



**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**for**

**PITOPIKO RIVER CULVERT REHABILITATION**

**SITE NO. 39W-004/C**

**HIGHWAY 11 – STATION 18+554**

**TOWNSHIP OF McCOIG, DISTRICT OF NEW LISKEARD**

**HEARST, ONTARIO**

**ASSIGNMENT NO. 5015-E-0009**

**GWP 5047-07-00**

**WP 5370-11-02**

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PML Ref.: 16TF013A  
Index No.: 086FIR and 087FDR  
GEOCRES No.: 42F-050  
May 24, 2017



**PART A – FOUNDATION INVESTIGATION REPORT**

**for**

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**PART A – FOUNDATION INVESTIGATION REPORT**

Pitopiko River Culvert Rehabilitation  
Site No. 39W-004/C  
Highway 11 – Station 18+554  
Township Of McCoig, District of New Liskeard, Hearst, Ontario  
Assignment No. 5015-E-0009, GWP 5047-07-00, WP 5370-11-02

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**1. INTRODUCTION**

GHD Ltd. (GHD) has retained Peto MacCallum Ltd. (PML) on behalf of the Ministry of Transportation of Ontario (MTO) to conduct the geotechnical investigation for the replacement or rehabilitation of thirteen (13) structures located on Highway 11 and three (3) structures on Highway 583. This foundation investigation work is part of an assignment (Assignment No: 5015-E-0009) to prepare a detail design for replacement or rehabilitation of 15 culverts and Fraser River Bridge on Highway 11 and Highway 583. The assignment involves five contracts carried out under four different General Work Plans (GWPs).

This report presents the results of the foundation investigation carried out for the rehabilitation of the Pitopiko River culvert (MTO Site No. 39W-004/C) located at the crossing of Pitopiko River and Highway 11, Sta. 18+554, approximately 82 km west of Hearst, in the Township of McCoig, District of New Liskeard. The purpose of the foundation investigation was to identify the subsurface conditions that may influence the proposed rehabilitation work.

**2. PREVIOUS INVESTIGATION**

A foundation investigation was carried out previously by PML at the existing culvert location for Philips Planning plus Engineering on behalf of MTO Northern Region and a report was issued in April 1998. This report is available on MTO Geocres (GEOCRES No: 42F-15) under the title:

*“Foundation Investigation and Design Report, WP 29-97-00, Highway 11, From the Fraser River Bridge Westerly to the Regional Boundary, 36.3 km, MTO District 53, New Liskeard, GEOCRES No: 42F-15, 1998.”*

As a part of the investigation, the field work was conducted in 1997 and consisted of advancing one (1) borehole located at the southeast end of the culvert, to a depth of 2.75 m.

A copy of the Foundation Investigation part of the report is provided in Appendix A.

**3. SITE DESCRIPTION**

Highway 11 in this area is a two-lane road and provides rural arterial road services for communities in the region. The highway at the culvert location consists of approximately 3.5 m wide lanes and



about 2 m wide shoulders. The topography surrounding the culvert is generally flat, and consists of dense vegetation with black spruce trees and thick brush. Based on the elevation of borehole locations, the grade of the road at center of the culvert is about El. 247.5 m.

The Request for Quotation (RFQ) dated June 2011 reveals that the existing culvert was constructed in 1976 and consist of twin-cell, each 4.0 m diameter and 33.0 m long round corrugated steel plate pipes with approximately 1.5 m high fill above the crown. The culvert also has cast-in-place wing walls and a retaining wall at the inlet. The existing culvert has no record of rehabilitation.

The approach embankments at the culvert location are about 3 m high with a slope of 2H:1V. The slopes were well vegetated and relatively stable with no sign of distress or cracks. The Pitopiko River is about 5 m wide at the structure location and flows from south to north.

Refer to Photographs A1 to A4 provided in Appendix B, for general conditions of the site and culvert.

#### **4. FIELD INVESTIGATION PROCEDURES**

The fieldwork for the foundation investigation consisted of drilling two (2) boreholes (Boreholes 16-004-01 and 16-004-02) on August 6, 2016, at the southeast and northwest ends of the existing culvert. The boreholes terminated on competent soil at depths of 5.0 m (El. 241.8 m) in Borehole 16-004-01 and 5.7 m (El. 241.8 m) in Borehole 16-004-02, below the existing grades.

The location of boreholes in relation to the culvert and their depth are provided in Table 4. In addition, the borehole locations are shown on Drawing 004/C-1.

**Table 4 – Borehole Locations and Depth**

<b>BOREHOLE NO.</b>	<b>LOCATION</b>	<b>DEPTH (m)</b>	<b>REMARK</b>
16-004-01	SE Culvert End	5.7	Terminated on Competent Soil
16-004-02	NW Culvert End	5.0	Terminated on Competent Soil

The boreholes were advanced using a CME 55 track-mounted drilling rig equipped with continuous flight 200 mm diameter hollow stem augers. The equipment used for drilling was owned and



operated by Landcore Drilling (Landcore) of Chelmsford, Ontario, a specialist drilling contractor, working under the full time supervision of an experienced PML field technician.

Soil samples were obtained from both Boreholes (16-004-01 and 16-004-02) at selected intervals, using a split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures described in the ASTM D1586. The drill rig was equipped with a 63.5 kg (140 lb) cathead automatic hammer calibrated to fall freely through 760 mm (30 in.).

Soil samples were visually identified in the field and stored in moisture-proof bags.

The groundwater conditions at the borehole locations were observed during drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in open boreholes. Upon completion of drilling, the boreholes were backfilled with drill cuttings and sealed with a bentonite/cement mixture in accordance with the MTO guidelines and Ministry of Environment (MOE) Reg. 903 for borehole abandonment.

Callon Dietz Inc. of London, Ontario was contracted by PML to carry out the survey of the as-drilled borehole locations and elevations. The coordinates were provided in MTM NAD 83 northing and easting. All elevations reported in this report are referred to the Geodetic datum.

## **5. LABORATORY TESTING**

All the soil samples were transported to PML laboratory, located in Toronto for detailed visual examination and laboratory testing. The laboratory tests included the following:

- Natural Moisture Content Determination (15)
- Atterberg Limit Tests (4)
- Grain Size Distribution (5)

Laboratory tests were performed on representative samples of each stratigraphic layers encountered. All the laboratory tests were conducted in accordance with MTO procedures, which follow ASTM guidelines, with the exception of hydrometer test (LS-702).

Chemical tests were carried out on a representative sample by AGAT Laboratories located in Mississauga, Ontario to determine the corrosivity characteristics of soils at the site. These tests



included the determination of sulphate and chloride contents, pH value and resistivity. The soil sample tested was taken at a depth of 4.8 m (El. 242 m) from Borehole 16-004-02.

All of the laboratory test results are provided on the individual Record of Borehole Sheets provided in Appendix C. Results of the grain size distribution tests are presented on Figures 004-GS-1 and 004-GS-2. Atterberg limit test results are provided on Figure 004-PC-1. Results of chemical tests are presented in Appendix D.

## **6. SITE GEOLOGY**

The project site is located within the southern part of the Canadian Shield. Maps published by Ontario Geological Survey suggests that the subsurface conditions at the site consist of glacial till and overlying clay and silt deposits. The till may contain lenses of clay, silt, sand, gravel, and occasional cobbles and boulders. According to a preliminary report prepared by Evans (1941), on the geology of the Trans-Canada Highway between Longlac and Hearst, the bedrock in the area is composed of pegmatitic granite (granitic-gneiss) with distinct light and dark bands. The granitic-gneiss belongs to the migmatitic metasedimentary-metavolcanic complex of the region.

## **7. SUBSURFACE CONDITIONS**

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets provided in Appendix C. The borehole locations and stratigraphic profile sections are shown on Drawing 004/C-1. The boundaries between soil strata have been established at borehole locations only. The boundaries of soil strata between and beyond the boreholes are assumed and it may vary from location to location.

In summary, the subsurface stratigraphy consists of 1.2 m to 1.4 m of granular (silty sand) fill material, followed by sandy silt till deposit to the depth of investigation. For classification purposes, the soils encountered at this site can be classified into the following three layers.

- a) Topsoil
- b) Silty Sand, Some Gravel (Granular Fill)
- c) Sandy silt, Some Clay, Trace to Some Gravel (Till)



## **7.1 Topsoil**

A layer of topsoil was encountered below the ground surface in Borehole 16-004-01 and Borehole 16-004-02. The thickness of this topsoil was in the range of 100 mm to 200 mm.

## **7.2 Silty Sand, Some Gravel (Granular Fill)**

Granular fill containing silty sand with some gravel was encountered below the topsoil. The fill also consists of organic inclusions and rootlets, and was brown in color and moist. The thickness of this fill ranges from 1.0 m to 1.4 m and extends to El. 245.6 m and El. 246.1 m.

The SPT “N”-values within the silty sand fill was in the range of 8 to 26 blows/300 mm, indicating a “loose” to “compact” state of compaction.

The moisture content of samples from the fill was in the range of 5% to 11.9%. The result of a grain size analysis performed on a representative sample taken at a depth of 1 m (El. 246.5 m) from Borehole 16-004-01, indicates that the fill is composed of 24% gravel, 53% sand, 19% silt and 4% clay. Results of grain size distribution analyses are provided on Figure 004-GS-1 in Appendix C.

