



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
NISSIAMKIKAM CREEK CULVERT REPLACEMENT
TEMPORARY MODULAR BRIDGE
HIGHWAY 11, DISTRICT OF THUNDER BAY,
TOWNSHIP OF WALTERS, ONTARIO
LATITUDE: 49.669263°, LONGITUDE: -87.712472°
G.W.P. 6561-16-00, SITE No. 48E-0123/C0**

GEOCRES Number: 42E-34

Report

to

HATCH

Date: February 23, 2021
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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed Temporary Modular Bridge (TMB) for use during the construction of the Nissiamkikam Creek Culvert replacement. The Nissiamkikam Creek Culvert is located on Highway 11, 18 kilometers northeast of the Town of Beardmore, Ontario

The purpose of this investigation was to explore the subsurface conditions at the proposed TMB abutments, and based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch to carry out this foundation investigation under the Ministry of Transportation (MTO) Northwest Region Agreement Number 6019-E-0009, Assignment #17.

2. SITE DESCRIPTION

The site is located on Highway 11, 18 km northeast of the Town of Beardmore, in the Township of Walters, Thunder Bay District, Ontario, at Latitude: 49.669263°, Longitude: -87.712472°. The existing culvert allows Nissiamkikam Creek to flow under the highway from north to south. Highway 11 runs in a general east – west direction at the culvert site. The highway along the site is classified as a two-lane undivided rural arterial highway.

The Ontario Structure Inspection report prepared by MTO on August 25, 2018 indicates that the existing structure is comprised of two closed, elliptical, corrugated steel culverts. The culverts are



approximately 42.7 m in length, 1.93 m wide, and 2.69 m high. Based on existing survey data for the site, the ground surface elevation of Highway 11 at the existing culverts is approximately 321 m. The invert level of the existing culverts is at approximate Elevation 313.5 m. Measurements collected in August 2016 indicate that the surface water level of Nissiamkikam Creek ranged from an approximate elevation of 314.41 to 314.06 m at the north and south ends of the culverts respectively.

The land surrounding the site is gently undulating and predominantly forested, with marshy conditions along the creek floodplain. A TransCanada Pipeline easement lies approximately 50 m to the north of the site. Bedrock is visible in roadcuts along the highway within 200 m west of the site. Possible rockfill is exposed along the Highway 11 embankment slope.

Photographs of the existing culverts and surrounding area are presented in Appendix C.

Based on published geological information, the culverts lie within an area consisting of glaciofluvial outwash deposits of sand and gravel, with recent organic deposits of peat, muck and marl. The bedrock surrounding the site is Pre-Cambrian metasedimentary rock, consisting of wacke, siltstone, arkose, argillite, slate, mudstone, marble, chert, iron formation, conglomerate, arenite, and some minor metavolcanic rocks.

An existing foundation investigation report for the culvert replacement was prepared by EXP in 2019, entitled, "Foundation Investigation and Design Report, Nissiamkikam Creek Culvert Replacement, Site No. 48e-123/C, Hwy 11, Township of Walters, Ontario", Geocres No. 42E-31, dated May 1, 2019. The borehole information from the EXP report is included in Appendix E.

3. INVESTIGATION PROCEDURES

The field investigation for the TMB was carried out on September 19th and 20th, 2020 and consisted of drilling and sampling two (2) foundation boreholes, labeled 20-01 and 20-02 and twelve (12) pavement boreholes, labelled PVT-01 to PVT-12. Further details regarding the pavement boreholes and investigation are discussed in a separate Pavement Design Memorandum by Thurber, entitled, "Pavement Design Memorandum, Highway 11 – Nissiamkikam Creek Culvert Replacement, GWP 6561-16-00, Site No. 48E-123/C Township of Walters, Ontario".

Boreholes 20-01 and 20-02 were drilled on the eastbound lane of Highway 11 and located near the approximate west and east abutment locations for the proposed TMB. The foundation boreholes were drilled to depths of 13.4 m and 16.5 m (Elevation 308.0 m and 304.8 m)



respectively. Full-time traffic protection was utilized in order to carry-out lane closures for the drilling program.

The borehole logs from the foundation investigation are included in Appendix A. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The northing and easting coordinates and the ground surface elevations for the boreholes were estimated based on field measurements from existing site features relative to the topographic drawing (E-903-11-1) provided to Thurber by MTO. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes.

A rubber tracked CME 55 drill rig was used to advance the boreholes, using solid stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) (ASTM D1586). NQ coring methods were used to advance Borehole 20-01 through boulders.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Water Levels were measured in the open boreholes immediately after drilling to assess the groundwater conditions. Upon completion of the investigation the boreholes were decommissioned as per O.Reg. 903.

Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
20-01	13.4 / 308.0	Borehole caved to 2.3 m. Backfilled with bentonite from 2.3 to 0.9 m, dry Cement to 0.2 m, then asphalt to surface.
20-02	16.5 / 304.8	Borehole caved to 2.5 m. Backfilled with bentonite from 2.5 m to 0.9 m, dry cement to 0.2 m, then asphalt to surface.



4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer), where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

The 2019 EXP report included soil testing for corrosivity parameters, and therefore no corrosion testing was completed during this investigation.

5. SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawings included in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the TMB foundation boreholes (20-01 and 20-02) consisted of asphalt, granular fill, and rock fill, underlain by native deposits of sand and gravel, silt, silty sand, and boulders. Bedrock was not encountered in the boreholes but is visible at surface near the site and underlies the overburden. Descriptions of the individual strata are presented below.

5.1 Asphalt

An asphalt layer ranging from 120 to 125 mm thick was encountered at the ground surface in both boreholes.

5.2 Granular and Rock Fill

The asphalt was underlain by a 500 to 600 mm thick layer of granular fill in both boreholes. The fill typically consisted of sand and gravel with some silt. The granular fill extended to depths ranging from 0.6 to 0.7 m (Elev. 320.7 m).



The measured moisture content in the granular fill ranged from 1 to 5%.

The granular fill was underlain by 2.4 to 3.7 m of rock fill / crushed gravel, extending to depths of 3.1 to 4.3 m (Elev. 318.3 to 317.0 m) in Boreholes 20-01 and 20-02 respectively. Wash boring drilling methods were required to penetrate the rock fill / crushed gravel.

5.3 Upper Sand and Gravel

A deposit of native sand and gravel containing trace silt was encountered below the rock fill in Borehole 20-02. The thickness of the deposit was 1.3 m and extended to a depth of 5.6 m (Elev. 315.7 m).

The SPT 'N' value measured in the sand and gravel deposit was 14 blows for 0.3 m of penetration, indicating that the deposit is compact. The measured moisture content of the deposit was 13%.

The results of a grain size analysis conducted on a sample of the sand and gravel are illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	41
Sand	51
Silt and Clay	8

5.4 Silt

A deposit of silt with trace sand and trace to some clay was encountered below the sand and gravel deposit in Borehole 20-02 and beneath the rock fill at 20-01. The thickness of the silt deposit ranged from 6 m to 8.7 m and extended to depths of 9.1 m to 14.3 m (Elev. 312.3 to 307.0 m)

SPT 'N' values measured in the silt deposit typically ranged from 14 to 35 blows for 0.3 m of penetration, indicating that the deposit is compact to dense. One N value of 52 blows for 0.3 m of penetration (very dense) was recorded in Borehole 20-01 immediately below the rock fill layer, and may therefore be higher due to the presence of rock fill or crushed gravel in the sample. The measured moisture contents in the silt ranged from 15 to 25%.

The results of grain size analyses conducted on samples of the silt are illustrated on Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 - 6
Silt	89 - 94
Clay	5 - 12

5.5 Lower Sand and Gravel

A deposit of sand and gravel with some silt and trace clay was encountered below the silt deposit in Borehole 20-01. The thickness of this deposit was approximately 1.3 m and extended to a depth of 10.4 m (Elev. 311.0 m).

An SPT 'N' value measured in the lower sand and gravel deposit was 40 blows for 0.3 m of penetration, indicating that the deposit is dense. The measured moisture content in the deposit was approximately 7%.

The result of a grain size analysis conducted on a sample of the sand and gravel are illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	35
Sand	44
Silt and Clay	21

5.6 Boulders

A layer of boulders with cobbles and occasional sand seams was encountered below the lower sand and gravel deposit in Borehole 20-01. Rock coring was required to advance through cobbles in this deposit. A boulder of approximately 580 mm diameter and cobbles of 30 to 80 mm diameter were observed within this deposit. Borehole 20-01 was terminated within the boulder deposit at a depth of 13.4 m (Elev. 308.0 m).

