



**DRAFT REPORT**

**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**Unnamed Creek Culvert Rehabilitation - Hwy 634  
Township of Adanac, District of Cochrane**

**Agreement No. 5015-E-0007**

**Assignment No. 1**

**WO 2016-11014**

**Geocres No. 39E-243/C**

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# Ontario Ministry of Transportation

## Northeastern Region Geotechnical Section

### Foundation Investigation and Design Report

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# 1 Part I: FOUNDATION INVESTIGATION REPORT

## 1.1 Introduction

This report presents the results of a geotechnical investigation completed by **exp** Services Inc. for temporary cofferdam design for the purpose of rehabilitation of the Unnamed Creek Culvert system on Highway 634, approximately 35.5 km north of Highway 11, in Adanac Township, District of Cochrane. The Unnamed Creek Culvert structure consists of two 2.4 m diameter SPCSP's each having a total length of approximately 24 m. The maximum depth of cover above the Unnamed Creek Culverts is approximately 1.4 m respectively.

The purpose of the investigation is to determine the existing soil conditions in the vicinity of the existing culverts and to provide geotechnical design recommendations for temporary cofferdams for the purpose of dewatering during the rehabilitation of the culverts.

The site specific geotechnical investigation consisted of a field investigation including visual inspections, drilling, soil sampling, and laboratory testing. Factual results of the investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the projects described in the report.

The work was undertaken under Agreement # 5015-E-0007, Assignment No. 1. The terms of reference (TOR) were as presented in MTO letter dated April 15, 2016.

## 1.2 Site Description and Geological Setting

### 1.2.1 Site Description

The Unnamed Creek Culverts are located along Hwy 634, approximately 35.5 km north of Hwy 11, in the Township of Adanac, at the approximate Station 20+280 (based on Drawing # 2 provided in the TOR). Hwy 634 is a two lane, north/south roadway with approximately 1 m wide granular shoulders. The highway crosses above the Unnamed Creek Culverts with approximately 1.4 m of embankment fill, and 2H:1V slopes. Photographs of the site is included in Appendix A of this report. The culvert locations and cross sectional profiles are as shown on Drawings No. 1 to 3 in Appendix B.

During the site reconnaissance on May 30, 2016, the general site conditions were assessed. Unnamed Creek flow from the south-west to the north-east towards The Trappers River tributary, which itself flows north into the Abitibi River. Vegetation at the site consists primarily of large pine trees and wild bushes. The inlet and outlet of the culverts are surrounded by trees and shrubs. The terrain surrounding the inlet is swampy due to fluctuating water levels and surface runoff water.

In general, the slopes of highway embankments are partly covered with grass and/or light vegetation and granular material (portions of the embankment slopes, generally above and around the culverts, are covered with large boulders (up to 1.5 m in diameter). Bedrock outcrops were not

observed at the site. The surface of Hwy 634 at the culvert locations was in a fair shape with a number of localized cracks on the asphalt. No major transverse cracks were observed.

During the field investigation, the water level at Unnamed Creek was approximately at Elevation 97.8 m. The road surface elevation at the Unnamed Creek Culvert location is at about 100.54 m (it should be noted that these are the elevations taken from Drawings #1 and #2 which were provided in the TOR. These elevations will be referenced for the remainder of the report). It was observed that the culverts were experiencing significant creek flow through them.

All relevant photographs can be found in Appendix A.

### 1.2.2 Geological Setting

According to the Ministry of Northern Development and Mines, Maps 2518 (Sacrificial Geology of Northern Ontario, 1987) and 2543 (Bedrock Geology of Ontario, East-Central Sheet, 1991), the site is located in the boundary between a clay-silt deposit and a till deposit underlain by Metasedimentary bedrock. The clay-silt deposit is mapped as glaciolacustrine deposit, while the till deposits is noted as unsorted mixture of boulders, sand, silt and clay sized particles. The Metasedimentary Rock Group comprises of argillite, slate, marble, chert, wacke, arkos, iron formation and minor metavolcanic rock intrusions (it should be noted that bedrock was not encountered in this investigation).

## 1.3 Investigation Procedures

### 1.3.1 Site Investigation and Field Testing

The field investigation was performed between June 1<sup>st</sup> and 2<sup>nd</sup>, 2016. The field program consisted of drilling four (4) sampled boreholes with a machine-powered drill rig (BH U1 to U4). These boreholes were located as close as possible to the locations instructed in the TOR: (i) BH-U1 was placed in the proximity of the northern outlet area; (ii) BH-U2 was placed in the proximity of the southern outlet area; (iii) BH-U3 was placed in the proximity of the northern inlet area; and (iv) BH-U4 was placed in the proximity of the southern inlet area.

The boreholes were advanced using a track mounted CME-55 drill rig equipped with hollow stem auger and standard soil sampling equipment owned and operated by Landcore Drilling out of Sudbury, Ontario.

The drilled boreholes were advanced to a depth of approximately 10.5 m below ground surface. Drawings in Appendix B show the locations of all eight boreholes and cross-sections of stratigraphy along the existing culvert alignment and the embankment.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by **exp** personnel following drilling. A temporary reference point (referred to as TBM) on the highway was selected because the other geodetic benchmarks could

not be found in the vicinity. The elevation of the temporary TBM is estimated to be approximately 100.54 m at Unnamed Creek, based on the MTO drawings.

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals ranging from 0.75 m to 1.5 m in depth as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT “N” values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (Section 4.5.2 ) and used to provide an assessment of in-situ consistency or relative density of non-cohesive soils.

Following completion of boreholes, groundwater level measurements were carried out from the boreholes. However, due to the very fine grained, cohesive nature of the soils encountered throughout the entire depth of all boreholes, the stabilized ground water level could not be established by short term observation (the boreholes appeared open and dry). The drilled boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act*).

The fieldwork was supervised by members of **exp's** engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System for Foundation Investigation Report, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags, and returned to **exp's** Brampton laboratory for additional visual, textual and olfactory examination. .

### 1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content and particle size distribution for approximately 25% of the collected soil samples. Atterberg limits test were carried out for cohesive soils. All of the laboratory tests were carried out according to MTO and/or ASTM Standards as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses and plasticity chart are presented graphically in Appendix D.

### 1.3.3 Previous Investigation

No foundation reports are available in the MTO GEOCRE library for this site.