## **7.3 Sandy Silt, Some Clay, Trace to Some Gravel (Till)**

A sandy silt deposit was encountered below the fill at depths ranging from 1.2 m (El. 245.6 m) to 1.4 m (El. 246.1 m). This sandy silt deposit consist of some clay and trace to some gravel. It was brown to grey in color and moist during drilling. The deposit extends to the full depth of investigation of 5.7 m (El. 241.8 m) in Borehole 16-004-01 and 5 m (El. 241.8 m) in Borehole 16-004-02.

The SPT “N”-values within the sandy silt deposit varied from 10 blows/300 mm to refusal, indicating compact to very dense compaction conditions. Below about El. 245.5 m to 245.0 m, this sandy silt deposit was found to be very dense with refusal to drive the spilt spoon in both boreholes.

The moisture content of the sandy silt deposit was observed to vary from 6% to 8%, with an average value of 7%. The liquid limit of representative samples was found to be 17 and the corresponding plastic limit was 12, resulting in a plasticity index of 5. Based on the results of the Atterberg limit tests, the soil may be classified as sandy silt of low plasticity (CL-ML) in the Unified Soil Classification System (USCS). The plasticity chart is provided on Figure 004-PC-1, in Appendix C.





The grain size analyses performed on sample from Borehole 16-004-01 and 16-004-02 indicate 10% gravel, 32% - 35% sand, 43% - 47% silt, and 12% - 14% clay. Figure 004-GS-2, in Appendix C provides the grain size distribution curve.

## **8. GROUNDWATER**

Groundwater was encountered in Borehole 16-004-01 at a depth of 5.1 m (El. 242.4 m) below the existing grade. Borehole 16-004-02 was dry upon completion of drilling.

During fieldwork, the depth of water flow in the Pitopiko River was estimated to be about 300 mm above existing culvert invert.

The groundwater level may change due to the influence of precipitation and seasonal fluctuations.

## **9. CHEMICAL CORROSIVITY TEST RESULTS**

A sample taken at a depth of 4.8 m (El. 242 m) from the sandy silt in Borehole 16-004-02, was tested to determine soil corrosivity. A summary of the chemical test results is provided in Table 9. The details of these results and a description of the test methods are given in Appendix D.

**Table – 9. A Summary of Corrosivity Test Results**

BOREHOLE NO.	SAMPLE NO.	DEPTH / ELEVATION (m)	SOIL TYPE	SULPHATE (µg/g)	CHLORIDE (µg/g)	pH	RESISTIVITY (Ohm.cm)
16-004-02	SS7	4.8 / 242	Sandy Silt	62	16	8.44	4630



## 10. CLOSURE

The drilling work was supervised by Mr. Kyle Daly, BSc. P.Eng., under the direction of Lulseged Yimam, PhD. P.Eng. The drilling equipment was supplied and operated by LandCore Drilling Ltd., of Chelmsford, Ontario. The laboratory tests were conducted at the PML laboratory in Toronto. Chemical tests were carried out by AGAT Laboratories of Mississauga, Ontario. Surveying of borehole locations was carried out by Callon Dietz Inc. of London, Ontario.

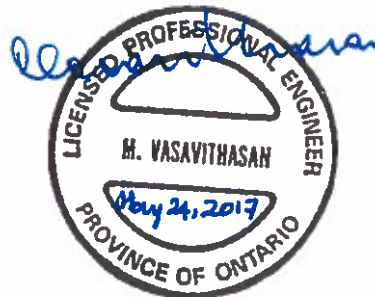
This report was prepared by Mr. L. Yimam, PhD. P.Eng., and reviewed by Mr. M. Vasavithasan, M.Sc. Eng., P. Eng. An independent review of the report was conducted by Mr. C.M.P. Nascimento, P.Eng, Project Manager and MTO Designated Principal Contact.

Yours very truly

Peto MacCallum Ltd.



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LY/MV/CN:ly-nk



## **APPENDIX A**

Previous Report for Pitopiko River Culvert (GEOCRES No.: 42F-15)

GEOCRES No. 42F-15DIST. 53 REGION           W.P. No. 29-97-00CONT. No.           W. O. No.           STR. SITE No.           HWY. No. 11LOCATION FROM THE FRASER RIVER BRIDGE  
WESTERLY TO THE REGIONAL BOUNDARY  
36.3KMNo of PAGES -OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.REMARKS:

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
W.P. 29-97-00  
HIGHWAY 11  
FROM THE FRASER RIVER BRIDGE  
WESTERLY TO THE REGIONAL BOUNDARY, 36.3 km  
MTO DISTRICT 53, NEW LISKEARD**

**for**

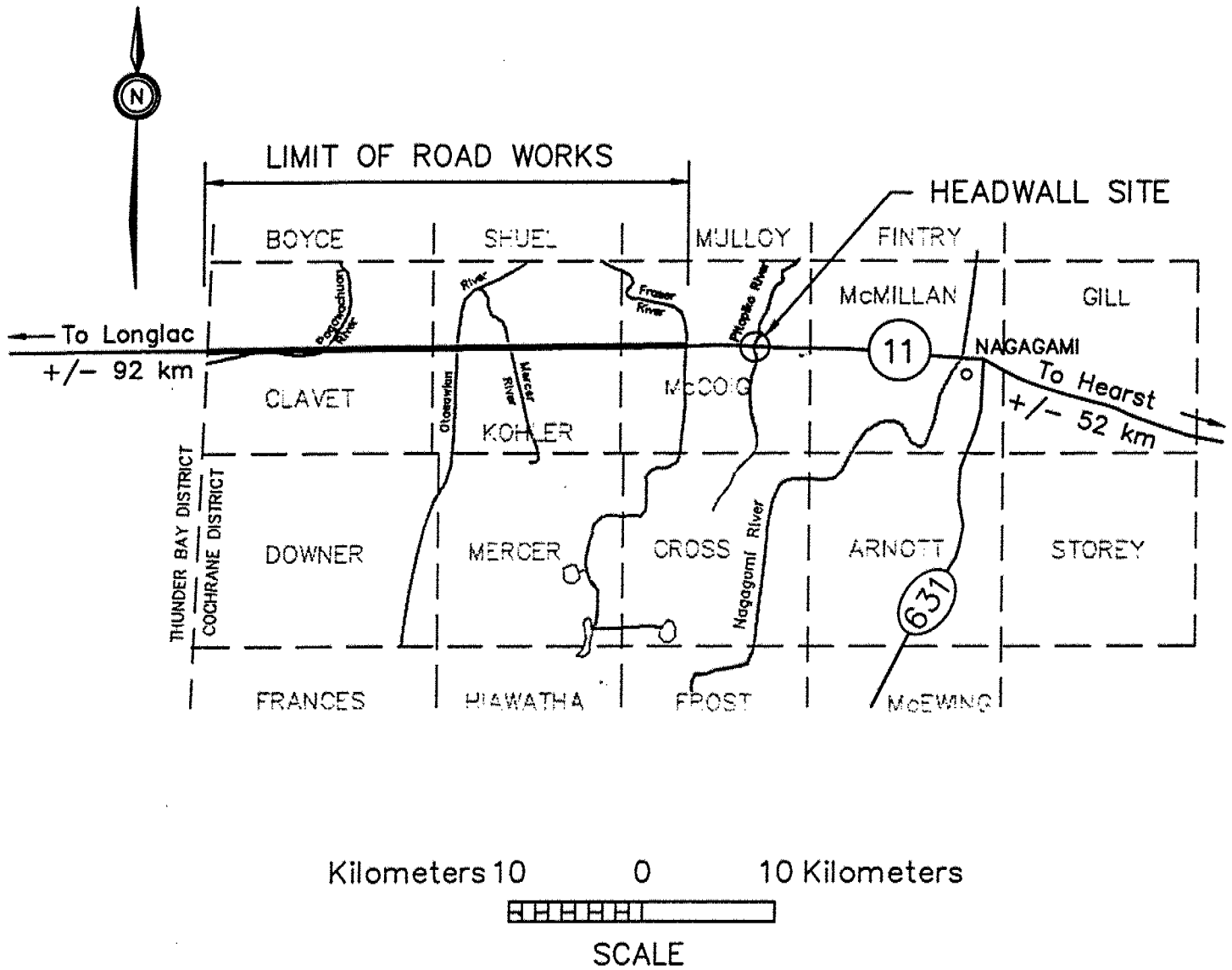
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APRIL, 1998



KEY PLAN  
W.P. 29-97-00

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FIGURE 1 TO 6                      PARTICLE SIZE DISTRIBUTION CHARTS

LIST OF ABBREVIATIONS

LOG OF BOREHOLE SHEETS

DRAWINGS 1 TO 4                      SITE SKETCHES

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
FOR CULVERT TREATMENTS  
HIGHWAY 11, FROM THE REGIONAL BOUNDARY WESTERLY  
TO THE FRASER RIVER BRIDGE, 36.3 km  
W.P. 29-97-00**

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**1.0 FOUNDATION INVESTIGATION REPORT**

**1.1 INTRODUCTION**

Peto MacCallum Ltd. was retained by Philips Planning and Engineering Limited as part of the Total Project Management (TPM) team to carry out a detailed soils investigation and to prepare a Pavement Design Report and Foundation Investigation and Design Report for Work Project (W.P.) 29-97-00. The Pavement Design Report has been forwarded under separate cover.