5.7 Silty Sand

A deposit of grey, silty sand with trace gravel and occasional cobbles was encountered below the silt deposit in Borehole 20-02. Borehole 20-02 was terminated within this deposit at a depth of 16.5 m (Elev. 304.8 m).



SPT 'N' values measured in the silty sand deposit ranged from 22 to 23 blows for 0.3 m of penetration, indicating that the deposit is compact. The measured moisture content in the deposit was approximately 12%.

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes. A summary of the water level measurements is provided in Table 5.1 below:

Table 5.1 - Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
20-01	September 19, 2020	7.7	313.7	Open borehole
20-02	September 20, 2020	7.8	313.5	Open borehole

The above measurements represent unstabilized, short-term water level readings that were collected upon completion of drilling each borehole.

The groundwater level should be anticipated to reflect the local creek water level. The water level of Nissiamkikam Creek in August 2016 was measured at approximate Elevation 314.4 to 314.1 m at the inlet and outlet of the existing culverts respectively.

Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by MTO.

RPM Drilling Ltd. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Randy Pomerleau of Thurber. The overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. of Thurber. Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory.



Interpretation of the field data and preparation of this report was carried out by Ms. Rachel Bourassa, E.I.T. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation design recommendations for the proposed construction of a temporary modular bridge (TMB) to facilitate the replacement of the Nissiamkikam Creek Culvert. The TMB is proposed to be designed by the contractor. Recommendations for the culvert replacement were provided in a previous report by EXP.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The site is located on Highway 11, 18 km northeast of the Town of Beardmore, in the Township of Walters, Thunder Bay District, Ontario at Latitude: 49.669263°, Longitude: -87.712472°. The existing culvert allows Nissiamkikam Creek to flow under the highway from north to south. Highway 11 runs in a general east – west direction at the culvert site. The highway along the site is classified as a two-lane undivided rural arterial highway.

The Ontario Structure Inspection report prepared by MTO on August 25, 2018 indicates that the existing structure is comprised of two closed, elliptical shaped, corrugated steel culverts. The



culverts are approximately 42.7 m in length, 1.93 m wide, and 2.69 m high. Based on existing survey data for the site, the ground surface elevation of Highway 11 at the existing culverts is approximately 321 m. The invert level of the existing culverts is at approximate Elevation 313.5 m. Measurements collected in August 2016 indicate that the surface water level of Nissiamkikam Creek ranged from an approximate elevation of 314.41 to 314.06 m at the north and south ends of the culverts respectively.

Based on preliminary General Arrangement (GA) drawings provided by Hatch, it is understood that an approximately 43 m long, in-line, temporary modular bridge (TMB), to be designed by the contractor, is proposed for staged construction to maintain a single lane of traffic during replacement of the culvert. The TMB is expected to be supported on concrete footings founded on engineered granular fill pads. The TMB is to be located at the existing highway grade level.

8. TEMPORARY MODULAR BRIDGE FOUNDATIONS

This section presents discussions on the proposed foundation alternatives for the Nissiamkikam Creek Culvert replacement temporary modular bridge.

In general, the foundation soil stratigraphy at the location of the TMB consists of sand and gravel fill and rock fill / crushed gravel, underlain by typically compact to dense native silt and sand and gravel deposits, silty sand and boulders.

The short-term water level in the boreholes ranged from Elevation 313.7 to 313.5 m, and the water level in the creek was measured at Elevation 314.4 to 314.1 m at the north and south ends of the culvert respectively. The groundwater level will likely reflect the creek water level.

Based on the subsurface conditions at this site, consideration was given to supporting the TMB on the following foundation types:

- Spread footings placed on engineered fill pads within the existing embankment fill; and
- Driven Steel H-piles.

Since relatively good foundation soils exist at shallow depth, footings on engineering granular fill pads are a cost-effective solution for the TMB bridge foundations. Driven piles for the TMB would not be cost-effective, and therefore recommendations have not been developed in this report for steel H-piles.

Recommendations for design of spread footings placed on engineered fill pads are provided in the following sections.



8.1 Spread Footings on Engineered Fill Pads

8.1.1 Founding Level

The use of concrete spread footings placed on minimum 500 mm thick granular engineered fill pads supported on rock fill / crushed gravel is considered feasible from a geotechnical perspective to support the temporary modular bridge.

Based on the GA drawings, the west and east abutment spread footings are founded at approximate Elevation 320 m. The base of the engineered fill pads should be placed on the existing rock fill / crushed gravel fill at a minimum of 500 mm below the footings, at or below approximate Elevation 319.5 m.

The length of the footings is reported to be between 7 and 7.5 m. The unfactored loads from the TMB superstructure per abutment are reported by MTO's structural designer to be approximately Live Load of 700 kN (including DLA) and Dead Load of 400 kN.

8.1.2 Forward Slope Stability Assessment

The GA drawings indicate that the culvert replacement excavations will be approximately 8 m deep in front of the TMB abutments, with the excavation sloped at 1.5H:1V above the water level and 3H:1V below the water level. The stability of the forward slopes in front of the TMB abutments was analysed using Slope/W 2020 software by GeoStudio, with the results shown on Figures 1 and 2 in Appendix G.

The analyses were done for both the 1.5 m wide (Figure 1) and 2 m wide (Figure 2) footing options, founded on engineered fill pads, with the footings set back a minimum of 2 m from the crest of the forward slopes. Figure 1 indicates that the Factor of Safety against slope failure is less than 1.3, based on 1.5 m wide footings. The 2 m wide footing shown in Figure 2 results in a Factor of Safety against slope failure of 1.3. For temporary slopes, a Factor of Safety of 1.3 is recommended, and therefore the 2 m wide footing option for the TMB is recommended over the 1.5 m wide footing option.

The temporary excavation slopes must be protected against scour and erosion as discussed in Section 11 to avoid undermining the TMB footings and compromising the stability of the slopes.



It should be noted that silt is known to be highly susceptible to mechanical and hydraulic disturbances and subsequent softening or loss of shear strength. Care must be taken when excavating in the sensitive silt below the rock fill / crushed gravel to avoid shallow slides and sudden release of perched water. Prior to excavating into silt below groundwater level, active dewatering should be carried out to minimize the potential for running ground and/or base boiling due to seepage flow. Reference should be made to the previous EXP report, Geocres No. 42E-31 for further recommendations on excavating and dewatering for the culvert replacement.

8.1.3 Engineered Fill Pad Construction

Since the footing founding level is within the existing embankment fill and therefore above the anticipated groundwater level, dewatering will likely not be required during construction of the engineered fill pads.

The engineered fill pads should consist of OPSS Granular A or Granular B Type II placed in 150 mm lifts and compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) at $\pm 2\%$ of Optimum Moisture Content (OMC). As the underlying embankment fill consists of rock fill / crushed gravel, the surface of the rock fill should be chinked with finer material before constructing the engineered fill pads to prevent loss of granular fill into the rockfill. The minimum depth of excavation should accommodate the concrete foundation slab and the thickness of engineered fill pad below the slab.

The dimensions of the base of the excavation should be determined by assuming a granular pad at least 1.0 m wider than the spread footing at the level of the footing base and projecting outward and downward at 1H:1V to the base of the granular pad. Sloped excavations through the existing granular fill and rock fill / crushed gravel will be required to construct the granular pad at the desired elevation.

The forward slope of the engineered granular fill pads should be embedded at least 0.5 m below the face of the forward slope of the temporary culvert excavation, with the edge of the concrete footing at a minimum of 2 m behind the crest of the forward slope. The forward slope must be inclined at no steeper than 1.5H:1V. Provision of properly designed erosion protection works will be critical to ensure adequate performance of the temporary excavation slopes so as not to undermine the TMB footings.

An NSSP on TMB construction is provided in Appendix F.

8.1.4 Geotechnical Resistances

The following geotechnical resistances are recommended for design of minimum 2 m wide spread footings placed on minimum 0.5 m thick engineered granular fill pads prepared as outlined above with the underside founded on rock fill / crushed gravel at or below approximate elevation 319.5 m or below:

Geotechnical Resistance	West Abutment	East Abutment
Factored Geotechnical Resistance at ULS (kPa)	165	165
Geotechnical Reaction at SLS (kPa) (for up to 25 mm settlement)	110	110

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the footing width or founding/invert elevation differs significantly from that given above.

The geotechnical resistance quoted above is for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be reduced in accordance with Section 6.10 of CHBDC 2019.

The lateral resistance of the concrete footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

8.2 Frost Cover

The depth of frost penetration at this site is approximately 2.6 m, as per OPSD 3090.100.