## 1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in

Appendix D. The “Explanation of Terms Used in Report” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and cross section subsurface profiles are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and cross section stratigraphic profiles are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the site was underlain by a native deposit of clayey silt till. Bedrock was not encountered at the locations of drilling. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### **1.4.1 Topsoil/ Organic/ Peat**

A layer of topsoil was encountered in all boreholes at the surface and had a thickness between 50 mm and 130 mm, extending to between Elev. 97.9 m to Elev. 98.4 m. The topsoil consisted mainly of peat and organics (i.e., bits of decayed wood, bark, roots and rootlets) as well as some silt and clay, trace sand and trace gravel. It was dark brown in colour, and wet. The SPT “N” values within the topsoil layer were between 2 and 12 blows per 300 mm penetration, classifying this material as very loose to compact in relative density.

Laboratory testing performed on selected samples consisted of three (3) moisture content tests. The test results are as follows:

Moisture content:

- 65% to 80%

The result of the laboratory test is provided on the Record of Borehole sheets in Appendix C.

#### **1.4.2 Sandy Silt**

Underlying the topsoil in BH-U1 and BH-U4, a layer of native sandy silt was encountered. The layer was approximately 0.4 m thick in both boreholes, extending to Elev. 97.5 m (BH-U1) and Elev. 97.7 m (BH-U4).

The sandy silt contained some clay and gravel and trace rootlets and ice chunks in BH-U1. The layer was blackish brown in colour at BH-U1 and grey at BH-U4 and moist to wet. Two (2) standard penetration resistance “N” values were obtained ranging from 2 (BH-U4) to 12 (BH-U1) suggesting a very loose to compact relative density.

Laboratory testing performed on a selected sample consisted of one (1) moisture content test. The test result is as follows:

Moisture Content:

- 28%

The result of the laboratory test is provided on the Record of Borehole sheets in Appendix C.

### 1.4.3 Clayey Silt

A single occurrence of native clayey silt was encountered in BH-U3 below the topsoil. The layer was approximately 0.7 m thick, extending to Elev. 97.2 m.

The clayey silt contained some sand and trace gravel and organics. The layer was brown in colour and wet. One (1) Standard penetration resistance “N” value of 2 was obtained suggesting a very soft consistency.

Laboratory testing performed on selected samples consisted of one (1) moisture content tests. The test results is as follows:

Moisture content:

- 42%

The result of the laboratory test is provided on the Record of Borehole sheets in Appendix C.

### 1.4.4 Clayey Silt Till

Native clayey silt till was encountered below the topsoil in BH-U2, below the sandy silt in BH-U1 and BH-U4, and below the clayey silt in BH-U3, and extended to the termination depth of all boreholes. The layer of clayey silt till extended to a depth of 10.3 m to 10.5 m below ground surface or to elevations ranging from 87.5 m to 88.2 m.

The clayey silt till contained trace to some sand and trace gravel. Borehole BH-U2 contained three separate seams of silt to sandy silt at approximate Elev. 97.3 m, Elev. 92.3 m and Elev. 89.2 m. Borehole BH-U3 contained a seam of sandy silt at Elev. 91.8 m and 0.8 m thick layer of silty sand, some gravel within the clayey silt till at Elev. 88.9 m. The one layer of sandy silt had an SPT “N” value of 21 blows indicating a compact relative density. The clayey silt till was brown to grey in colour and moist to wet. SPT “N” values within the till ranged from 2 to >100 blows per 300 mm penetration indicating a very soft to hard, but generally firm to very stiff consistency.

Laboratory testing performed on a selected samples of the clayey silt till consisted of forty (40) moisture content, nine (9) grain size distribution and five (5) Atterberg Limits tests. The test results are as follows:

Moisture Content:

- 12% to 30%

Grain Size Distribution:



- 0% to 4% gravel
- 8% to 18% sand
- 59% to 62% silt, and
- 21% to 25% clay

Atterberg Limits:

- Liquid Limit: 21% to 22%
- Plastic Limit: 12% to 13%
- Plasticity Index: 8% to 9%

Laboratory testing performed on the sample of silty sand consisted of one (1) moisture content and one (1) grain size distribution tests. The test results are as follows:

Moisture Content:

- 12%

Grain Size Distribution:

- 13% gravel
- 52% sand
- 35% fines

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figures 1 to 4 in Appendix D. The results of the Atterberg Limits tests are provided on Figure 3 in Appendix D.

## 1.5 Groundwater Conditions

The Information regarding groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion. However, due to the very fine grained, cohesive nature of the soils encountered throughout the entire depth of all boreholes, the stabilized ground water level could not be established by short term observation.

At the time of the investigation, the water level at Unnamed Creek were approximately at Elevation 97.8 m. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

## **2 Part II ENGINEERING DISCUSSIONS AND RECOMMENDATIONS**

### **2.1 Introduction**

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for temporary cofferdam design at the Unnamed Creek Culverts. Cofferdams are needed for the purpose of rehabilitation of the culvert system.

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 or design-build contractor. The design-build contractor 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 Unnamed Culvert system is located on Highway 634, approximately 35.5 km north of Hwy 11, in Adanac Township, District of Cochrane. The Unnamed Creek Culvert structure consists of two 2.4 m diameter SPCSP's each having a total length of approximately 24 m. The maximum depth of cover above the Unnamed Creek Culverts is approximately 1.4 m.

The rehabilitation of the culvert systems will require that the work be undertaken in the dry conditions, as such the water at the inlet and outlet sides will need to be controlled by cofferdams. The locations of cofferdams at the inlet and outlet sides of the are proposed in Drawing #1 in Appendix B. The geotechnical investigation has been conducted to determine the existing soil conditions in the vicinity of cofferdams at the inlet and outlet sides of the culvert system location. This report provides soil parameters to be used for the design of the cofferdams at the inlet and outlet sides the culvert system.

The report will facilitate the design of the cofferdams for dewatering by providing geotechnical design parameters in accordance with the latest edition of the Canadian Highway Bridge Design Code, the Canadian Foundation Engineering Manual, and good practice, in general. Suggestions are also made in relation to the constructability of cofferdams, but these should in no way be constructed to be definitive instructions to the Contractor in undertaking the culvert replacement and dewatering structure construction.