The original Terms of Reference identified seven culverts as potentially requiring treatment. Upon review, Philips Planning + Engineering Limited recommended remedial work be carried out at the following four locations:

- 1) 20+420, Township of Clavet - concrete culvert
- 2) 24+441, Township of Kohler - timber culvert
- 3) 13+408, Township of McCoig - corrugated steel pipe (CSP) sideroad culvert
- 4) Pitopiko River, Township of McCoig - twin (CSP) culvert south headwall



## 1.2 SITE DESCRIPTION

The four foundation investigation locations are located on Highway 11, in the Townships of Clavet, Kohler and McCoig between about 70 and 100 km west of Hearst, Ontario within District 53 - New Liskeard. The work will be carried out as part of Work Project (W.P.) 29-97-00 which extends from the Fraser River Bridge, westerly 36.3 km to the Regional Boundary. Location 4 (Pitopiko River) is located east of the work project limits.

The project is located in the Abitibi Uplands, part of the Canadian Shield physiographic province. The local topography is very flat and is typified by poorly drained sphagnum muskeg and black spruce dominated forest (Smith, S.L., Quaternary Stratigraphic Drilling Transect Timmins to the Moose River Basin, Ontario, Geologic Survey of Canada, 1992). Typical soils comprise Cochrane Till which is described as non-sorted silt and clay tills with granulars, cobbles and boulders. The inorganic soils are typically overlain by varying depths of peat and muck and underlain by relatively hard, primarily igneous bedrock (Sado, E.V., Fullerton, D.S., and Farrand, W.R., Quaternary Geologic Map of the Lake Nipigon 4° x 6° Quadrangle, U.S.A. and Canada, 1994).

## 1.3 INVESTIGATION PROCEDURES

The field work was carried out inconjunction with the pavement design soils investigation during October and November, 1997. The field work specific to the foundation investigations comprised a total of ten (10) boreholes and four (4) dynamic cone penetration tests advanced to depths of 0.60 to 11.90 m below existing grade.

The boreholes were advanced with a CME 55 track mounted drillrig and a CME 45 truck mounted drillrig equipped with continuous flight hollow and solid stem augers, supplied and operated by specialist drilling contractors. Manual hand augering was also carried out to obtain supplemental surficial organic thicknesses.

Representative samples of the overburden were secured at regular intervals throughout the depth explored. Standard penetration tests were carried out during sampling operations using conventional split spoon equipment. Groundwater observations were made in the boreholes during and following completion of drilling.

The field work was supervised throughout by a member of our engineering staff who directed the drilling and sampling process, prepared the stratigraphic logs, monitored groundwater conditions and cared for the recovered samples. The borehole locations and ground surface elevations were surveyed by Philips Planning + Engineering Limited and are related to the geodetic datum. The borehole at Location 4 (Pitopiko River) was referred to a local temporary benchmark set at 100.00.

All samples secured during the investigation were returned to our laboratory for detailed visual examination. The laboratory testing program consisted of natural moisture content determination tests on most recovered samples, six particle size distribution analyses and three atterberg limit tests.

#### 1.4 SUBSURFACE CONDITIONS

We refer to the appended Log of Borehole sheets for details of the drilling work including pavement construction details, soil descriptions, inferred stratigraphy, standard penetration "N" and dynamic cone values, shear strength test results, groundwater observations during and upon completion of drilling, and natural moisture content determination test results. The logs of testholes drilled locally as part of the pavement design investigation have also been included for convenience.

##### Location 1 - 20+420, Township of Clavet

The culvert at Location 1 is a 3.0 m wide by 1.8 m high rigid frame concrete structure with approximately 3 m of earth cover. Surface water flow through the culvert was negligible at the time of the field work. The culvert is showing signs of distress including lowering of the mid-section of the culvert relative to the ends, and two major breaks at the approximate edge-of-shoulder locations. The distress also includes cracking throughout the length of the culvert, and some deterioration and spalling of the concrete at the ends. Discussions with the MTO Patrol Supervisor indicate that loss of granular material has been experienced from the north road shoulder which may be caused by migration of material through the culvert cracks. It is understood that concrete has been poured into these road shoulder voids in the past.

In general, the subsurface stratigraphy contacted at Location 1 comprised road embankment fills and surficial peat overlying native silt and glacial till deposits.

The road embankment contacted in borehole 101, drilled through the road, comprises the surficial pavement structure over interstratified sand and silt with traces of gravel and clay. The borehole was terminated at 5.10 m depth, near the base of the culvert, upon refusal to auger on wood which may be part of the original culvert form. Borehole 102 located near the edge of the embankment contacted silt with clay. The embankment fills are generally loose to compact based on standard penetration "N" values of 8 to 15 blows per 0.30 m penetration of the split spoon sampler. The embankment soils below the road are typically moist based on moisture contents of 8 to 13% and the soils near the edge of the embankment are wet based on a moisture content of 31%.

Surficial wet black amorphous peat was contacted to 0.60 m depth in borehole 103 located near the south end of the culvert.

The native inorganic deposits encountered below the road embankment fills and peat consist of silt with varying amounts of clay and traces of sand and gravel. The silt is underlain by glacial tills comprising silty clay and silt with sand, a trace of gravel, and occasional cobbles and boulders. The native deposits range from very loose to loose/soft and become compact with depth based on standard penetration "N" and dynamic cone values in the range of 4 to 12 and shear strengths of 18 to 50 kPa. Moisture contents of 13 to 40% reflected moist/drier than plastic limit (D.T.P.L.) conditions becoming saturated/wetter than plastic limit (W.T.P.L.) with depth. A typical particle size distribution chart for the silt is presented on Figure 1 appended.

Soil colouring and moisture contents indicate that the stabilized groundwater level lies around 3.0 m below the culvert level or 7.5 m below the road grade, at about elevation 229.

Location 2 - 24+441, Township of Kohler

The culvert at Location 2 is a 1.5 m wide by 1.4 m high timber culvert. The culvert accommodates a watercourse with a water depth of about 1 m at the time of the field work. Asphalt patching indicates that the overlying roadway has experienced distortions/settlements over the south half (east-bound lane) of the culvert.

The subsurface conditions around the timber comprised the surficial road embankment, fill, and peat overlying silt and silt till deposits.

The road embankment contacted in borehole 205 located on the road comprised the surficial pavement over sand fill with silt and gravel, a trace of clay and silty zones. The embankment fill extends to 3.80 m below the road grade, near the base of the culvert. The sand fill is loose to compact based on standard penetration "N" values of 5 to 12 and is moist, becoming saturated near the creek level. Typical particle size distribution charts for the road embankment fill are presented on Figures 2 and 3, appended.

Boreholes 201 and 204 located off the road embankment encountered localized fill and peat to depths of 0.10 m to 0.80 m below existing grade.

The native inorganic deposits encountered beneath the road embankment, fill and peat comprised a major silt till deposit with a localized silt deposit in borehole 204. The native deposits are generally loose to dense based on standard penetration "N" and dynamic cone values of 5 to 47 blows per 0.30 m. The deposits are typically moist becoming saturated at depth based on moisture contents of 5 to 22%. A typical particle size distribution analysis of the sandy silt till is presented on Figure 4, appended.

The stabilized groundwater level is believed to lie around the creek level at about 3.3 m below the road grade or elevation 253.0, based on soil colouring and groundwater conditions.

Location 3 - 13+408, Township of McCoig

The culvert at Location 3 comprises a CSP (approximate diameter 600 mm) about 25 m south of Highway 11 on a one-lane sideroad. The culvert appears to be located too high and is blocking local drainage patterns as evidenced by surface water ponding around the culvert. The CSP is also in a state of disrepair.

Borehole 301 drilled near the CSP culvert contacted a surficial sand road structure over loose to compact/stiff sandy and clayey silt till. The till is typically moist becoming wet at depth. A particle size distribution chart for the sandy silt till is included on Figure 5, appended.

Surface water existed near the culvert, however the stabilized regional groundwater level is believed to lie below the depth of exploration.

