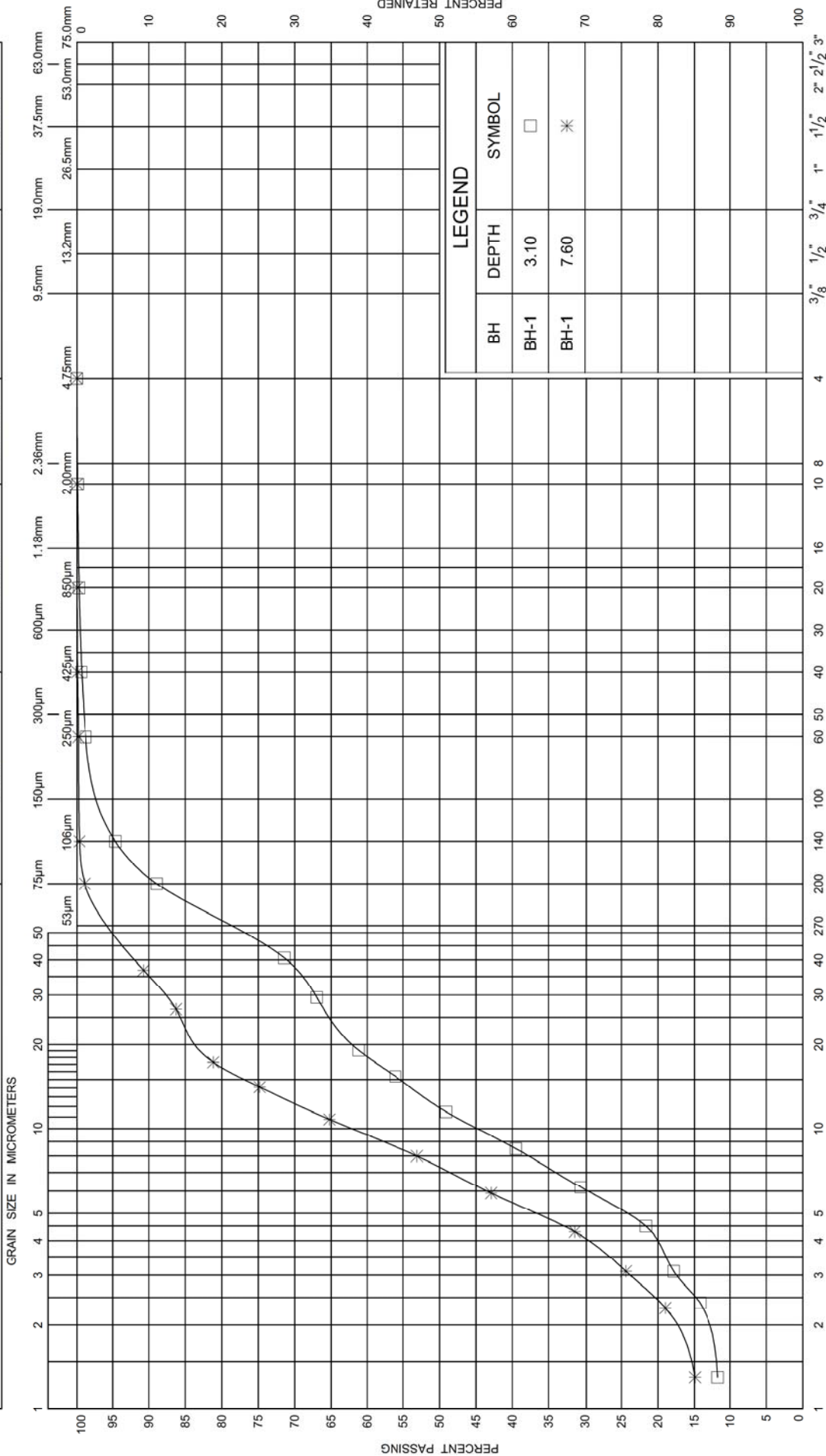
GRAIN SIZE DISTRIBUTION
SAND AND GRAVEL

ENCLOSURE 4
GWP 6909-12-00
HWY 11- LAKE HELEN



UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | | SAND | | | GRAVEL | |
|-------------|--|------|--------|--------|--------|--------|
| | | Fine | Medium | Coarse | Fine | Coarse |



MINISTRY SIEVE DESIGNATION (Imperial)