The TMB concrete spread footings founded on granular engineered fill pads, provided they consist of non-frost susceptible, free draining engineered fill, above the creek water level may be provided with a minimum embedment of 0.5 m. These footings do not need to be placed below the depth of frost, particularly since the temporary modular bridge can accommodate some movement.



9. EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the existing fill and native soils may be classified as Type 3 soil above the water level and Type 4 soil below the water level.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902. Excavations for placement of footings and engineering fill pads will be carried out through the existing granular fill and rock fill / crushed gravel. It must be emphasized that cobbles and boulders and other potential obstructions will likely be encountered during excavation in the fill. Suggested wording for an NSSP on obstructions is included in Appendix F. It is anticipated that all excavations for the TMB foundations will be above the groundwater level and creek level, and therefore will not require significant dewatering. However, seepage or perched water from the granular fill is to be expected. The Contractor should be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation.

Selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment and interpretation of the site conditions.

10. LATERAL EARTH PRESSURES

If any new backfill is placed behind the TMB abutments, it should be placed in accordance with OPSS 902. All backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II or Type III conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 3101.150, as appropriate. Compaction equipment to be used adjacent to the abutment walls should be restricted in accordance with OPSS.PROV 501.

Earth pressures acting on the structures may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K (\gamma h + q)$$

Where:

- p_h = horizontal pressure on the wall at depth h (kPa)
- K = coefficient of lateral earth pressure (see Table 10.1)
- γ = unit weight of retained soil (see Table 10.1)
- h = depth below top of fill where pressure is computed (m)
- q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are given in Table 10.1.

Table 10.1 – Coefficients of Lateral Earth Pressure (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
	Horizontal Backfill	Horizontal Backfill
Active K_A (Unrestrained Wall)	0.27	0.31
At-rest K_0 (Restrained Wall)	0.43	0.47
Passive K_P	3.7	3.3

* For abutment walls, if required

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill which linearly decreases to 0 kPa at a depth of 1.7 m (for Granular B Type I) or at a depth of 2.0 m (for Granular A or B Type II).

11. SCOUR AND EROSION PROTECTION

Erosion protection must be provided at the temporary excavation forward slopes.

The temporary excavation in front of the TMB abutments will be through rock fill / crushed gravel and native silt, which is erodible. Options to protect the temporary slopes may include gravel sheeting or tarps. Typically, rock protection should also be provided over all surfaces with which creek water is likely to be in contact.

12. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Cobbles, boulders and other buried obstructions will be encountered in the existing embankment fill or native deposits and may interfere with excavation. Suggested wording for an NSSP on obstructions is included in Appendix F.
- Scour and erosion protection measures for the temporary slopes in front of the TMB footings must be provided in order to prevent undermining of the TMB abutments and compromising the stability of the temporary excavation slopes. Suggested wording for an NSSP on TMB construction is included in Appendix F.

13. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No 20-01

1 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 754.2 E 253 353.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.09.19 - 2020.09.19 LATITUDE 49.669264 LONGITUDE -87.712769 CHECKED BY MF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
						20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
321.4	GROUND SURFACE												
0.0	ASPHALT: (120mm)												
0.1	SAND and GRAVEL, some silt Moist/Dry (FILL)		1	GS									
320.7	ROCKFILL/CRUSHED GRAVEL Wash bored through rockfill		2	GS									
0.7													
318.3	SILT, trace sand, trace clay Very Dense Light Brown Moist		1	SS	52								0 1 94 5
3.1													
	Becoming compact		2	SS	14								
			3	SS	21								
			4	SS	19								0 2 89 9
312.3	SAND and GRAVEL, some silt, trace clay Dense Grey Moist		5	SS	40								35 44 21 (SI+CL)
9.1													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-29478.GPJ 2017TEMPLATE(MTO).GDT 1/14/21

RECORD OF BOREHOLE No 20-01

2 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 754.2 E 253 353.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.09.19 - 2020.09.19 LATITUDE 49.669264 LONGITUDE -87.712769 CHECKED BY MF

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100	20	40	60			
	Continued From Previous Page																
311.0																	
310.4	BOULDERS occasional sand seams																
10.5	Boulder (580mm diameter) Cored through cobbles ranging from 30 to 80mm diameter		1	RUN													
310.3																	
11.1																	
			2	RUN													
308.0																	
13.4	END OF BOREHOLE AT 13.4m UPON CASING REFUSAL. BOREHOLE CAVED TO 2.3m AND WATER LEVEL AT 7.7m IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, DRY CEMENT TO 0.2m, THEN COLD PATCH TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5 0
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S2 MTO-29478.GPJ 2017TEMPLATE(MTO).GDT 1/14/21

RECORD OF BOREHOLE No 20-02

2 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 753.7 E 253 396.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2020.09.20 - 2020.09.20 LATITUDE 49.669263 LONGITUDE -87.712174 CHECKED BY MF

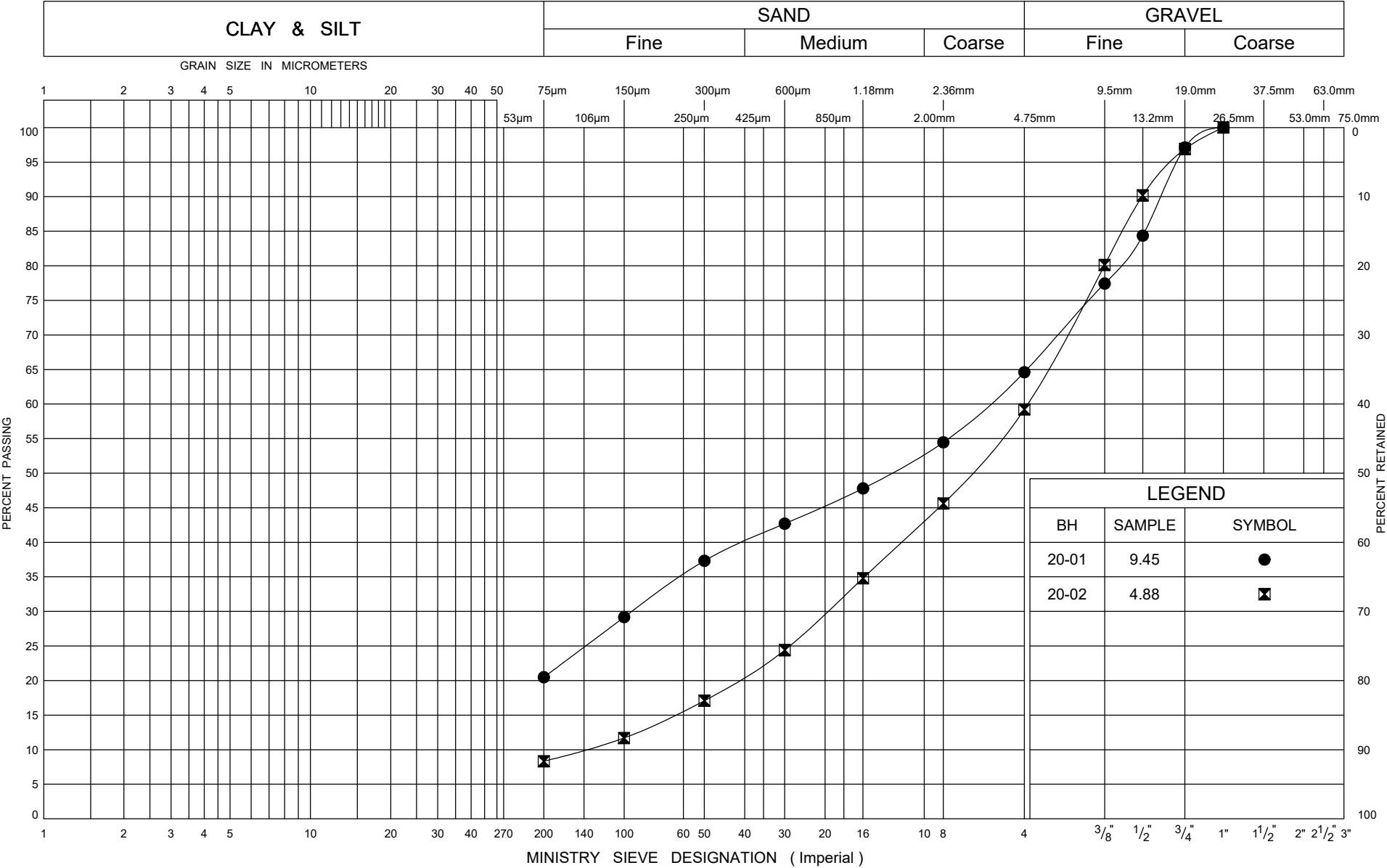
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
	Continued From Previous Page						20	40	60	80	100	20	40	60					
307.0							311												
			7	SS	14														
			8	SS	17														
			9	SS	16														
14.3	Silty SAND , trace gravel, occasional cobbles Compact Grey Wet						307									0	1	90	9
							306												
304.8			10	SS	22														
			11	SS	23														
16.5	END OF BOREHOLE AT 16.5m. BOREHOLE CAVED TO 2.5m AND WATER LEVEL AT 7.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, DRY CEMENT TO 0.2m, THEN COLD PATCH TO SURFACE.						305												