Location 4 - Pitopiko River, Township of McCoig

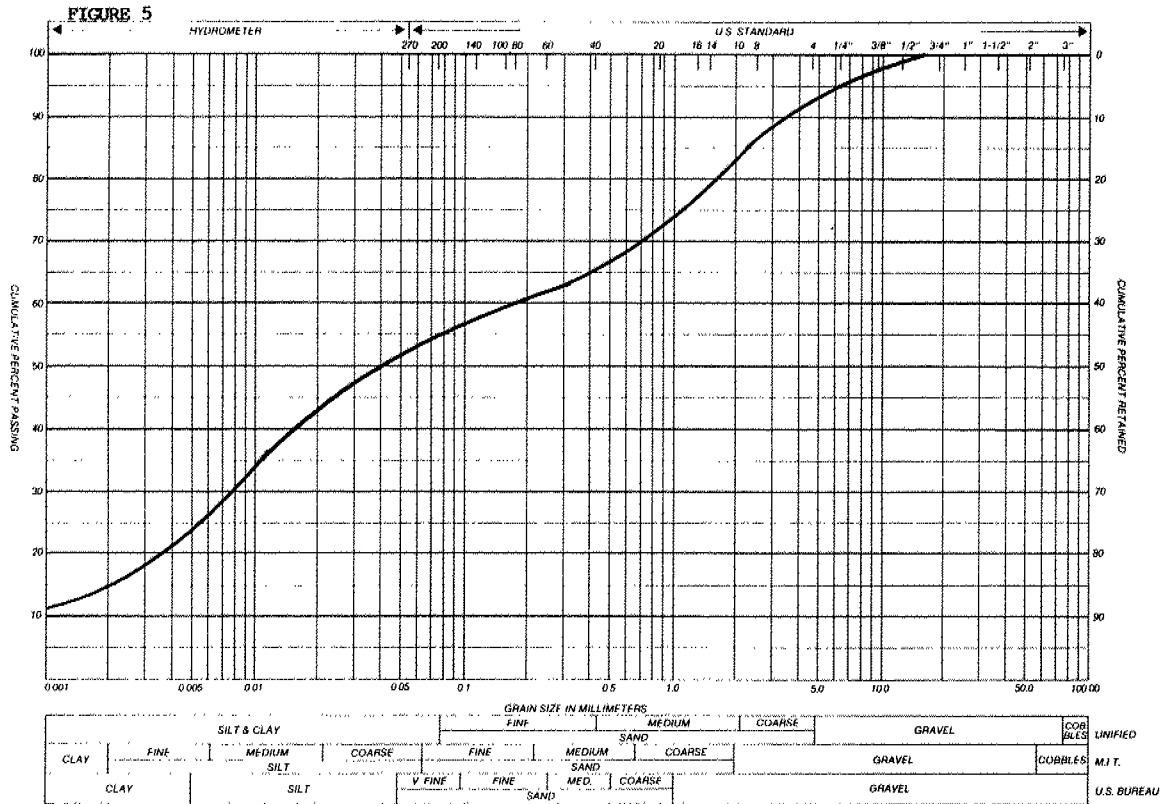
Location 4 comprises the south concrete headwall of twin 3.7 m diameter CSP's which accommodate the Highway 11/Pitopiko River crossing. The headwall is in a serious state of deterioration in that the upper portion of the wall has fractured from its foundation section and rotated.

Borehole 401 located by the south headwall contacted 1.20 m of loose sandy silt fill over sandy silt till. The native till is loose becoming very dense at depth based on standard and dynamic cone penetration "N" values in the range of 9 to 50 blows per 0.30 m. Moisture contents of 8 to 17% reflect saturated conditions. A typical particle size distribution chart for the sandy silt till is presented on Figure 6, appended.

The stabilized groundwater level matches the water level of the Pitopiko River at a depth of about 1.5 m at the borehole location, or elevation 95.8.

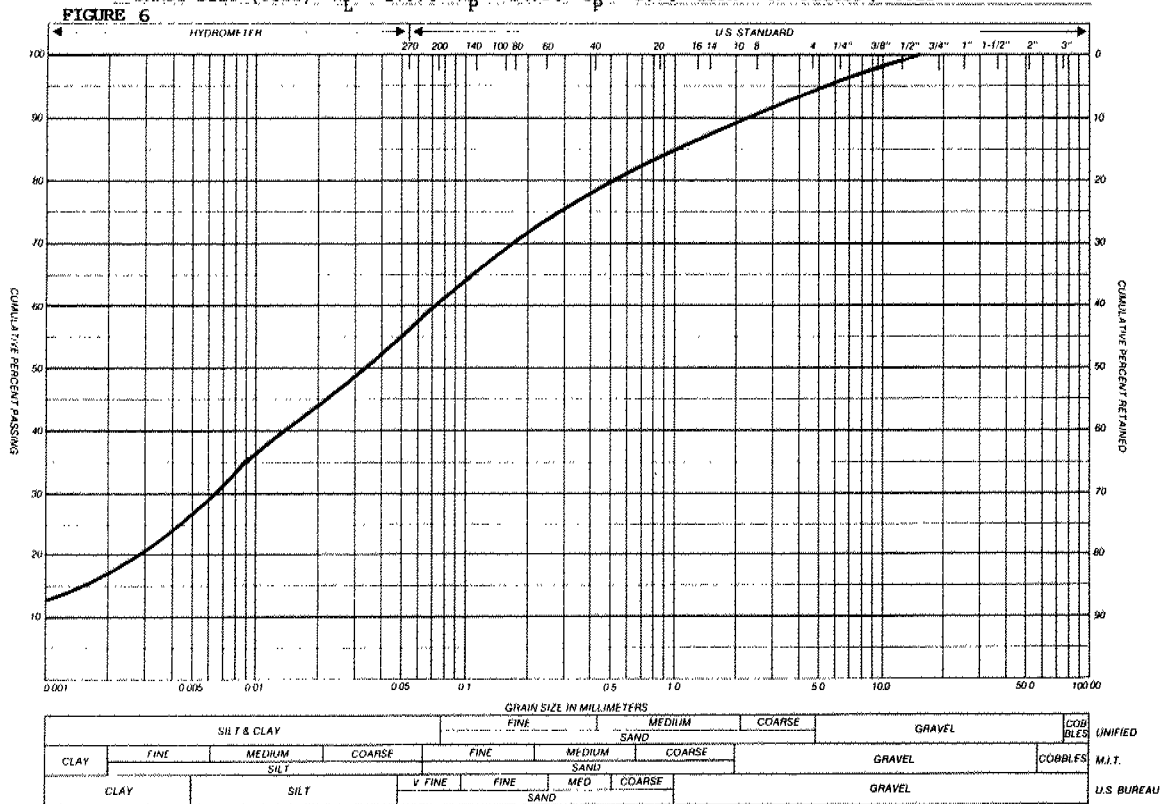
## PARTICLE SIZE DISTRIBUTION CHART

OUR PROJECT NO. 97 TF 78



REMARKS Borehole 301, (Sta. 13+407, 25.00 m Rt C/L, McCoig Twp.) Sample 2, Depth 0.65 to 1.35 m

SANDY SILT (TILL)  $W_L = 17.7\%$   $W_p = 14.0\%$   $I_p = 3.7\%$  LSPH "K" Factor = 0.23



REMARKS Borehole 401 (Pitopiko River), Sample 4, Depth 1.80 to 2.45 m

SANDY SILT (TILL)  $W_L = 15.9\%$   $W_p = 13.1\%$   $I_p = 2.8\%$  LSPH "K" Factor = 0.27



LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N', - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 0.3m INTO THE SUBSOIL. DRIVEN BY MEANS OF A 63.5kg HAMMER FALLING FREELY A DISTANCE OF 0.76m.

DYNAMIC PENETRATION RESISTANCE: - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 51mm, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS. 0.3m INTO THE SUBSOIL. THE DRIVING ENERGY BEING 475J PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:-

<u>CONSISTENCY</u>	<u>'N' BLOWS/0.3m</u>	<u>c kPa</u>	<u>DENSENESS</u>	<u>'N' BLOWS/0.3m</u>
VERY SOFT	0 - 2	0 - 12	VERY LOOSE	0 - 4
SOFT	2 - 4	12 - 25	LOOSE	4 - 10
FIRM	4 - 8	25 - 50	COMPACT	10 - 30
STIFF	8 - 15	50 - 100	DENSE	30 - 50
VERY STIFF	15 - 30	100 - 200	VERY DENSE	> 50
HARD	> 30	> 200		
W.T.P.L.	WETTER THAN PLASTIC LIMIT		D.T.P.L.	DRIER THAN PLASTIC LIMIT
	A.P.L.		ABOUT PLASTIC LIMIT	

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H.	SAMPLE ADVANCED HYDRAULICALLY	
	P.M.	SAMPLE ADVANCED MANUALLY	

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL		

GEOTECHNICAL SURVEY DATA	
W.P. 29-97-00	
SURVEY DATE	TYPE OF SURVEY
October, November, 1997	Peto MacCallum Ltd. Power Auger, Power Excavator, Hand Auger
<p>NOTES</p> <ol style="list-style-type: none"><li>1. Conditions and pavement depths apply only to the date of survey.</li><li>2. The boundaries between the strata have been established only at core/borehole locations. Between cores/boreholes the boundaries are assumed and may be subject to error.</li><li>3. Soils are described according to the MTO Soils Classification System.</li><li>4. Pavement core locations were established using random numbers.</li><li>5. Abbreviations for boring and test data conform to OPSD 100.06.</li><li>6. Dimensions are in metres and/or millimetres unless otherwise shown. Stations in kilometres + metres.</li><li>7. In the logs of testholes, the abbreviation D+/- represents the difference in ground surface elevation of points offset from the C/L. Geodetic elevations are provided where available.</li></ol>	