GRAIN SIZE DISTRIBUTION

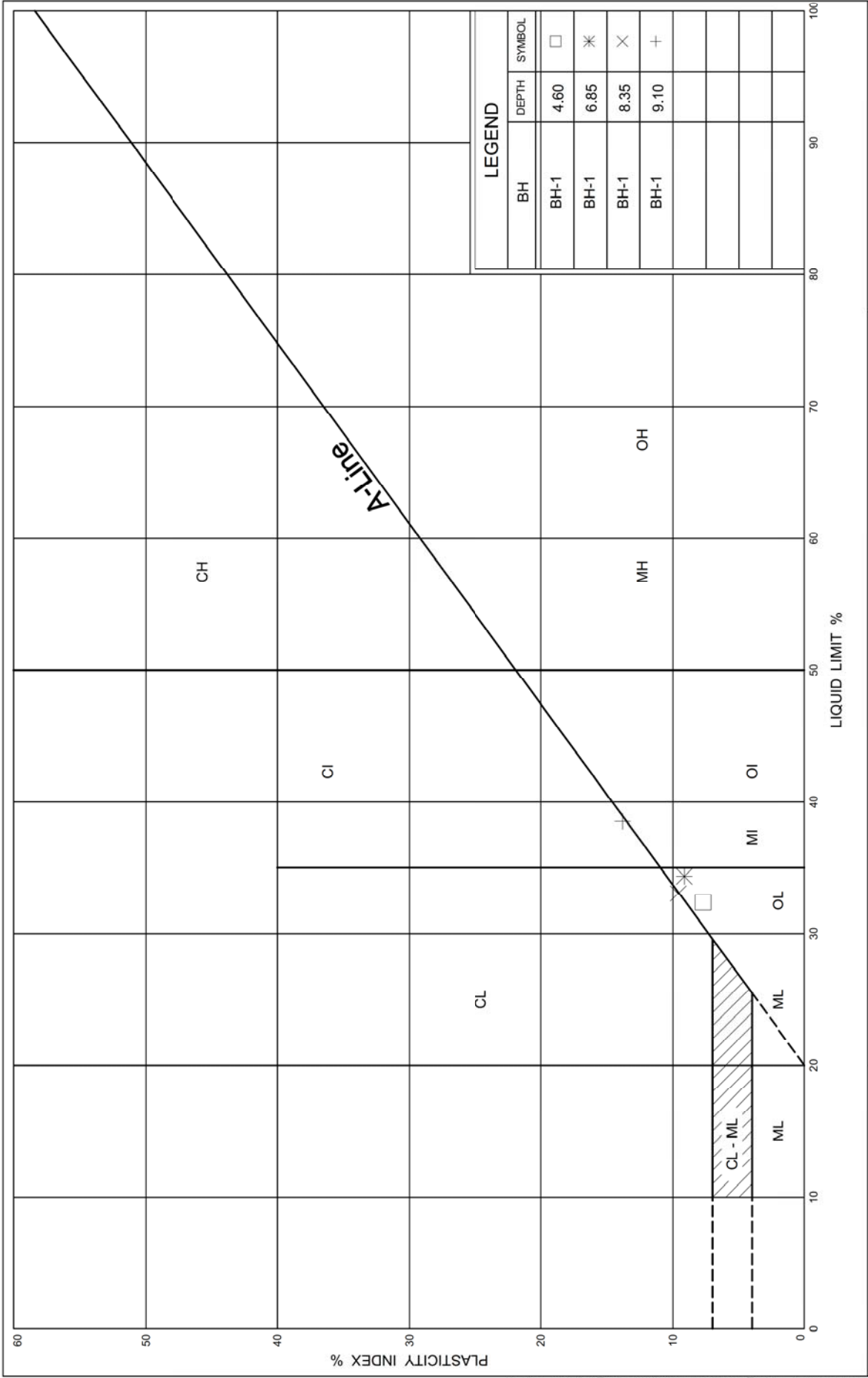
SILT

ENCLOSURE 5

GWP 6909-12-00

HWY 11 - LAKE HELEN







Ministry of
Transportation
Ontario

PLASTICITY CHART
LOW TO INTERMEDIATE PLASTICITY

ENCLOSURE 6

GWP 6909-12-00

HWY 11 - LAKE HELEN



APPENDIX D

Non-Standard Special Provisions

SUBGRADE PROTECTION – Item No.

Non-Standard Special Provision

Scope of Work

The native subgrade soils at and immediately underlying the culver founding grade at this site are comprised of deposits of silt and clayey silt to silty clay, which are susceptible to disturbance and loosening from construction traffic and ponded water. A 300 mm thick protection layer, or bedding layer, comprised of Granular A or Granular B Type II material should be placed on the prepared subgrade in a timely manner. The subgrade should be inspected and approved immediately before placing the bedding layer to confirm the subgrade conditions and any loosened or disturbed soils below the plan limits of the proposed works should be sub-excavated and replaced with compacted engineered fill.

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

DEWATERING OF STRUCTURE EXCAVATION - Item No.

Non-Standard Special Provision

Construction of the Helen Lake culvert will require excavations to extend below the groundwater level. The silt stratum that is 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 dewatering system to enable construction in dry conditions, to 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.

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