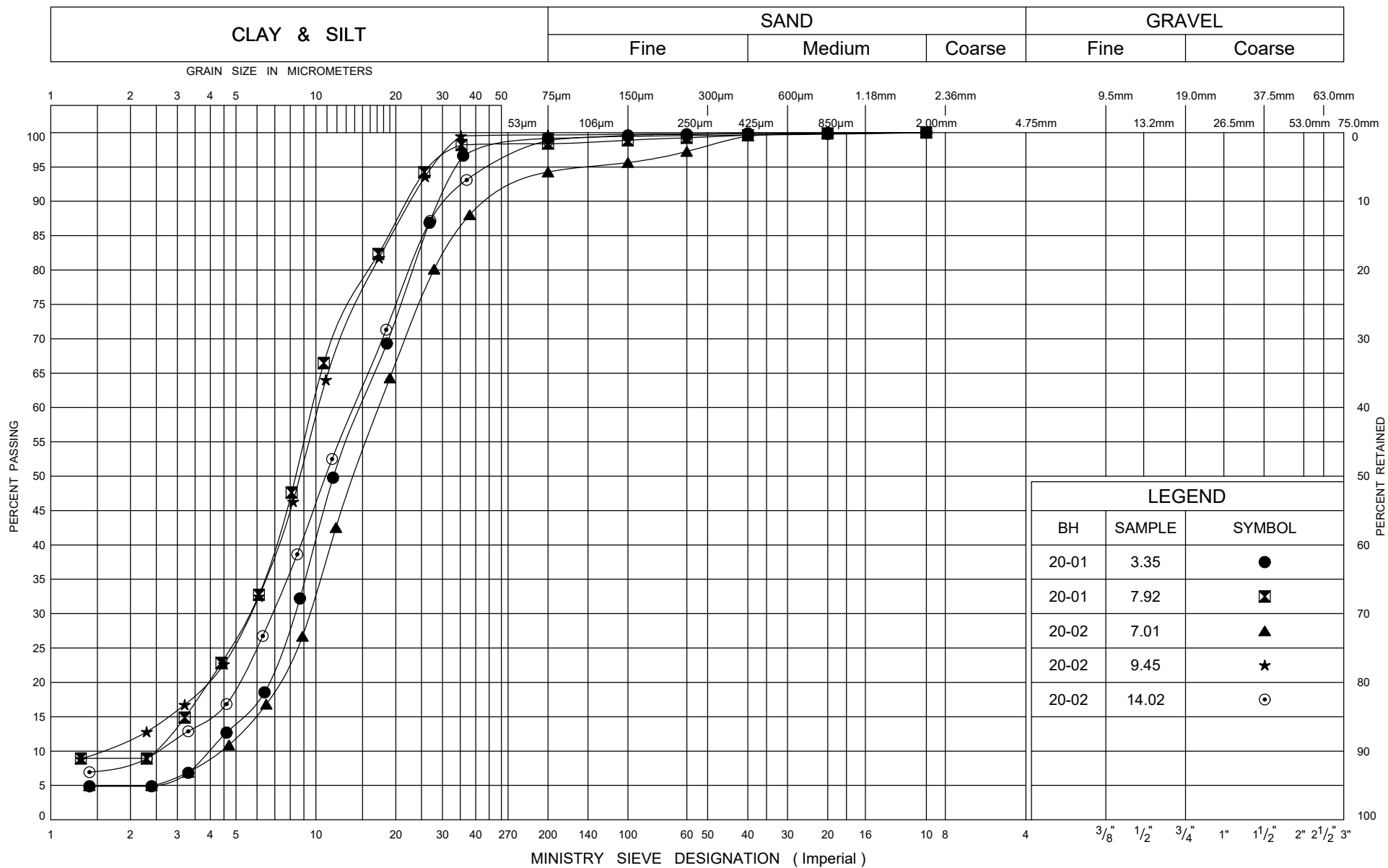
ONTMT4S2 MTO-29478.GPJ 2017TEMPLATE(MTO).GDT 1/14/21



Appendix B

Geotechnical Laboratory Test Results







Appendix C

Site Photographs



**Photo C1: East approach to existing culvert looking west along Highway 11.
(Date taken: September 20, 2020)**



**Photo C2: West approach to existing culverts, looking east along Highway 11.
(Date taken: September 20, 2020)**



**Photo C3: South side of Highway 11, south end of culverts looking north.
(Date taken: September 20, 2020)**



**Photo C4: North side of Highway 11, above culverts looking north along Nissiamkikam Creek.
(Date taken: September 20, 2020)**



**Photo C5: South side of Highway 11, above south end of culverts looking west.
(Date taken: September 20, 2020)**



**Photo C6: South side of Highway 11, above south end of culverts looking east.
(Date taken: September 20, 2020)**



**Photo C7: North side of Highway 11, above north end of culverts looking west.
(Date taken: September 20, 2020)**

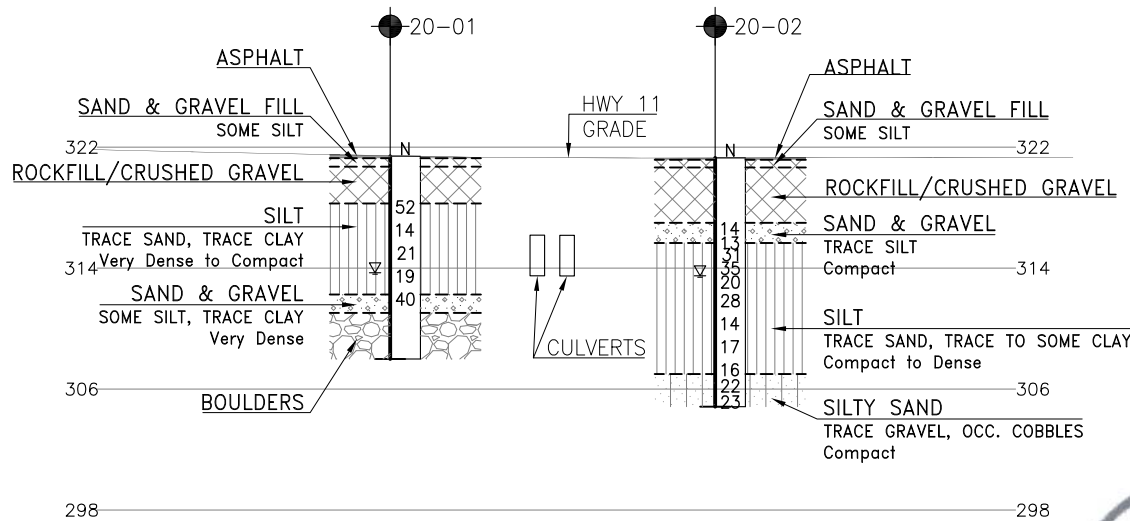
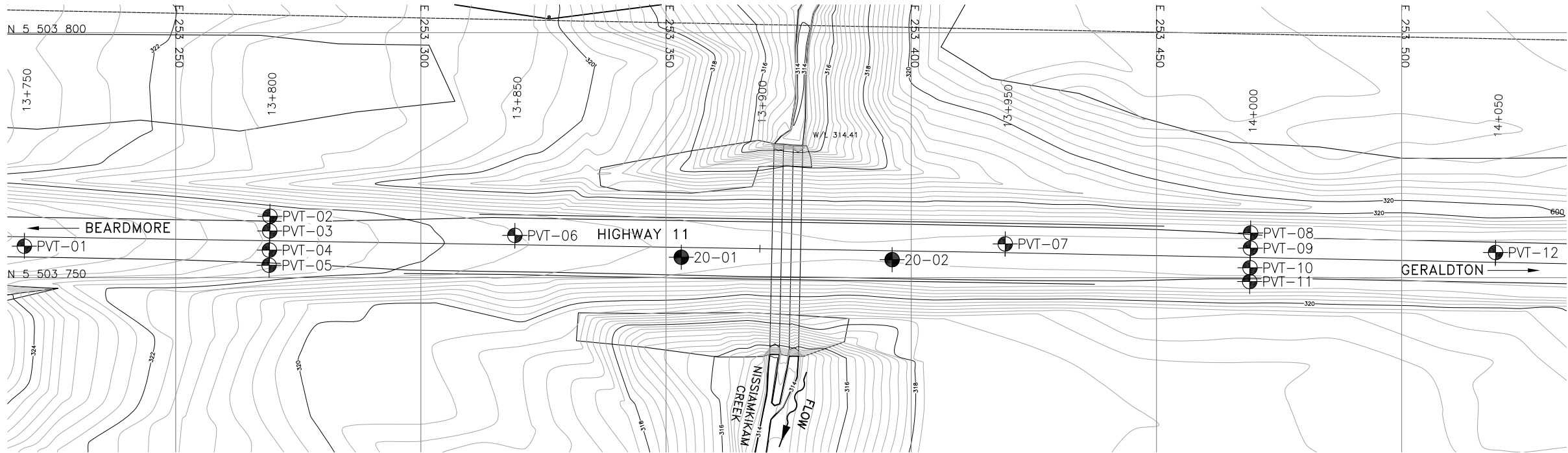