## LOG OF BOREHOLE NO. 401 (Pitopiko River)

PROJECT W.P. 29-97-00, Highway 11

OUR PROJECT NO. 97 TF 78

**LOCATION** From Fraser River, Westerly to the Regional Boundary, 36.3 km

BORING DATE 1997 11 06

ENGINEER G. Mitchell

BORING METHOD Continuous Sampling

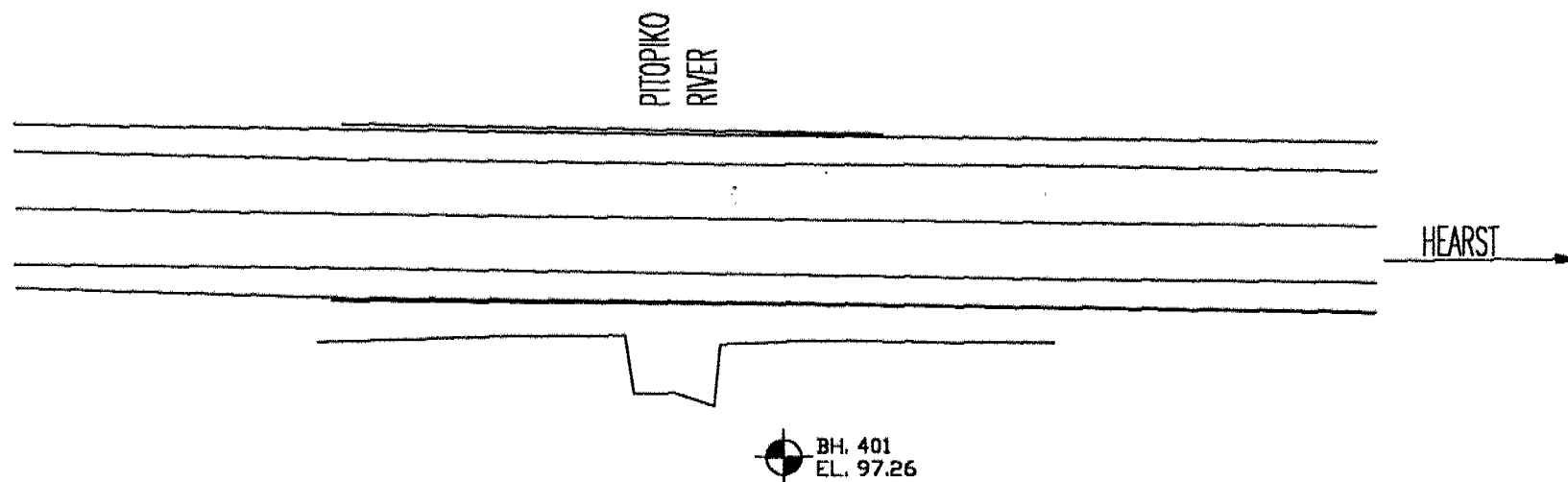
TECHNICIAN D. MacRae

SOIL PROFILE				SAMPLES		SHEAR STRENGTH $C_u$		LIQUID LIMIT $W_L$		GROUND WATER OBSERVATIONS AND REMARKS		
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	DYNAMIC CONE PENETRATION * STANDARD PENETRATION TEST *	PLASTIC LIMIT $W_p$	WATER CONTENT $W$			
								BLOWS/0.3M			WATER CONTENT %	
	GROUND ELEVATION 97.26											
	FILL: 050 mm of dark brown silt topsoil, moist, over brown sandy silt, trace gravel, moist		97	1	SS	4						
1.20			96	2	SS	7						
1.5				3	SS	9						
	SANDY SILT: Loose to very dense light grey sandy silt with clay, gravel layers, occasional cobbles and boulders, saturated (till)		95	4	SS	11						
2.75				5	SS	28						
3.0	BOREHOLE TERMINATED AT 2.75 m											

NOTES:

CHECKED BY:

**SITE SKETCH  
LOCATION 4**



NOTE:  
ELEVATION REFERRED TO A LOCAL TEMPORARY BENCH  
MARK SET AT ELEVATION 100.00 (METRIC, ASSUMED)

***Peto MacCallum Ltd.***  
CONSULTING ENGINEERS

DATE	SCALE	PML REF.	DRAWING NO.
APRIL, 1998	N.T.S	97 TF 78	4



## **APPENDIX B**

### Site Photographs



**Photograph A1:** Looking East, South Side of the Pitopiko River Culvert (July 25, 2016).





**Photograph A2:** North Side of the River and the Culvert End (July 25, 2016).





**Photograph A3:** Looking West, North Side of the Embankment Slope (July 25, 2016).





## **APPENDIX C**

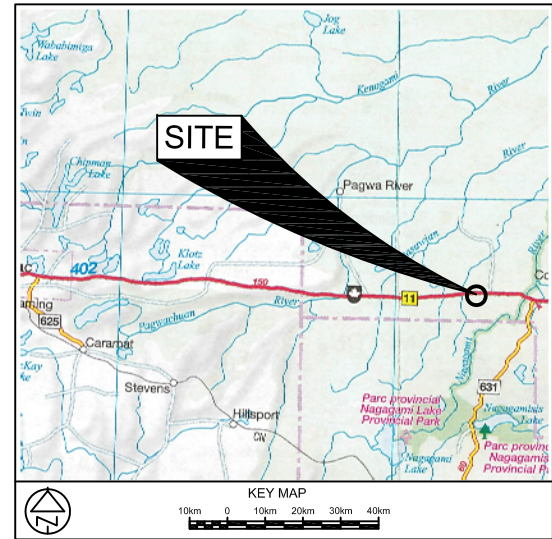
Borehole Location Plan and Soil Strata

Explanation of Terms used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Curves – Figures 004-GS-1 and 004-GS-2

Plasticity Chart – Figure 004-PC-1



LEGEND			
	Borehole		
	Cone		
	Borehole and Cone		
N	Blows/0.3m (Std. Pen Test, 475 J/blow)		
CONE	Blows/0.3m (60 Cone, 475 J/blow)		
	WL at time of investigation July 2016		
WH	Penetration due to weight of hammer and rod		
*	Water level not established		
	Head		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		

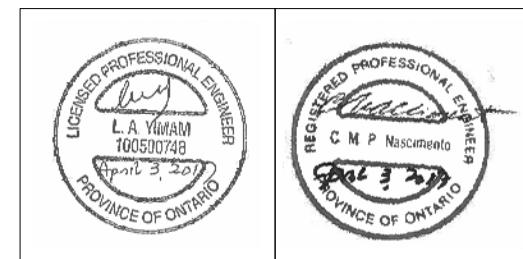
BH No	ELEVATION	NORTHINGS	EASTINGS
16-004-01	247.5	5 514 811.4	249 257.4
16-004-02	246.8	5 514 847.8	249 240.6