## 2.2 Site Dewatering

Cofferdams will be required at both upstream and downstream ends to envelop the construction site and keep it free of water during culvert installation. Based on the geotechnical conditions, the cofferdam construction can be undertaken with cantilever steel sheet piling.

If sheet piles are used, they should be placed at least 5 m beyond the inlet and outlet ends of the existing culvert system, enclosing and protecting it from the water flow (as shown in Drawing #1 in Appendix B). To address issues of stability and piping, the sheeting should be embedded into the subgrade a depth of approximately 2.0 to 2.5 times the height of the exposed height of proposed sheet pile wall. The anticipated cofferdam heights are 3 m above original ground. The proposed sheet pile wall should be at least one meter above 100 year flood. Some fill on the inside facing can be considered in the design. The required minimum section modulus and embedment sheet pile length should be designed based on the recommended design parameters. The cross-section in Drawing #2 and #3 (Appendix B) show the depth of the reasonably expected surface at the proposed location of the cofferdam. The bedrock was not encountered at the inlet and outlet sides of Unnamed Creek.

Alternatively, a rockfill cofferdam can be used. This cofferdam will have to be constructed to the same topographic constraints as the sheet pile cofferdam, i.e. at each end of the existing culvert and, if necessary, adjacent to it due to the river diversion. The size of material suitable for use depends on the erosion potential, stream flow velocity, etc. The rockfill cofferdam should be designed with a more impervious water barrier at the outside face to create a more watertight enclosure. Schemes involving 2 inch minus crusher run with finer facing material upstream have been successfully used in similar setting. Any required permitting must be determined.

As mentioned, which cofferdam system is best suited depends on many technical and economic factors. The advantages and disadvantages of both cofferdam systems are summarized in Table 1.

*Table 1. Comparison of Cofferdam Systems*

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequence
Steel sheet piles	<ul style="list-style-type: none"> <li>• Provide watertight base</li> <li>• Structural elements and seals easier to positively construct</li> <li>• increased safety with appropriate design</li> <li>• Easily removed</li> <li>• Less seepage</li> <li>• Reusable</li> </ul>	<ul style="list-style-type: none"> <li>• More costly</li> <li>• More likely time consuming for installation</li> <li>• May present issues for seepage and/or piping the rock where shallow and sloping</li> <li>• Larger machines required</li> </ul>	MEDIUM TO HIGH	<ul style="list-style-type: none"> <li>• Possible piping problem</li> <li>• May take longer to install</li> <li>• Less dewatering</li> </ul>
Rock fill	<ul style="list-style-type: none"> <li>• Less costly</li> <li>• Relatively less time consuming for installation</li> <li>• Native material can be usable</li> </ul>	<ul style="list-style-type: none"> <li>• Require more space for installation</li> <li>• Less safe</li> <li>• Subjected to wave erosion</li> <li>• Less watertight</li> <li>• Prone to land shifts, slides and collapse</li> <li>• More likely time consuming for remove</li> </ul>	LOW TO MEDIUM	<ul style="list-style-type: none"> <li>• Less stable and safe</li> <li>• May take longer to remove</li> <li>• May require to install clay cutoff</li> <li>• More dewatering</li> </ul>

Given the soil conditions, topography of the surrounding terrain and available space, the use of a cantilevered steel sheet pile system is recommended for the inlets or outlets of these locations. The combination with the rockfill at the sides for additional support is also possible.

The design of these cofferdams which are temporary retaining structures is the responsibility of the Contractor. The cofferdam must be designed to withstand the anticipated design loads and to be watertight as practically possible. The Contractor is also responsible for cofferdam's materials, construction, monitoring and removal. Cofferdams should be designed by a licensed Professional Engineer experienced in shoring design and should be in accordance with OPSS 539. If sheet piles are employed, piling shall be according to OPSS 903.

## 2.3 Subsurface conditions for Cofferdams

The investigation revealed that the subsurface conditions along the proposed cofferdam alignment at the inlet side (BH-U3 & BH-U4) of the Unnamed Creek Culvert system consist of topsoil underlain by a small layer of native sandy silt to clayey silt underlain by clayey silt till which extended the remaining depth of the boreholes. The 0.7 m layer of clayey silt in BH-U3 had one STP "N" value of 2, indicating a very soft consistency. The 0.7 m layer of sandy silt in BH-U4 had one STP "N" value of 2, indicating a very loose relative density. The upper 3 m to 6 m of the clayey silt till had a very soft to firm consistency with STP "N" values between 3 and 8 (Avg. 6). The remaining depth of the boreholes saw STP "N" values between 12 and 100 blows per 210 mm (Avg. 36), indicating a stiff to hard consistency. It should be noted that BH-U3 also saw a 0.8 m layer of silty sand within the clayey silt till. This layer had one STP "N" value of 21, indicating a compact relative density.

The outlet side (BH-U1 & BH-U2) of the culvert system saw very similar subsurface conditions. Below the topsoil, a 0.7 m thick layer of native sandy silt was encountered (BH-U1) which was underlain by clayey silt till extending the remaining depth of both boreholes. The sandy silt had one STP "N" value of 12, indicating a compact relative density. The upper 5 m of the clayey silt till had a very soft to firm consistency with STP "N" values between 2 and 8 (Avg. 5). The remaining depth of the boreholes saw STP "N" values between 10 and 21 (Avg. 14), indicating a stiff to very stiff consistency.

## 2.4 Soil Parameters for Cofferdam Design

Suggested soil parameters (total stress) for material types that will be encountered in the design of the cofferdam are provided in Table 2.

Table 2. Material Types and Total Stress Parameters for Cofferdam Design

Location	Relevant Boreholes	Material Types	Approx. Elev. (m)	Friction Angle ( $\phi$ )	Cohesion $c_u$ (kPa)	Unit Weight $\gamma$ (kN/m <sup>3</sup> )
Unnamed Creek Inlet	BH-U3 & BH U4	Sandy Silt (Very Loose)	98.4 - 97.7	28	-	18.0
		Clayey Silt (Very Soft)	97.9 - 97.2	-	10	18.0
		Clayey Silt Till (Very Soft to Firm)	97.7 - 90.8	-	30	18.5
		Clayey Silt Till (Stiff to Hard)	90.8 - 87.5	-	100	19.5
		Silty Sand (Compact)	88.9 - 88.1	31	-	20.0

Unnamed Creek Outlet	BH-U1 & BH U2	Sandy Silt (Compact)	98.2 - 97.5	30	-	19.0
		Clayey Silt Till (Very Soft to Firm)	98.4 - 92.2	-	30	18.5
		Clayey Silt Till (Stiff to Hard)	92.2 - 87.7	-	75	19.0

## 2.5 Lateral Earth Pressures

Section 6.9, Chapter 6 of the CHBDC addresses lateral pressure relationships for the design of earth structures. These are also applicable to the design of the proposed cofferdam. For unbraced design, the triangular pressure relationship outlined below is applicable, as follows:

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

where  $p$  = Lateral earth pressure (kPa).