**Photo C8: South side of Highway 11, West edge of site looking north west toward bedrock
outcrops. (Date taken: September 20, 2020)**

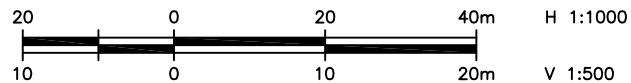


Appendix D

Borehole Locations and Soil Strata Drawings



PROFILE ALONG CL HWY 11



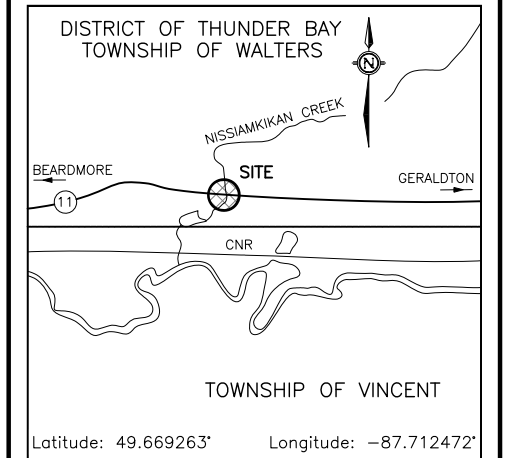
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 6561-16-00

HIGHWAY 11
NISSIAMKIKAM CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
13



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

PVT-11	321.2	5 503 749.2	253 469.0
PVT-12	321.4	5 503 755.1	253 519.1

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42E-34

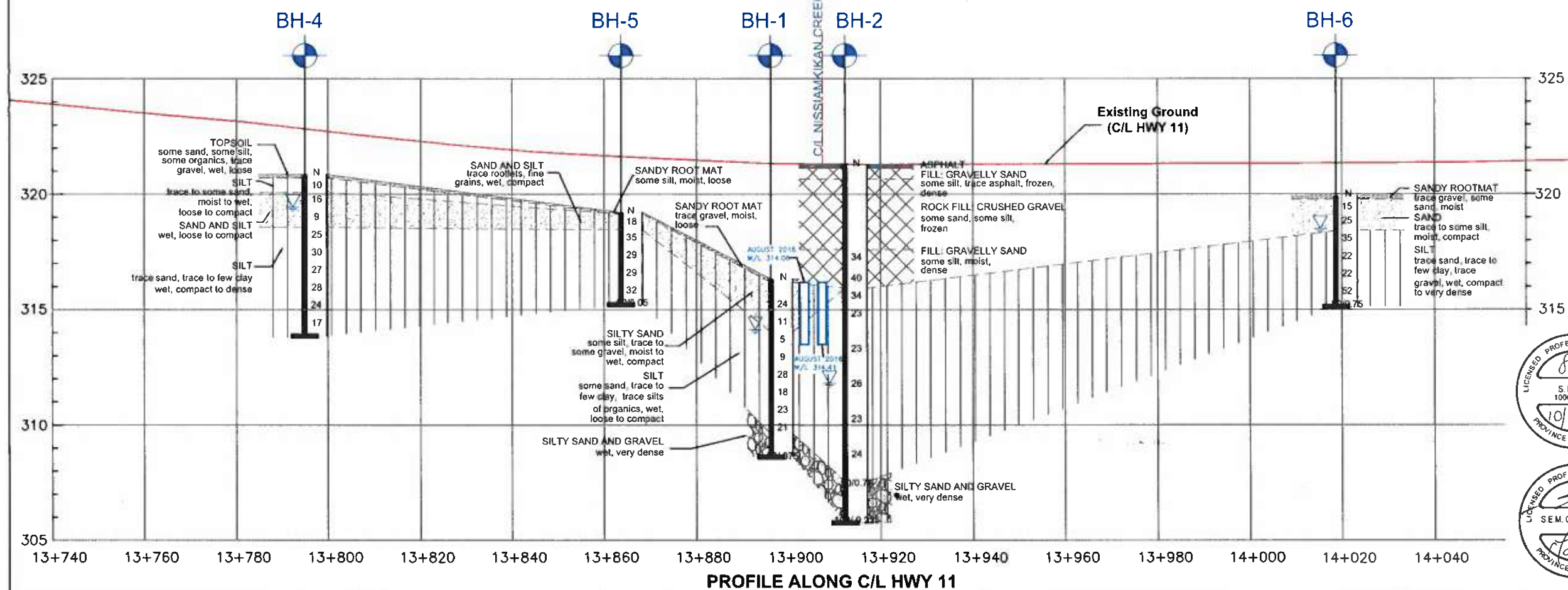
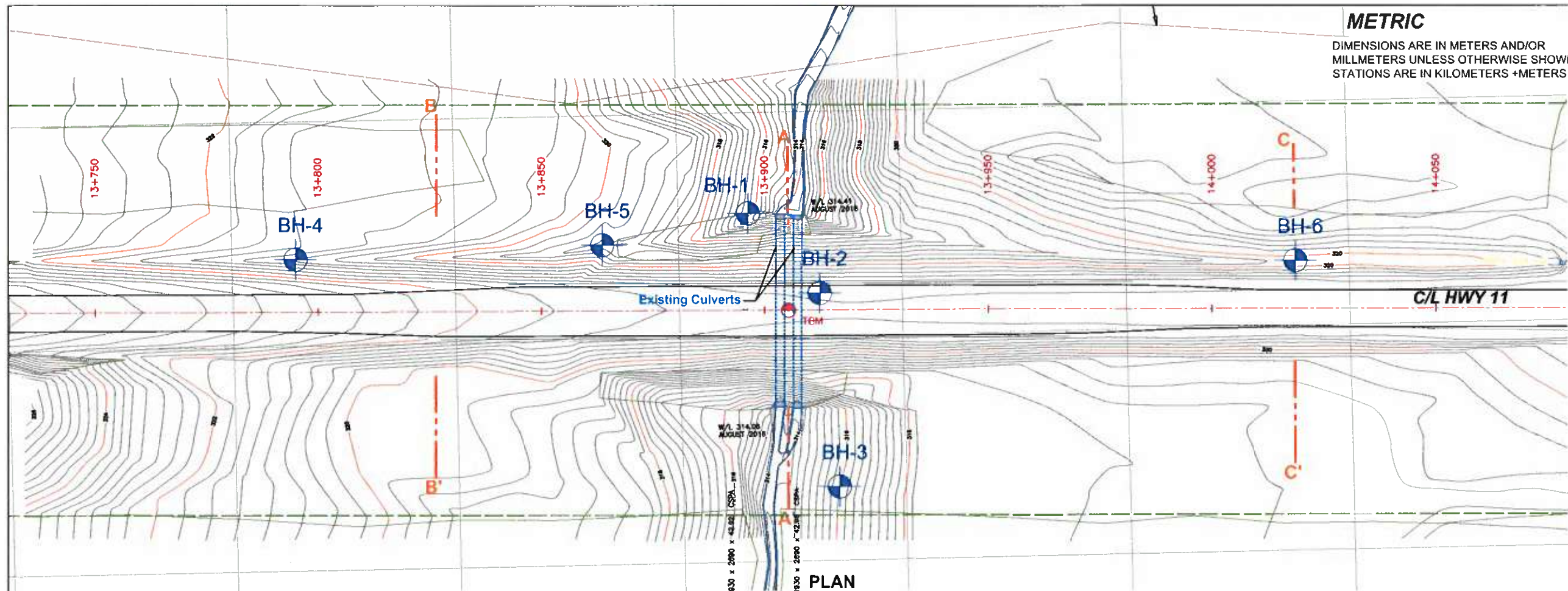


REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RB	CHK MEF	CODE
DRAWN	AN	CHK RB	SITE 48E-0123/CO
			STRUCT
			DWG 1
			DATE FEB 2021



Appendix E

Borehole Data from Geocres Report 42E-31



Agreement No.: 6017-E-0066
Assignment No. 2
GWP 6561-00



NISSIAMKIKAN CREEK CULVERTS REPLACEMENT
Hwy 11, ONTARIO, CANADA
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

exp. Services Inc.