— NOTE —  
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

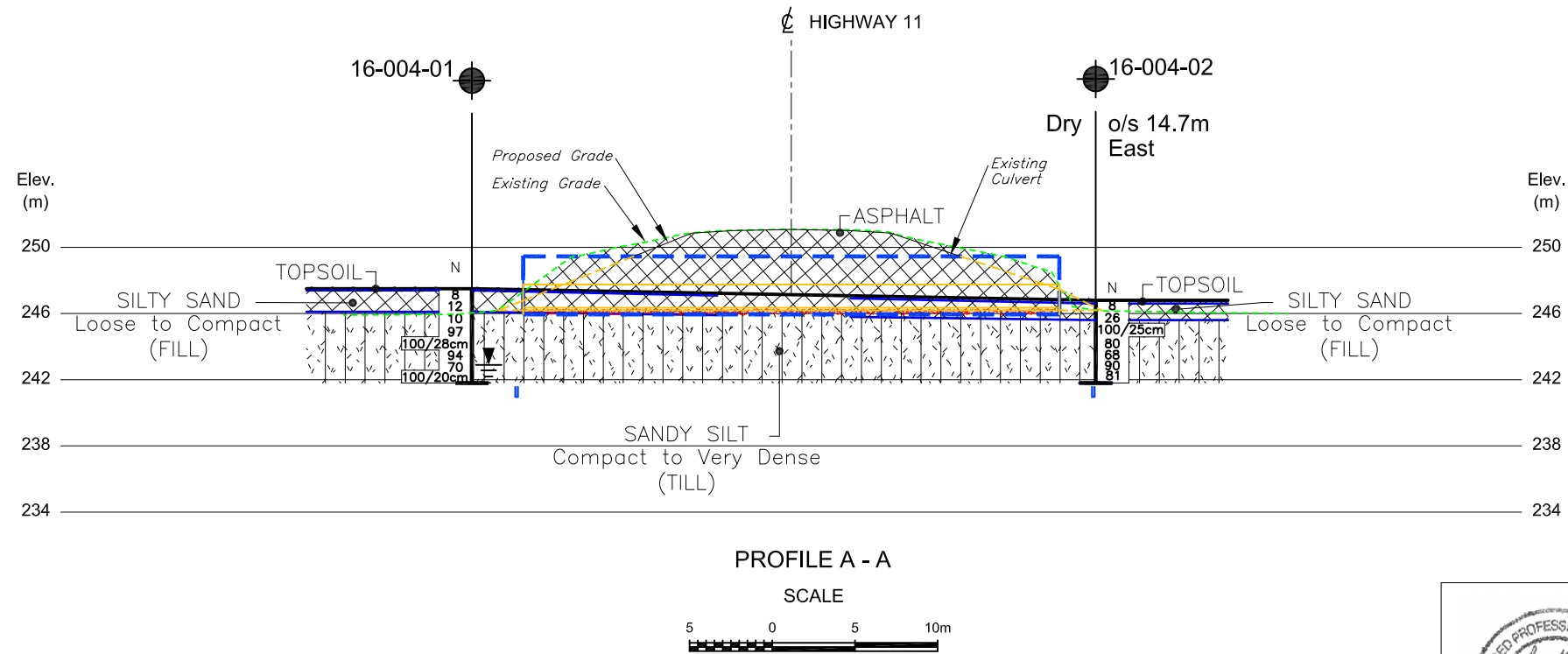
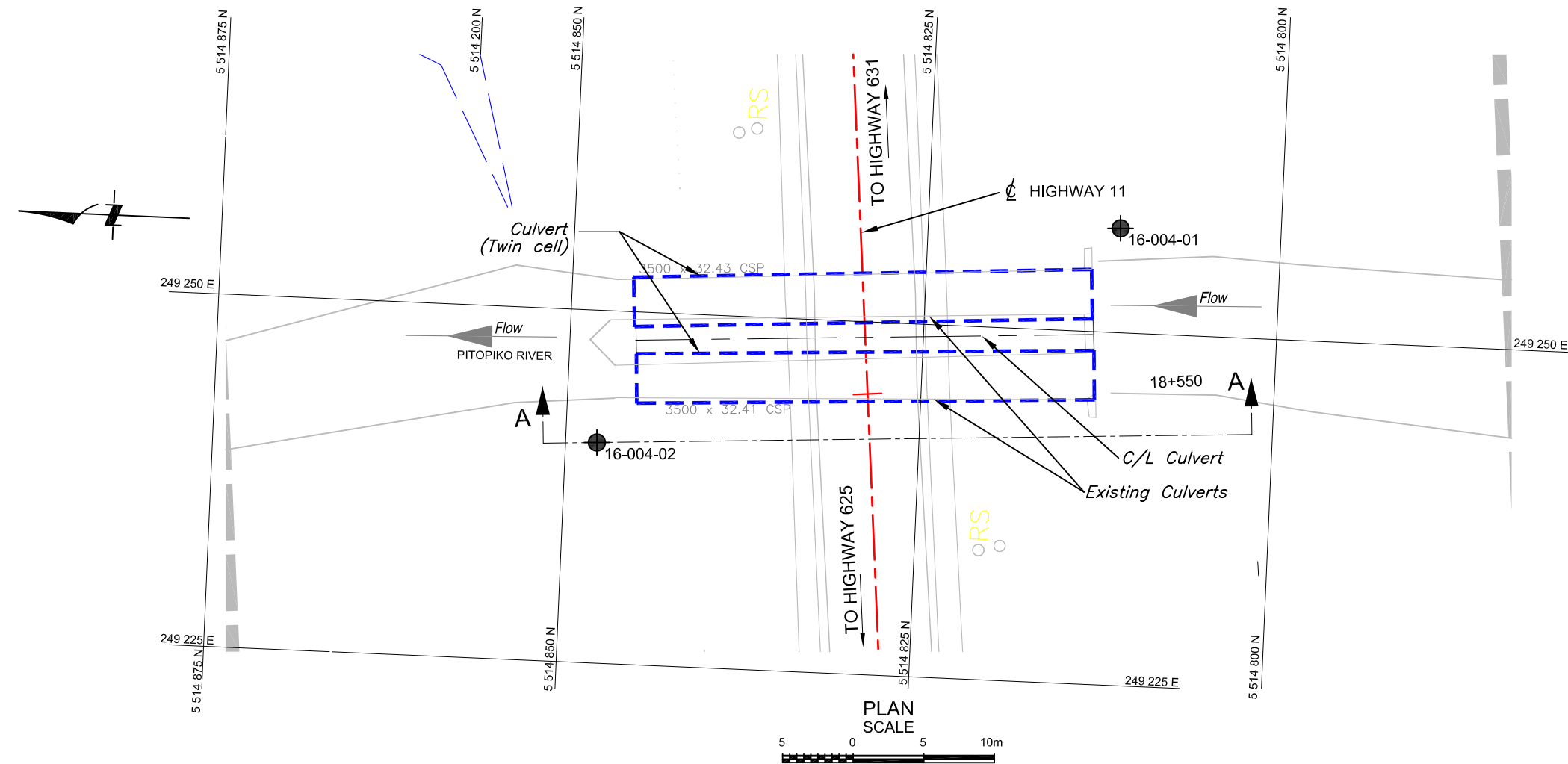
DATE	BY	DESCRIPTION

Geocres No. 42F-050

HWY No	11	DIST	NEW LISKEARD
SUBM'D	NA	CHECKED	LY
DATE	APR. 03, 2017	SITE	39W-004/C
DRAWN	NA	CHECKED	MV
APPROVED	CN	DWG	004/C-1



REF GHD Drawing: X-11116826\_Contract 39W-004\_GA.dwg dated January 2017



NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**COMPOSITION:** SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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

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

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

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

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$n$	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$w$	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	$D$	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$v$	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL				$i$	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	$j$	kN/m <sup>3</sup>	SEEPAGE FORCE
$e$	1, %	VOID RATIO	WTPL		WETTER THAN PLASTIC LIMIT			

**RECORD OF BOREHOLE No 16-004-01**

1 of 1

**METRIC**

G.W.P. 5047-07-00 LOCATION Co-ords: 5 514 811.4 N ; 249 257.4 E ORIGINATED BY K.D.  
 DIST New Liskeard BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY L.Y.  
 DATUM Geodetic HWY 11 DATE August 06, 2016 CHECKED BY M.V.

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  kN/m <sup>3</sup>	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						
247.5	Ground Surface						20	40	60	80	100						
0.0	Topsoil																
247.4	Silty sand some gravel, trace clay organic inclusions, rootlets		1	SS	8							○					
0.1	Loose to Brown Moist compact (FILL)		2	SS	12							○				24 53 19 4	
246.1	Sandy silt, some clay trace to some gravel		3	SS	10							○					
1.4	Compact to Grey Moist very dense (TILL)		4	SS	97							○ H					
			5	SS	100/28cm							○				6 35 45 14	
			6	SS	94							○					
			7	SS	70							○				7 34 47 12	
			8	SS	100/20cm							○ H					
241.8	End of borehole																
5.7																	
	* 2016 08 06																
	▽ Water level observed during drilling																
	▼ Water level measured after drilling																

\* 2016 08 06

▽ Water level observed during drilling

▼ Water level measured after drilling

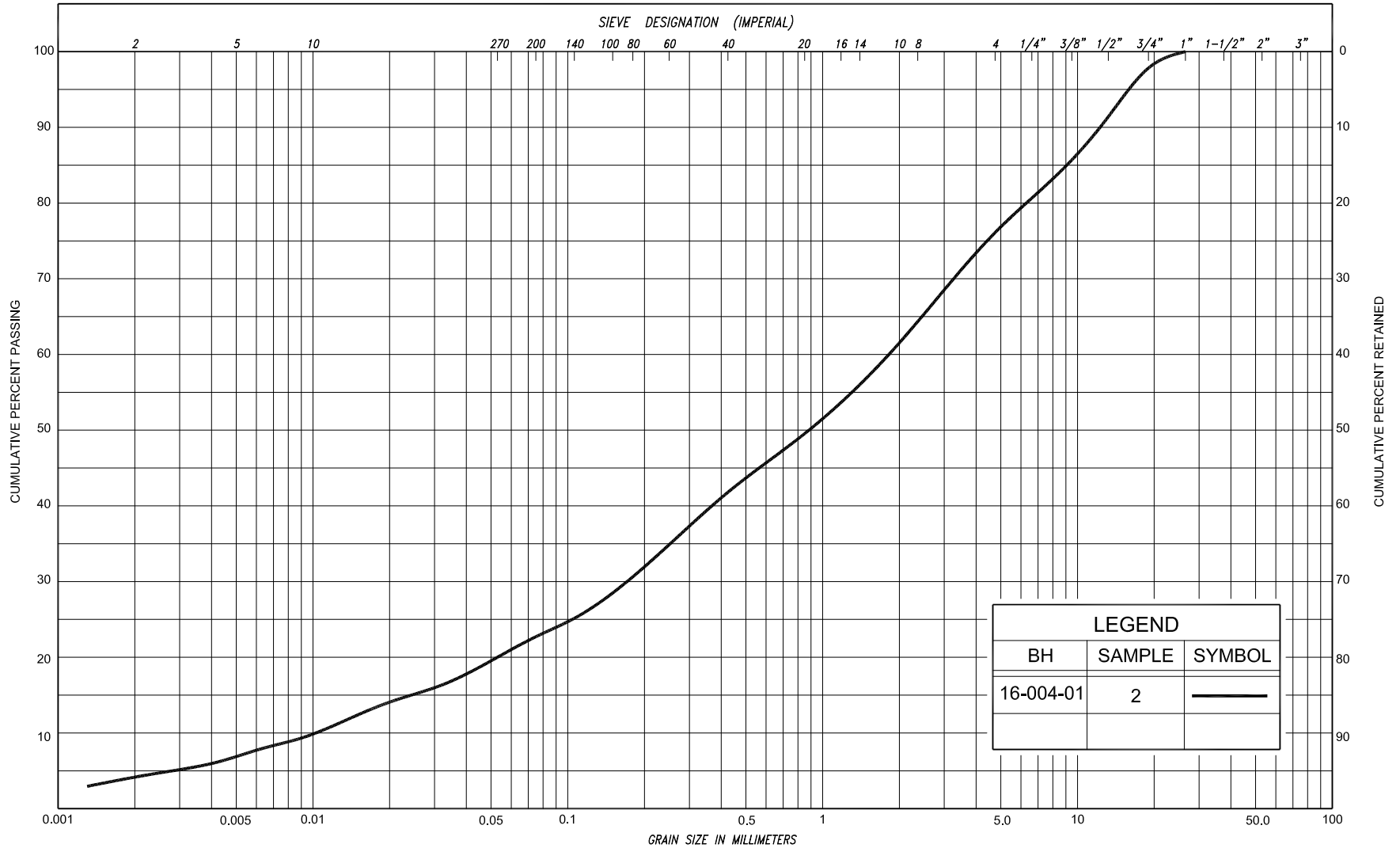
**RECORD OF BOREHOLE No 16-004-02**

1 of 1

**METRIC**

G.W.P. 5047-07-00 LOCATION Co-ords: 5 514 847.8 N ; 249 240.6 E ORIGINATED BY K.D.  
DIST New Liskeard BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY L.Y.  
DATUM Geodetic HWY 11 DATE August 06, 2016 CHECKED BY M.V.