$K$  = Coefficient of earth pressure.

$\gamma$  = Unit weight of backfill (kN/m<sup>3</sup>).

$h$  = Depth to point of interest (m).

$q$  = Surcharge load acting adjacent to the wall at the ground surface (kPa).

The above expression does not take into account hydrostatic pressure, which must be included for the groundwater within the existing ground and within the depth of the structure, and for water in the river. The appropriate values of the parameters for use in the design of structures subjected to earth pressure for sheet pile are given in Table 3.

The appropriate values of the parameters for use in the design of structures subjected to unbalanced earth pressure are given in Table 3.

**Table 3. Material Types and Earth Pressure Parameters for Sheet Piles**

			Total Stress Properties					Effective Stress Properties				
Strata	Approx. Elev. (m)	Bulk Unit Weight, $\gamma$ (kN/m <sup>3</sup> )	Cohesion (kPa)	Angle of Friction $\phi$ (°)	Coefficient of Active Earth Pressure (K <sub>a</sub> )	Coefficient of Passive Earth Pressure (K <sub>p</sub> )	Coefficient of Earth Pressure at Rest (K <sub>o</sub> )	Cohesion (kPa)	Angle of Friction $\phi$ (°)	Coefficient of Active Earth Pressure (K <sub>a</sub> )	Coefficient of Passive Earth Pressure (K <sub>p</sub> )	Coefficient of Earth Pressure at Rest (K <sub>o</sub> )
Unnamed Creek Inlet (BH-U3 & BH U4)												
Sandy Silt (Very Loose)	98.4 - 97.7	18.0	-	28	0.36	2.77	0.53	-	28	0.36	2.77	0.53
Clayey Silt (Very Soft)	97.9 - 97.2	18.0	10	0	1	1	-	0	22	0.45	2.20	0.63
Clayey Silt Till (Very Soft to Firm)	97.7 - 90.8	18.5	30	0	1	1	-	0	24	0.42	3.37	0.59
Clayey Silt Till (Stiff to Hard)	90.8 - 87.5	19.5	100	0	1	1	-	0	27	0.38	2.66	0.54
Silty Sand (Compact)	88.9 - 88.1	20.0	-	31	0.32	3.12	0.48	-	31	0.32	3.12	0.48

Unnamed Creek Outlet (BH-U1 & BH U2)												
Sandy Silt (Compact)	98.2 - 97.5	19.0	-	30	0.33	3.00	0.5	-	30	0.33	3.00	0.5
Clayey Silt Till (Very Soft to Firm)	98.4 - 92.2	18.5	30	0	1	1	-	0	24	0.42	3.37	0.59
Clayey Silt Till (Stiff to Very Stiff)	92.2 - 87.7	19.0	75	0	1	1	-	0	26	0.39	2.56	0.56

*Note: Values given for horizontal earth pressures are for horizontal backfill. For sloping backfill, the design requirements outlined in Sec C6.9.1(c) of the Canadian Highway Bridge Design Code should be used.*



The mobilization of full active or passive resistance requires a measurable and perhaps significant wall movement or rotation. Therefore, unless the structural element can tolerate these deflections, the at-rest earth pressure should be used in design.

### 2.5.1 Dewatering

At the upstream end, Unnamed Creek can be diverted by the cofferdams away from the existing culvert system if the terrain allows, or into one of the existing pipes (for example, use the one culvert to convey the creek flow below the road while other culverts are under rehabilitation work). This will require extensions of the existing culverts beyond the cofferdams and suitable staging and configuration of the containment. Otherwise the retained water can be pumped across the highway.

Dewatering requirements behind the cofferdams to keep the construction site dry will be impacted by water levels in the river at the time of construction activities. Dewatering shall be carried out in accordance with OPSS 517 and OPSS 518. It is responsibility of the Contractor to propose a suitable dewatering system based on the time of construction, water levels and river flow conditions for prior approval of the MTO. The method used should not undermine the existing culvert, highway embankment or adjacent side slopes. In this connection the provision of toe protection at side slopes during drawdown may be required to minimize sloughing and undercutting during dewatering.

Dewatering may require water taking permits (i.e. Permit To Take Water PTTW). A PTTW is required for any water taking if the volume exceeds 50,000 L/day. The rate and volume required for dewatering will be dependent on construction methods and staging chosen by the Contractor.

### **3 Part III CLOSURE**

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the works, should, in this light, decide on their own investigations as well as their own interpretations of the factual borehole results so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The borehole investigation program for this project was supervised by Robert Bradford, P.Eng. and Mo'oud Nasr, P.Eng. with **exp** Services Inc. This Foundation Investigation and Design Report has been prepared by Robert Bradford P.Eng. and Silvana Micic, Ph.D., P.Eng and reviewed by Stan Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact.

We trust that these comments provide you with sufficient information to proceed with design. Should you have any questions, please do not hesitate to contact this office.

#### **exp Services Inc.**

Robert Bradford, P.Eng.  
Geotechnical Engineer

Silvana Micic, Ph.D, P.Eng.  
Senior Geotechnical Engineer

Stan E. Gonsalves, M.Eng., P.Eng.  
Principal Engineer  
Designated MTO Foundation Contact

Encl.