KEY PLAN



LEGEND

- Location of Drilled Boreholes
- N Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 321.31m)

SOIL STRATA SYMBOLS

- TOPSOIL/ SANDY ROOT MAT
- ASPHALT
- FILL/ ROCK FILL
- SILT
- SILTY SAND AND GRAVEL
- SILTY SAND/ SAND AND SILT

BH No.	APPROX. ELEV.	MTM CO-ORDINATES (ZONE ON-14)	
		NORTH	EAST
BH-1	316.3	5503777.6	253365.8
BH-2	321.3	5503759.5	253381.5
BH-3	316.1	5503716.3	253385.1
BH-4	320.9	5503769.4	253264.3
BH-5	319.2	5503771.2	253333.1
BH-6	319.9	5503764.4	253488.1

NOTE

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 Contract Documents.

The complete foundation investigation and design report for this project and other related documents may be examined at the Matens Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

SCALE:



29/04/2019	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRE NO. 42E-31	
		PROJECT NO. ADM-00248798-B0	
SUBMD SM	CHECKED SM	DATE	29/04/2019
DRAWN SH	CHECKED SG	APPROVED SG	DWG. 1

METRIC

DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

Agreement No.: 6017-E-0066
Assignment No. 2
GWP 6561-00

NISSIAMKIKAN CREEK CULVERTS REPLACEMENT
Hwy 11, ONTARIO, CANADA
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

exp Services Inc.

KEY PLAN



LEGEND

- Location of Drilled Boreholes
- N Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 321.31m)

SOIL STRATA SYMBOLS

- TOPSOIL
- SANDY ROOT MAT
- ASPHALT
- FILL/ROCK FILL
- SILTY SAND/ SAND AND SILT
- SILT
- SILTY SAND AND GRAVEL

BH No.	APPROX. ELEV.	MTM CO-ORDINATES (ZONE ON-14)	
		NORTH	EAST
BH-1	316.3	5503777.6	253365.8
BH-2	321.3	5503759.5	253381.5
BH-3	316.1	5503716.3	253385.1
BH-4	320.9	5503769.4	253264.3
BH-5	319.2	5503771.2	253333.1
BH-6	319.9	5503764.4	253488.1

NOTE

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.

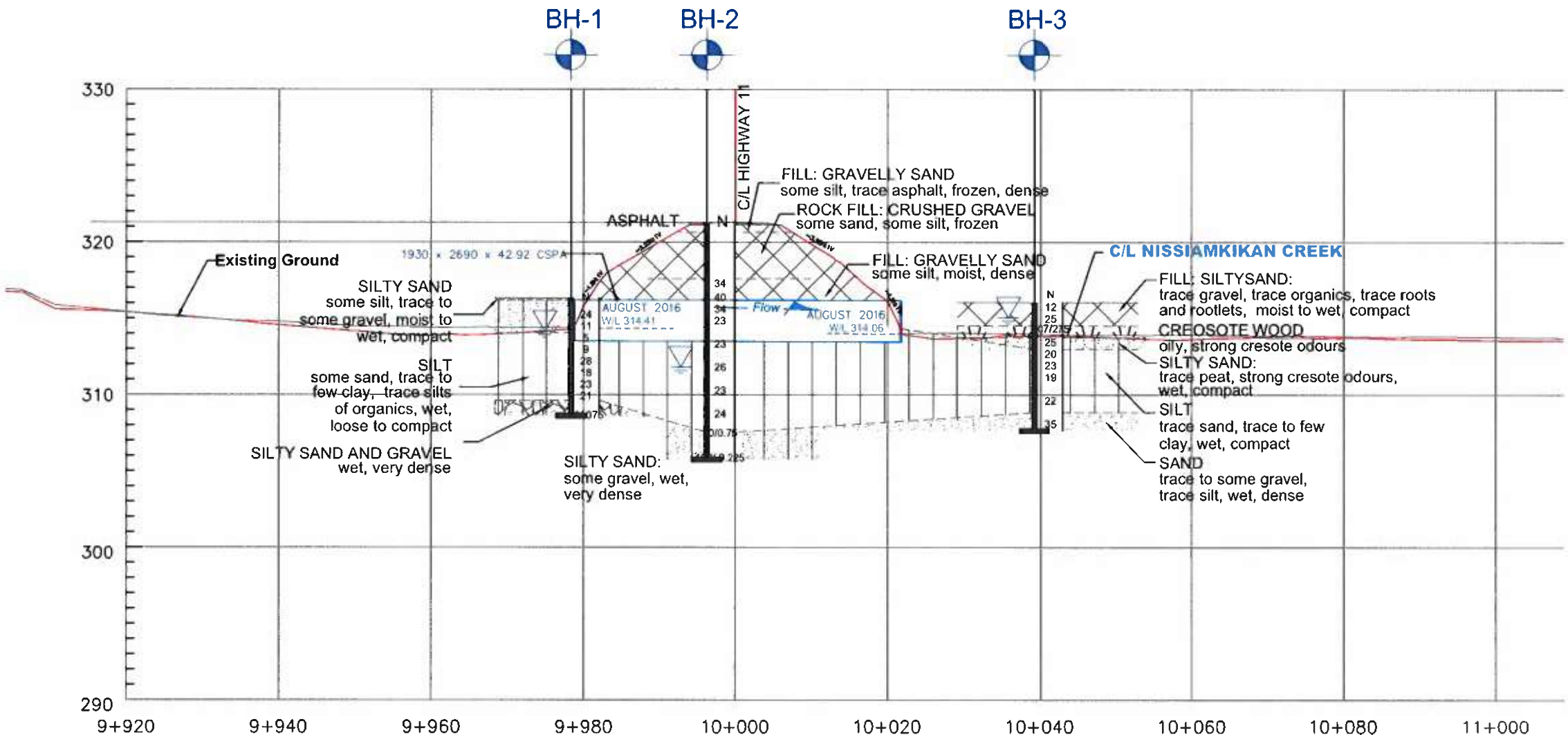
The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

SCALE:



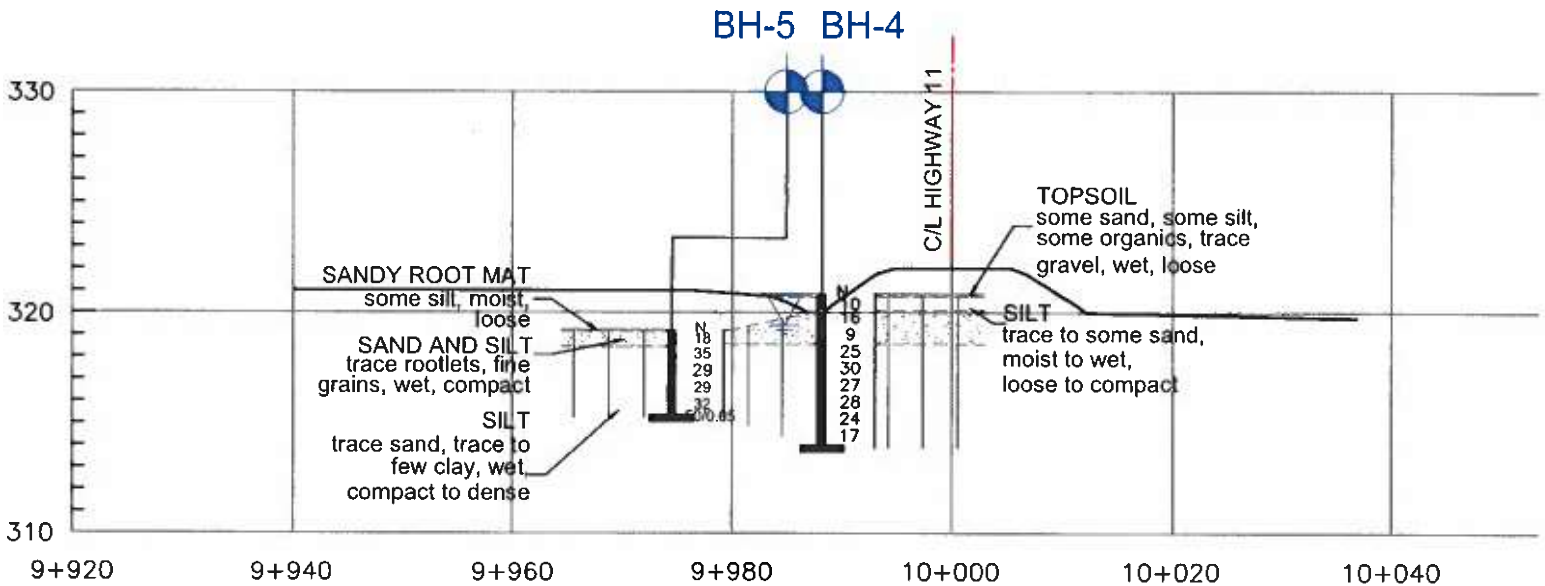
29/04/2019	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRE NO. 42E-31	
		PROJECT NO. ADM-00248798-B0	
SUBMD	SM	CHECKED	SM
DRAWN	SH	CHECKED	SG
DATE	29/04/2019	APPROVED	SG
DWG.	2		