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  kN/m <sup>3</sup>	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									
					WATER CONTENT (%)												
246.8	Ground Surface						20	40	60	80	100						
246.6	Topsoil																
0.2	Silty sand some gravel, trace clay organics, rootlets		1	SS	8								○				
245.6	Loose to Brown Moist compact (FILL)		2	SS	26								○				
1.2	Sandy silt, some clay trace to some gravel		3	SS	100/25cm								○ H				
	Very dense Grey Moist																
	(TILL)		4	SS	80								○			10 34 43 13	
			5	SS	68								○ H				
			6	SS	90								○			10 32 44 14	
241.8			7	SS	81								○				
5.0	End of borehole																
	* Borehole dry																

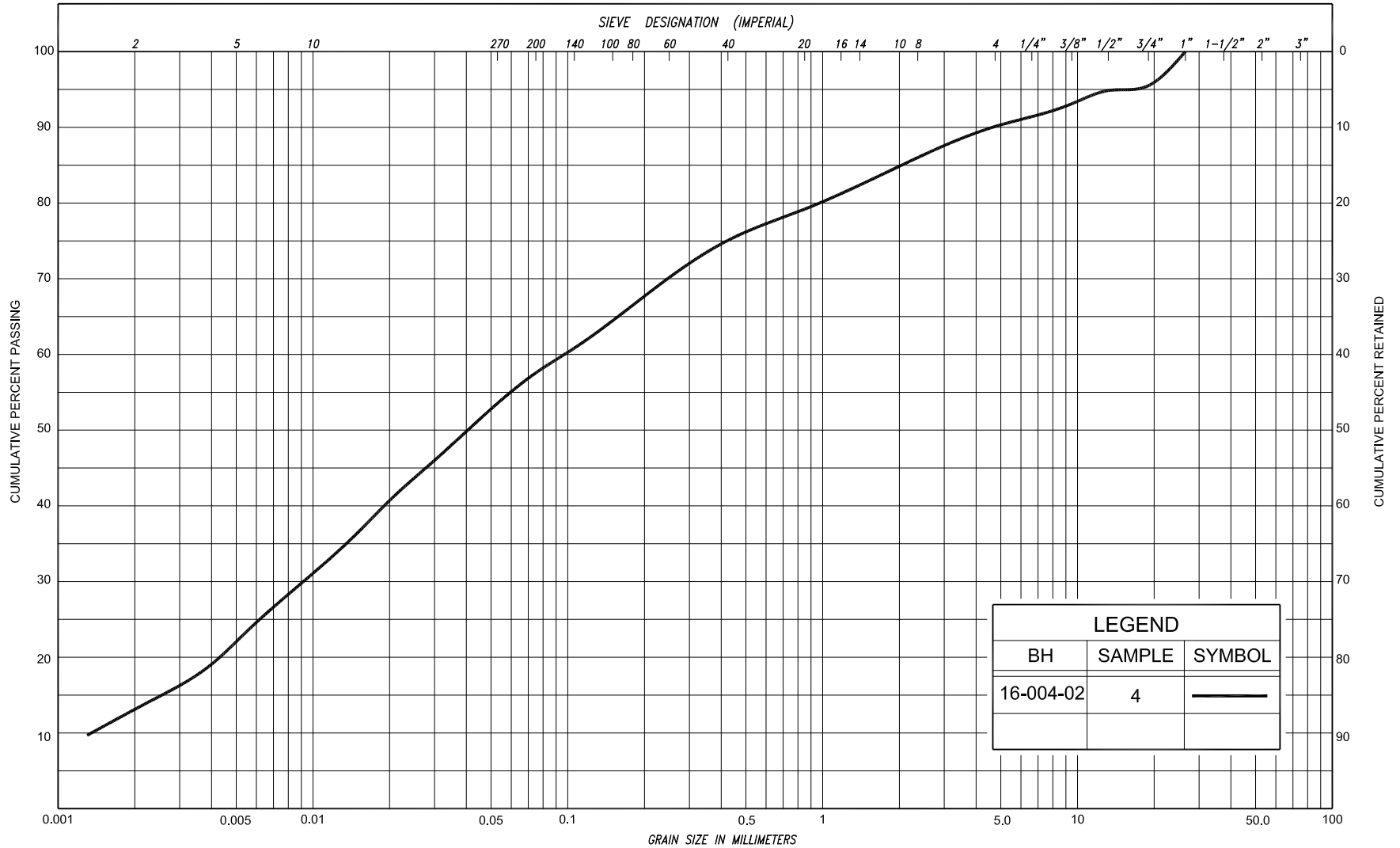


SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COBBLES	UNIFIED
				SAND								
CLAY	FINE		MEDIUM	COARSE	FINE		MEDIUM	COARSE	GRAVEL		COBBLES	M.I.T.
SILT												
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL				U.S. BUREAU
				SAND								



# GRAIN SIZE DISTRIBUTION SILTY SAND, some gravel, trace clay (GRANULAR FILL)

FIG No. 004-GS-1  
HWY 11  
G.W.P. 5213-05-00



LEGEND		
BH	SAMPLE	SYMBOL
16-004-02	4	—

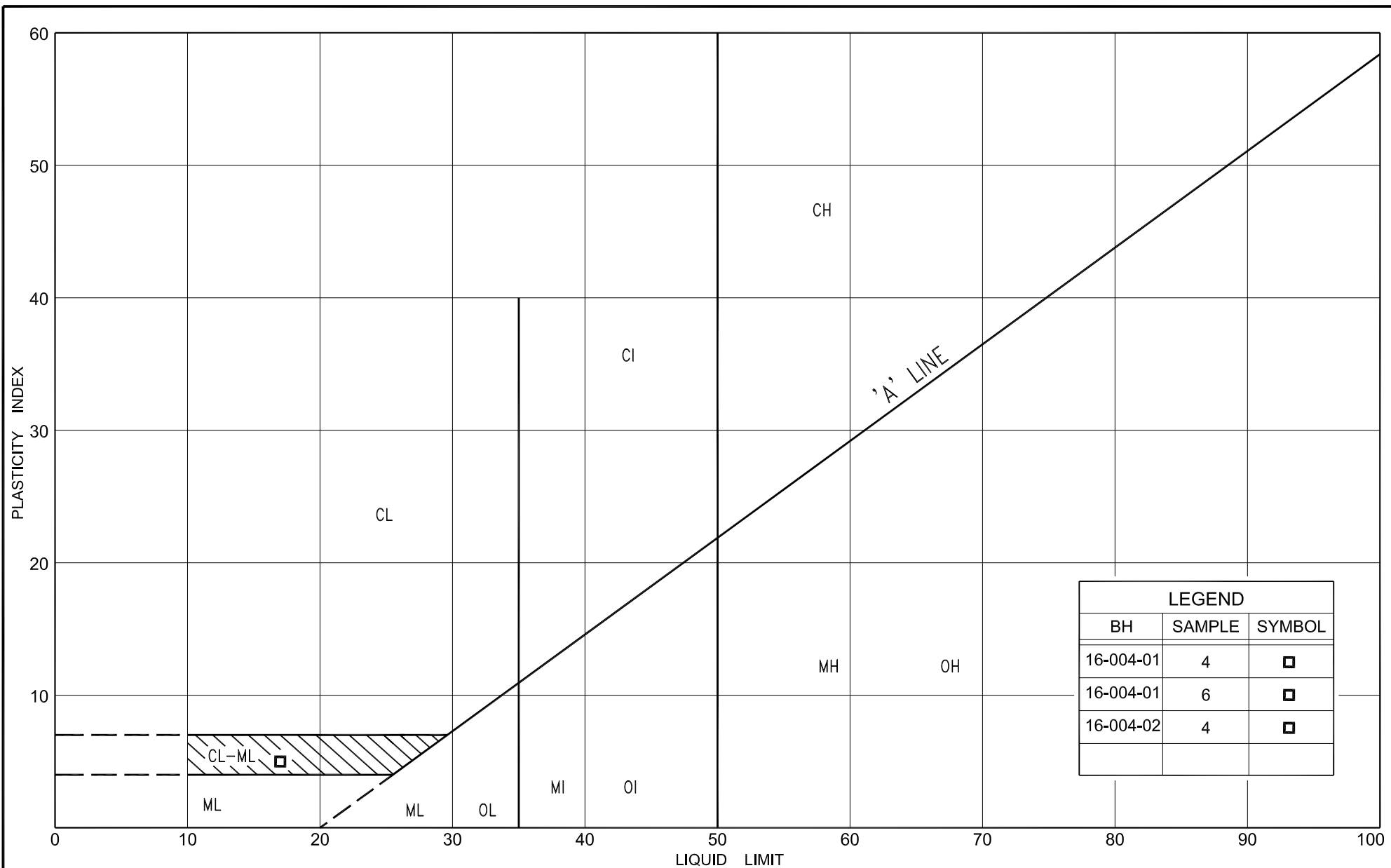
SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COBBLES	UNIFIED
				SAND								
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL				COBBLES	M.I.T.
	SILT			SAND								
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL				U.S. BUREAU
				SAND								