## **Appendix A – Photographs**



Photo 1. BH-U3 at Unnamed Creek Culvert (facing west) on June 1, 2016





Photo 2. Outlet side of Unnamed Creek Culvert System (facing east) on June 1, 2016





Photo 3. BH-U2 at Unnamed Creek Culvert (facing north-east) on June 2, 2016

## **Appendix B – Drawings**

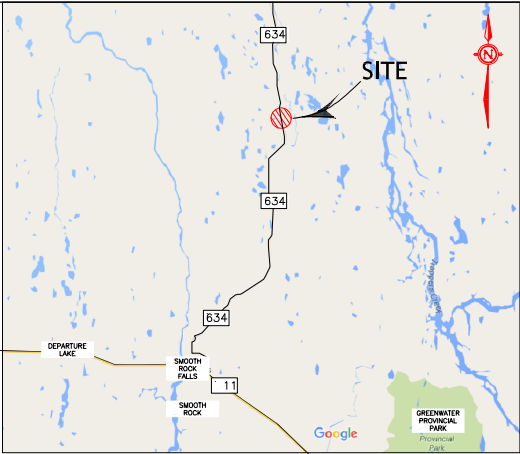
DRAFT

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

AGREEMENT NO. 5015-E-0007 ASSIGNMENT NO. 1 GEOCRES NO. 39E-242/C & 39E-243/C	
UNNAMED CREEK CULVERT (TOWNSHIP OF ADANAC)	SHEET 1

exp. exp Services Inc.

KEY PLAN



LEGEND

Approx. Current Investigated Borehole Locations

LEGEND

ASPHALT	PEAT/SANDY PEAT
FILL	SILTY SAND
COBBLES AND BOULDERS	SAND AND GRAVEL
BEDROCK	

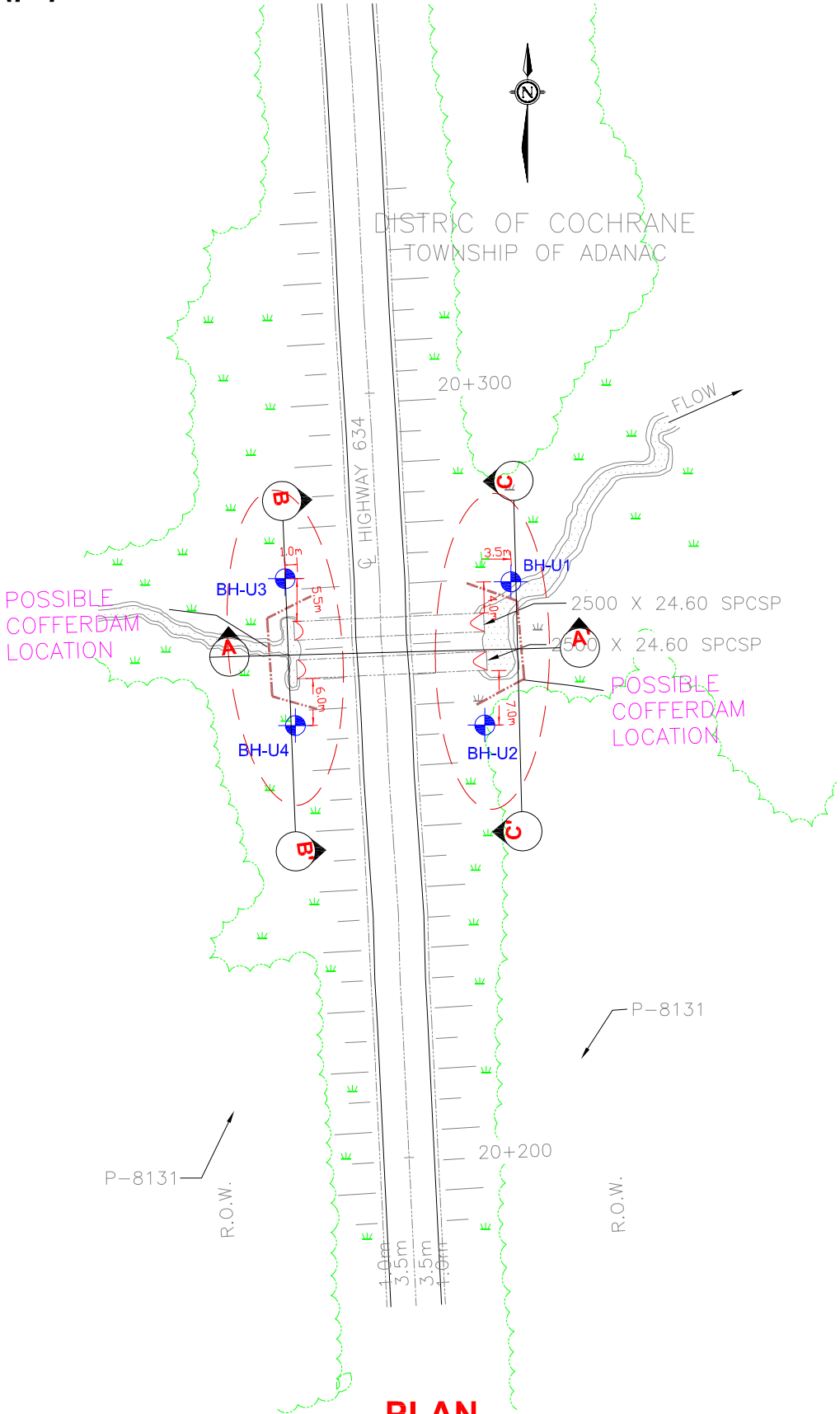
BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-U1	98.3	5 488 213	268 225
BH-U2	98.5	5 488 189	268 217
BH-U3	98.0	5 488 013	268 196
BH-U4	98.5	5 486 984	268 431