SECTION A-A' ALONG
C/L CULVERT

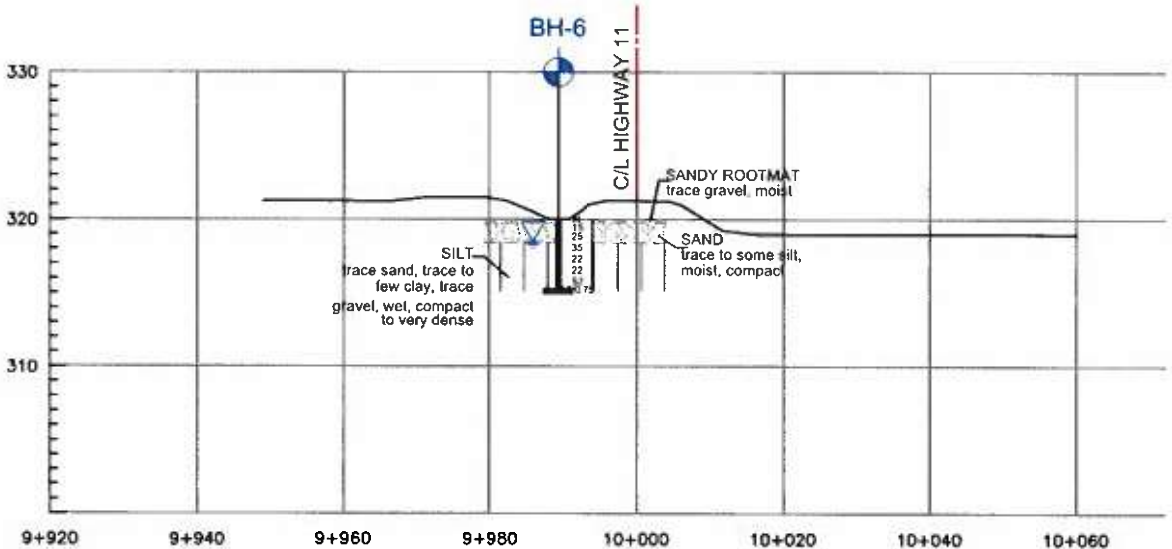


METRIC

DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS



SECTION B-B'



SECTION C-C'

Agreement No. 6017-E-0066
Assignment No. 2
GWP 6561-00

NISSIAMKIKAN CREEK CULVERTS REPLACEMENT
Hwy 11, ONTARIO, CANADA
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

exp. exp Services Inc.

KEY PLAN



LEGEND

- Location of Drilled Boreholes
- N Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 321.31m)

SOIL STRATA SYMBOLS

- TOPSOIL/ SANDY ROOT MAT
- ASPHALT
- FILL/ ROCK FILL
- SILT
- SILTY SAND AND GRAVEL
- SILTY SAND/ SAND AND SILT

BH No.	APPROX. ELEV.	MTM CO-ORDINATES (ZONE ON-14)	
		NORTH	EAST
BH-1	316.3	5503777.6	253365.8
BH-2	321.3	5503759.5	253381.5
BH-3	316.1	5503716.3	253385.1
BH-4	320.9	5503769.4	253264.3
BH-5	319.2	5503771.2	253333.1
BH-6	319.9	5503764.4	253488.1

NOTE

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SCALE:



29/04/2019	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRE NO. 42E-31	
		PROJECT NO. ADM-00248798-B0	
SUBMD	SM	CHECKED	SG
DRAWN	SH	CHECKED	SG
DATE	29/04/2019	APPROVED	SG
DWG	3		

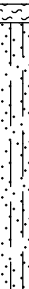

Brampton, Ontario

RECORD OF BOREHOLE No BH-1

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253365.784E, 5503777.576N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.12 - 2018.12.13 LATITUDE 49.6694753 LONGITUDE -87.7125968 CHECKED BY SM

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								WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER										
316.3	Ground Surface																	
316.0	SANDY ROOTMAT: trace gravel, dark brown, moist, loose SILTY SAND: trace to some gravel, brown to greyish brown, moist to wet, compact		1	AS		▽												
0.2			2	SS			316											
			3	SS	24												14 57 (29)	
			4	SS	11			315										
314.0	SILT: some sand, trace to few clay, trace organics, light brown to light grey, wet, loose to compact -becoming sandy silt		5	SS	5		314											
2.3																		
			6	SS	9			313									0 38 55 7	
			7	SS	28			312										
			8	SS	18													

ONTARIO MTO ASSIGNMENT #2.GPJ ONTARIO MTO.GDT 2/7/19

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-2

1 OF 2

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253381.543E, 5503759.512N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 112 mm SSA, 108 mm ID HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.14 - 2018.12.14 LATITUDE 49.6693143 LONGITUDE -87.7123761 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100		W _P	W	W _L		
321.3	Road Surface																	
320.0	ASPHALT 125 mm thick asphalt		1	AS							○						12	61 (27)
0.1	FILL: GRAVELLY SAND some silt, trace asphalt, frozen, brown, dense		2	AS							○							
320.7			3	AS							○							
0.6	ROCK FILL: CRUSHED GRAVEL some sand, some silt, brown, frozen		4	AS							○							
			5	AS							○							
			6	AS							○							
			7	AS							○							
			8	SS	2												no recovery	
317.6	FILL: GRAVELLY SAND some silt, brown, moist, dense		9	SS	34						○						27	59 (14)
3.7			10	SS	40						○							
315.9	SILT: trace sand, trace to few clay, light brown to light grey, wet, dense to compact		11	SS	34						○						0	4 90 6
5.3			12	SS	23						○							
			13	SS	23						○							
			14	SS	26						○						0	1 (99)
			15	SS	23						○							

Continued Next Page

+³, X³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-3

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253385.115E, 5503716.303N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.11 - 2018.12.12 LATITUDE 49.6689261 LONGITUDE -87.7123209 CHECKED BY SM

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
316.0	Ground Surface																
0.0	FILL: SILTY SAND: trace gravel, trace organics, trace roots and rootlets, brown, moist to wet, compact		1	SS	12												
			2	SS	25												
314.5																	
1.5	CREOSOTE WOOD oily, strong creosote odours refusal to SPT @ 1.9 m auger through wood		3	SS	107/ 0.225												
313.8																	
2.3	SILTY SAND: trace peat, strong creosote odours, dark brown, wet, compact		4	SS	25												
313.0																	
3.1	SILT: trace sand, trace to few clay, grey, wet, compact		5	SS	20												
			6	SS	23												
			7	SS	19												
			8	SS	22												
308.8	noted harder strata or change in layer @ approximate 7.2 m.																
7.2	SAND: trace to some gravel, trace silt, grey, wet, dense		9	SS	35												
307.6																	
8.4	End of Borehole: auger/ split-spoon refusal @ 8.4 m Notes: 1. Upon completion of borehole, groundwater level measured at 1.0 m.																