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

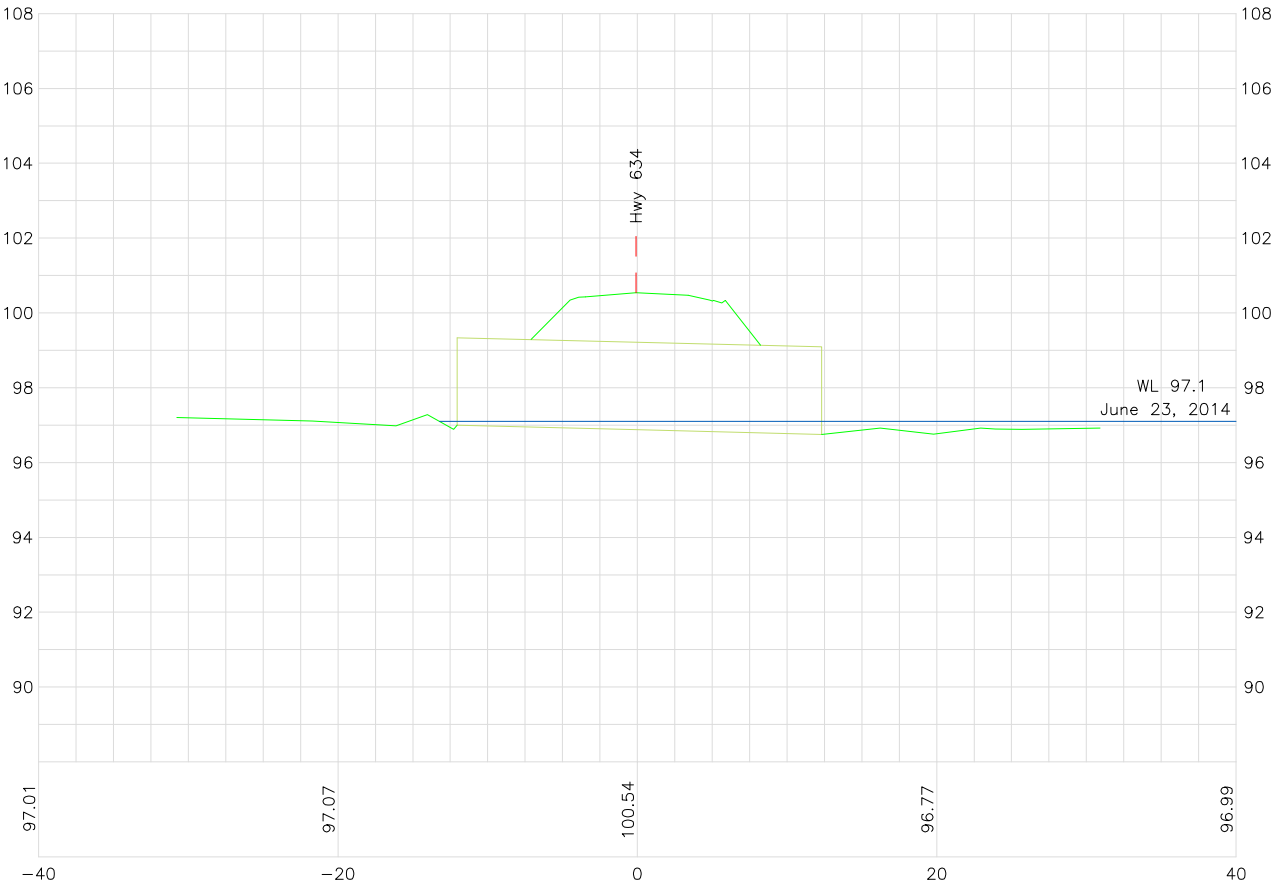
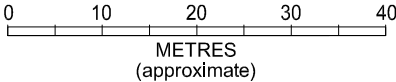
The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview, Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section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

JULY 2016	TK	SUBMISSION FOR REVIEW
DATE	BY	DESCRIPTION
SCALE		PROJECT NO. ADM 00233185-A0
SUBM'D TK	CHECKED TK	DATE JULY 2016 SITE No.
DRAWN RB	CHECKED TK	APPROVED ST DWG. 04



PLAN

UNNAMED CREEK CULVERT SITE 39E-243/C  
(SCALE 1:800)  
35.3 KM NORTH OF HIGHWAY 11



SECTION A-A'



DRAFT

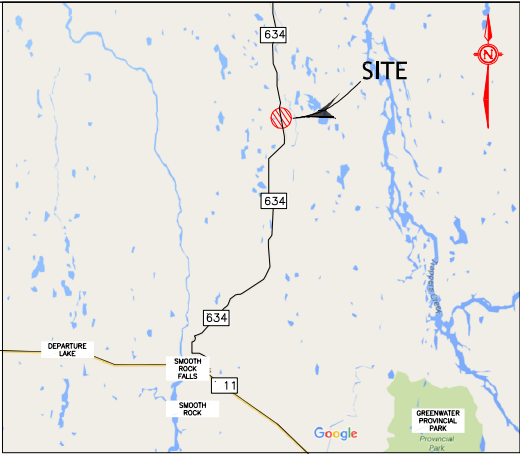
METRIC  
DIMENSIONS ARE IN METERS AND/OR MILLMETERS UNLESS  
OTHERWISE SHOWN. STATIONS ARE IN KILOMETERS +METERS

AGREEMENT NO. 5015-E-0007 ASSIGNMENT NO. 1 GEOCRES NO. 39E-242/C & 39E-243/C	
UNNAMED CREEK CULVERT (TOWNSHIP OF ADANAC)  SECTION B-B'	SHEET  1

exp

exp Services Inc.

KEY PLAN



LEGEND



Approx. Current Investigated Borehole Locations

LEGEND

Topsoil

Clayey Silt Till

Sandy Silt

Silty Sand

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-U3	98.0	5 488 013	268 196
BH-U4	98.5	5 486 984	268 431

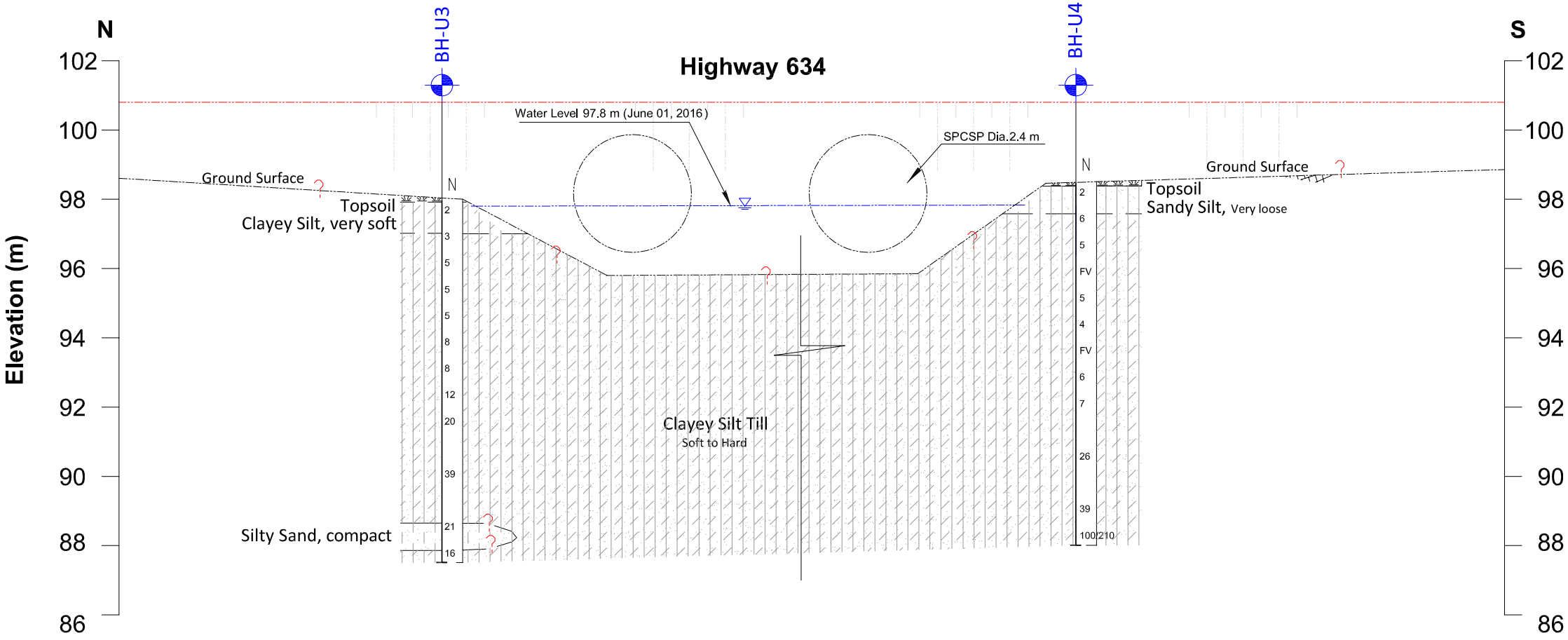
NOTE

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.

JULY 2016	TK	SUBMISSION FOR REVIEW
DATE	BY	DESCRIPTION
SCALE		PROJECT NO. ADM 00233185-A0
SUBM'D TK	CHECKED TK	DATE JULY 2016 SITE No.
DRAWN RB	CHECKED TK	APPROVED ST DWG. 05

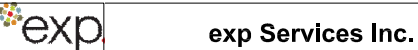
Unnamed Creek Culvert Inlet



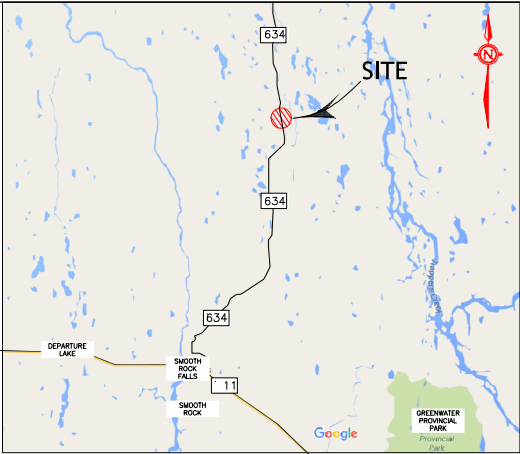
DRAFT

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

AGREEMENT NO. 5015-E-0007 ASSIGNMENT NO. 1 GEOCRES NO. 39E-242/C & 39E-243/C	
UNNAMED CREEK CULVERT (TOWNSHIP OF ADANAC) <b>SECTION C-C'</b>	SHEET 1



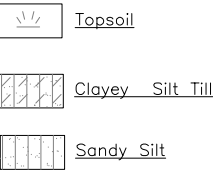
KEY PLAN



LEGEND



LEGEND



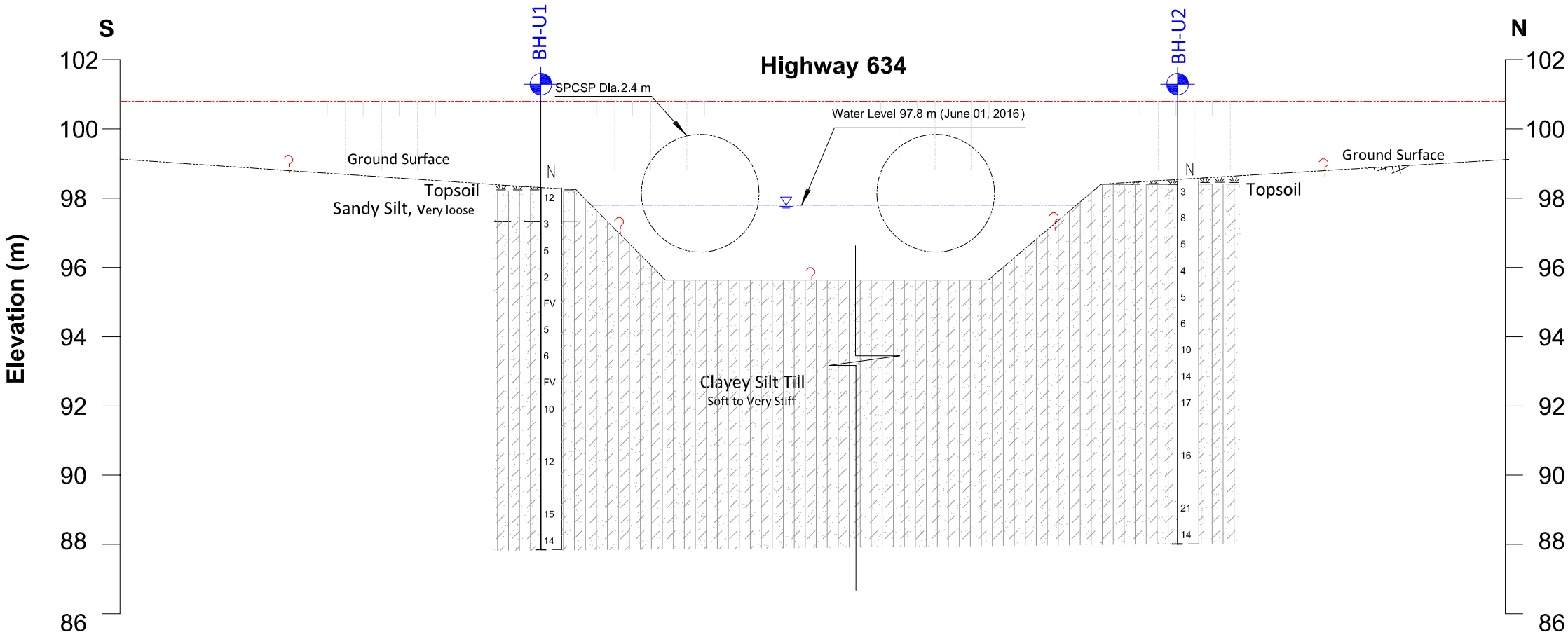
BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-U1	98.3	5 488 213	268 225
BH-U2	98.5	5 488 189	268 217

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.