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







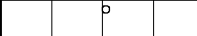


Brampton, Ontario

RECORD OF BOREHOLE No BH-4

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253264.348E, 5503769.383N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.13 - 2018.12.13 LATITUDE 49.669393 LONGITUDE -87.7140016 CHECKED BY SM

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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
320.9	Ground Surface		1	AS																		
320.0	TOPSOIL: some sand, some silt, some organics, trace gravel, dark brown to black, wet, loose		2	SS	10																	0 16 (84)
320.1	SILT trace to some sand, light brown with oxidation, moist to wet, loose to compact		3	SS	16																	0 46 (54)
0.8	SAND AND SILT brown, wet, loose to compact		4	SS	9																	
318.6	SILT trace sand, trace to few clay, light brown to grey, wet, compact to dense	5	SS	25																		0 1 90 9
2.3		6	SS	30																		
		7	SS	27																		
		8	SS	28																		
		9	SS	24																		
		10	SS	17																		
313.9	End of Borehole: auger/ split- spoon refusal @ 7.0 m Notes: 1. Upon completion of borehole, groundwater level measured at 1.4 m.																					
7.0																						

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-5

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253333.101E, 5503771.195N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.13 - 2018.12.13 LATITUDE 49.6694152 LONGITUDE -87.7130487 CHECKED BY SM

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 (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER												
319.2	Ground Surface		1	AS			319	20	40	60	80	100	20	40	60		1 78 (21)			
319.0	SANDY ROOT MAT some silt, dark brown, moist, loose		2	SS	18															
318.5	SILTY SAND trace rootlets, fine grains, brown to light brown, wet, compact																			
318.0	SILT trace sand, trace to few clay, light brown, wet, compact to dense		3	SS	35				318											
			4	SS	29															
		5	SS	29		317										0 1 90 9				
		6	SS	32		316														
315.2			7	SS	50/ 0.05															
4.0	End of Borehole: auger/ split-spoon refusal @ 4.0 m. Notes: 1. No measurable groundwater level in open hole.																			

+³, X³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No BH-6

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253488.055E, 5503764.451N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.12 - 2018.12.12 LATITUDE 49.6693677 LONGITUDE -87.7109012 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER					W _P W W _L WATER CONTENT (%)				GR	SA	SI	CL		
319.9	Ground Surface		1	AS			319	20	40	60	80	100										
319.8	SANDY ROOTMAT trace gravel, brown, moist		2	SS	15																	
0.2	SAND trace to some silt, light brown, moist, compact		3	SS	25																	
318.4	SILT trace sand, trace to few clay, trace gravel, light brown to grey, wet, compact to very dense	4	SS	35				318														
1.5		5	SS	22																		
		6	SS	22					317													
		7	SS	52																		
		8	SS	50/ 0.075					316													
315.1	End of Borehole: auger/ split-spoon refusal @ 4.8m Notes: 1. Upon completion of borehole, groundwater level measured at 1.4 m.																					
4.8																						

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE



Appendix F

List of OPSSs and OPSDs and Suggested Wording for NSSP



1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- OPSD 3101.150 (Walls Abutment, Backfill Minimum Granular Requirements)

2. Suggested Wording for NSSPs

- **“Obstructions”**

Excavations for Temporary Modular Bridge footings and engineered granular fill pads will encounter obstructions such as cobbles and boulders embedded in the fill. Such obstructions may impede excavation progress. The Contractor shall be prepared to remove these obstructions to achieve the design depths.

- **“Temporary Modular Bridge Construction”**

The Contractor is alerted to the following considerations for construction of the Temporary Modular Bridge (TMB):

- The native silt is known to be highly susceptible to mechanical and hydraulic disturbances and subsequent softening or loss of shear strength. Care must be taken when excavating in the sensitive silt below the rock fill / crushed gravel to avoid shallow slides and sudden release of perched water. Prior to excavating into silt below the groundwater level, active dewatering should be carried out to minimize the potential for running ground and/or base boiling due to seepage flow.



- The embankment fill consists of rock fill / crushed gravel. Prior to constructing engineered granular fill pads for the TMB abutment footings, the surface of the rock fill should be chinked with finer material to prevent loss of granular fill into the rockfill.
- The forward slopes of the temporary culvert replacement excavation in front of the TMB abutment footings must be inclined at no steeper than 1.5H:1V. Provision of properly designed scour and erosion protection works will be critical to ensure adequate performance of the temporary excavation slopes so as not to undermine the TMB footings and compromising the stability of the slopes.










Appendix G

Stability Analysis Figures

FIGURE 1

NISSIAMKIKAM CREEK CULVERT TEMPORARY MODULAR BRIDGE 1.5 M WIDE FOOTING & 2 M SETBACK - 105 KPA FOOTING LOAD

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Backfill	Mohr-Coulomb	20	0	35
	Boulders	Mohr-Coulomb	19	0	42
	Granular A or B Type II	Mohr-Coulomb	22	0	35
	Rockfill	Mohr-Coulomb	19	0	38
	Sand and Gravel - Very Dense	Mohr-Coulomb	22	0	34
	Sand and Gravel Fill	Mohr-Coulomb	21	0	32
	Silt - Very Dense to Compact	Mohr-Coulomb	20	0	32

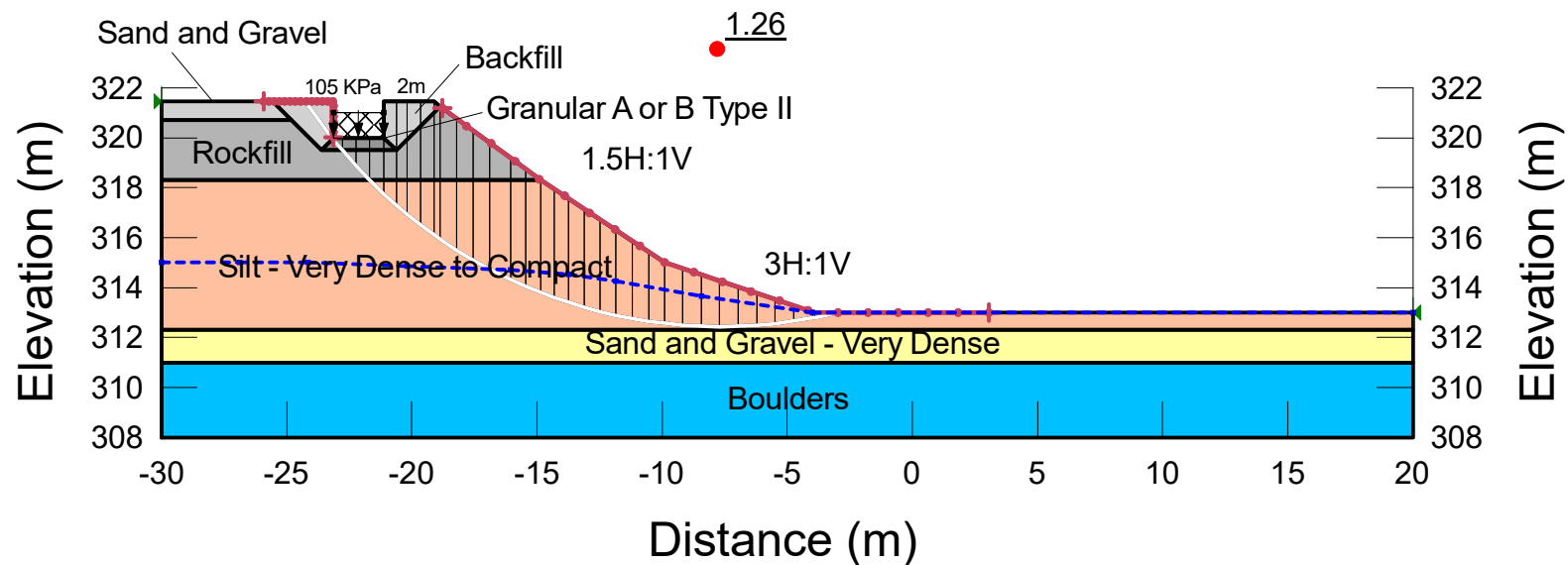









FIGURE 2

**NISSIAMKIKAM CREEK CULVERT
TEMPORARY MODULAR BRIDGE
2 M WIDE FOOTING & 2 M SETBACK - 80 KPA FOOTING LOAD**

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Backfill	Mohr-Coulomb	20	0	35
	Boulders	Mohr-Coulomb	19	0	42
	Granular A or B Type II	Mohr-Coulomb	22	0	35
	Rockfill	Mohr-Coulomb	19	0	38
	Sand and Gravel - Very Dense	Mohr-Coulomb	22	0	34
	Sand and Gravel Fill	Mohr-Coulomb	21	0	32
	Silt - Very Dense to Compact	Mohr-Coulomb	20	0	32