Unnamed Creek Culvert Outlet



SECTION C-C'

JULY 2016	TK	SUBMISSION FOR REVIEW
DATE	BY	DESCRIPTION
SCALE		PROJECT NO. ADM 00233185-A0
SUBM'D TK	CHECKED TK	DATE JULY 2016 SITE No.
DRAWN RB	CHECKED TK	APPROVED ST DWG. 06

## **Appendix C – Borehole Logs**

Brampton, Ontario

## RECORD OF BOREHOLE No U1

1 OF 1

METRIC

W. P. ADM-00233185-A0

LOCATION Highway 634, Ontario

ORIGINATED BY R.B.

DIST

BOREHOLE TYPE CME 55 Track

COMPILED BY M.N.

DATUM Geodetic

DATE 2016/06/01 - 2016/06/01

CHECKED BY S.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
98.3	Ground Surface																
98.4	<b>TOPSOIL:</b> (~51 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.		1	SS	12		98										
97.5	<b>SANDY SILT:</b> some clay, trace gravel, trace rootlets, frozen ground, black and brown, moist, very loose.		2	SS	3		97							o			2 18 (80)
0.8	<b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, brown to grey, wet to moist, soft to very stiff.		3	SS	5		96							o			
	- becoming grey		4	SS	2		95							o			
				VANE			94							o			2 14 61 23
			5	SS	5		93							o			
			6	SS	6		92							o			
				VANE			91							o			
			7	SS	10		90							o			
			8	SS	12		89							o			1 13 62 24
			9	SS	15		88							o			
87.7			10	SS	14												
10.5	<b>END OF BOREHOLE</b>																
	Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																

OPG\_EXP RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 7/13/16

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

Brampton, Ontario

## RECORD OF BOREHOLE No U2

1 OF 1

METRIC

W. P. ADM-00233185-A0

LOCATION Highway 634, Ontario

ORIGINATED BY R.B.

DIST

BOREHOLE TYPE CME 55 Track

COMPILED BY M.N.

DATUM Geodetic

DATE 2016/06/02 - 2016/06/02

CHECKED BY S.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
98.5	Ground Surface																
98.4	<b>TOPSOIL:</b> (~50 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose. <b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, brown to grey, wet to moist, soft to very stiff. - sandy silt seam (~75 mm) - brown with orange stains		1	SS	3		98										
			2	SS	8		97										1 27 (72)
			3	SS	5		96										
	- becoming grey		4	SS	4		95										
			5	SS	5		94										
			6	SS	6		93										
			7	SS	10		92										
			8	SS	14		91										3 13 63 21
			9	SS	17		90										
	- sandy silt seam, some gravel (~300 mm)		10	SS	16		89										
			11	SS	21		88										1 8 (91)
	- silt seam, becoming dry		12	SS	14												
87.9																	
10.5	<b>END OF BOREHOLE</b>																
	Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																

OPG\_EXP RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 7/13/16

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

Brampton, Ontario

## RECORD OF BOREHOLE No U3

1 OF 1

METRIC

W. P. ADM-00233185-A0

LOCATION Highway 634, Ontario

ORIGINATED BY R.B.

DIST

BOREHOLE TYPE CME 55 Track

COMPILED BY M.N.

DATUM Geodetic

DATE 2016/06/01 - 2016/06/01

CHECKED BY S.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
98.0	Ground Surface																
97.9 0.1	<b>TOPSOIL:</b> (~130 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.		1	SS	2											80.4 41.6	
97.2 0.8	<b>CLAYEY SILT:</b> some sand, trace gravel, trace organics, brown, wet, very soft. <b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, brown to grey, wet to moist, soft to hard. - becoming grey		2	SS	3		97							o			
			3	SS	5		96							o			
			4	SS	5		95							o			
			5	SS	5		94							o			
			6	SS	8		93							o			
			7	SS	8		92							o			
			8	SS	12		91							o			
	- sandy silt seam, trace clay (~150 mm)		9	SS	20		90							o			
			10	SS	39		89							o			
88.9 9.1	<b>SILTY SAND:</b> some gravel and clay, grey, wet, compact.		11	SS	21		88							o			2 13 61 24
88.1 9.9	<b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, grey, moist, very stiff.		12	SS	16									o			
87.5 10.5	<b>END OF BOREHOLE</b>  Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																13 52 (35)

OPG\_EXP\_RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 7/13/16

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Brampton, Ontario

## RECORD OF BOREHOLE No U4

1 OF 1

METRIC

W. P. ADM-00233185-A0

LOCATION Highway 634, Ontario

ORIGINATED BY R.B.

DIST

BOREHOLE TYPE CME 55 Track

COMPILED BY M.N.

DATUM Geodetic

DATE 2016/06/01 - 2016/06/01

CHECKED BY S.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
98.5	Ground Surface																
98.4	<b>TOPSOIL:</b> (~51 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.		1	SS	2		98										
97.7	<b>SANDY SILT:</b> trace rootlets, grey, wet, very loose.																
0.8	<b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, brown grey, moist to dry, firm to hard.		2	SS	6		97										
			3	SS	5												
				VANE			96			+							
	- becoming grey		4	SS	5		95										1 13 61 25
			5	SS	4		94										
				VANE						+							
			6	SS	6		93										
			7	SS	7		92										
							91										
			8	SS	26		90										4 13 59 24
	-becoming dry		9	SS	39		89										
88.2	<b>END OF BOREHOLE</b>		10	SS	100/ 210 mm												
10.3	Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																

OPG\_EXP RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 7/13/16

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

## **Appendix D – Laboratory Data**