## GRAIN SIZE DISTRIBUTION

CLAYEY SILT, with sand, trace to some gravel (CL-ML)

FIG No. 004-GS-2  
 HWY 11  
 G.W.P. 5213-05-00



## PLASTICITY CHART

CLAYEY SILT, with sand, trace to some gravel (CL-ML)

FIG No. 004-PC-1

HWY 11

G.W.P. 5213-05-00





## **APPENDIX D**

### Results of Chemical Corrosivity Tests



**AGAT** Laboratories

## Certificate of Analysis

AGAT WORK ORDER: 16T131831

PROJECT: 16TF013A

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: PETO MACCALLUM LIMITED

SAMPLING SITE:

ATTENTION TO: Lul Yimam

SAMPLED BY: Kyle Daly

### Corrosivity Package

DATE RECEIVED: 2016-08-29

DATE REPORTED: 2016-09-07

			BH16-004-02	BH16-008-03	BH16-112-04	BH16-131-04	BH16-133-02	
SAMPLE DESCRIPTION:			SS7	SS7	SS4A	SS4	SS3	
SAMPLE TYPE:			Soil	Soil	Soil	Soil	Soil	
DATE SAMPLED:			8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	
Parameter	Unit	G / S	RDL	7813058	7813065	7813066	7813067	7813068
Chloride (2:1)	µg/g		2	16	7	159	44	559
Sulphate (2:1)	µg/g		2	62	47	43	3	14
pH (2:1)	pH Units		NA	8.44	8.56	8.07	8.61	8.37
Electrical Conductivity (2:1)	mS/cm		0.005	0.216	0.167	0.441	0.179	0.986
Resistivity (2:1)	ohm.cm		1	4630	5990	2270	5590	1010
Redox Potential (2:1)	mV		5	258	249	261	243	254

**Comments:** RDL - Reported Detection Limit; G / S - Guideline / Standard

**7813058-7813068** EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By:

*Amanjot Bhela*

## Quality Assurance

CLIENT NAME: PETO MACCALLUM LIMITED

PROJECT: 16TF013A

SAMPLING SITE:

AGAT WORK ORDER: 16T131831

ATTENTION TO: Lui Yimam

SAMPLED BY: Kyle Daly

### Soil Analysis

RPT Date: Sep 07, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

#### Corrosivity Package

Chloride (2:1)	7813068	7813068	559	551	1.4%	< 2	91%	80%	120%	102%	80%	120%	104%	70%	130%
Sulphate (2:1)	7813068	7813068	14	14	0.0%	< 2	96%	80%	120%	102%	80%	120%	101%	70%	130%
pH (2:1)	7813068	7813068	8.37	8.29	1.0%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	7813068	7813068	0.986	0.986	0.0%	< 0.005	100%	90%	110%	NA			NA		
Redox Potential (2:1)	7813068	7813068	254	254	0.0%	< 5	103%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By:



## Method Summary

**CLIENT NAME:** PETO MACCALLUM LIMITED

**AGAT WORK ORDER:** 16T131831

**PROJECT:** 16TF013A

**ATTENTION TO:** Lui Yimam

**SAMPLING SITE:**

**SAMPLED BY:** Kyle Daly

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
<b>Soil Analysis</b>			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE



**PART B – FOUNDATION DESIGN REPORT**

**for**

**PITOPIKO RIVER CULVERT REHABILITATION**

**SITE NO. 39W-004/C**

**HIGHWAY 11 – STATION 18+554**

**TOWNSHIP OF McCOIG, DISTRICT OF NEW LISKEARD**

**HEARST, ONTARIO**

**ASSIGNMENT NO. 5015-E-0009**

**GWP 5047-07-00**

**WP 5370-11-02**

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**PART B – FOUNDATION DESIGN REPORT**

Pitopiko River Culvert Rehabilitation  
Site No. 39W-004/C  
Highway 11 – Station 18+554  
Township Of McCoig, District of New Liskeard, Hearst, Ontario  
Assignment No. 5015-E-0009, GWP 5047-07-00, WP 5370-11-02

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**11. INTRODUCTION**

This foundation design report with the interpretation and recommendations are intended for the use of GHD Ltd. (GHD) on behalf of the Ministry of Transportation of Ontario (MTO), 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 contractors must make their own interpretation based on the factual data provided in the foundation investigation report (Part A). Where comments are made in this report on construction, they are provided only to highlight aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual data, as it may affect equipment selection, proposed construction methods, and scheduling.

**12. PROJECT DESCRIPTION**

**12.1 General**

This report provides geotechnical recommendations useful to assist the design team in the rehabilitation of the existing culvert located at the crossing of Highway 11 and the Pitopiko River, Sta. 18+554, in the Township of McCoig, District of New Liskeard.

The discussions and recommendations presented in this report are based on the data obtained from the geotechnical investigation carried out by PML and the information given in the General Arrangement (GA) drawing, dated April, 2017, provided by GHD. The list of Ontario Provincial Standard Specifications (OPSSs) and Ontario Provincial Standard Drawings (OPSDs) recommended in this report is provided in Appendix E.

**12.2 Existing Culvert**

The existing culvert is a twin cell, circular corrugated steel pipe (CSP) structure, with each barrel having a diameter of 4.0 m and a length of 33.0 m. The fill height above the deck is 1.5 m. According to the GA drawing, the elevation of the culvert invert is at about El. 245.9 m. The structure includes cast-in-place (CIP) wing walls and a retaining wall at the inlet located on the south side.

Based on the RFQ, the culvert was constructed in 1976 and had no record of rehabilitation.



The inspection of this culvert carried out by AECOM Canada Ltd (AECOM) on July 20, 2011 identified the breakdown of protective paint coating of structural steel plates and light to medium corrosion, from the high water level to the invert on both east and west barrels of the culvert. Further, the inspection report dated September 25, 2015 also shows light scaling, narrow stained and unstained cracks, and light stratification on the retaining wall and wing walls.

### **12.3 Foundation Conditions**

The subsurface at the culvert location consists of 1.2 m to 1.4 m thick loose to compact silty sand fill underlain by sandy silt till deposit that extends to the full depth of investigation of El. 241.8 m. The sandy silt till was found to be compact to very dense.

The foundation investigation report prepared by PML in 1998, provided in Appendix A, also indicates the presence of dense to very dense till below the depth of 1.2 m (El. 245 m).

The groundwater level during the fieldwork was observed at about El. 242.4 m. The groundwater level at the site is expected to be influenced by the flow of the Pitopiko River, and may also change due to the influence of precipitation and seasonal fluctuations.

## **13. CULVERT REHABILITATION**

The RFQ indicates that the scope of rehabilitation is expected to involve total lining of the culvert or only the invert, and removal and patching of deteriorated areas of the concrete in the wing walls and retaining wall. Since the scope of the work is limited to rehabilitation, no recommendation for new foundation design or geotechnical resistances are provided in this report.

The approach embankments were found to be stable and no sign of erosion was observed. Embankment slopes on both sides of the highway were well vegetated. Hence, slope maintenance or use of protective measures may not be required during culvert rehabilitation.

However, as part of the culvert rehabilitation, any existing inlet and outlet protection may be upgraded in accordance with OPSS 511 (Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting), OPSS. PROV 1004 (Material Specification for Aggregates) and OPSD 810.010 (General Rip-Rap Layout Sewer and Culvert Outlets) to prevent long-term erosion adjacent to the culvert as well as scour, and washouts in the embankment slopes.





In accordance with OPSD 3090.100, a minimum of 2.6 m earth cover is required to protect against the frost penetration in the area where the structure is located.

## 14. **CONSTRUCTION CONSIDERATIONS**

### 14.1 **General**

It is assumed that there will be no staging and Highway 11 will be opened to regular traffic during the proposed culvert rehabilitation work. The rehabilitation on the culvert invert, wing walls and retaining wall, and placement of erosion protection measures are assumed to be carried without roadway protection measures. Should excavation of the roadway be required, a single lane closure and detour with temporary traffic signals may be utilized to maintain traffic on the highway.

### 14.2 **Lateral Earth Pressure for Shoring Systems**

Computation of lateral earth pressure for shoring systems should be as per Clause 6.12.2 (b) of the Canadian Highway Bridge Design Code (CHBDC), 2014. For walls that are designed to allow for rotation, “active” earth pressure may be used for design. For rigidly tied structures, where sufficient movement is not permitted, “at rest” conditions may be assumed to compute earth pressure. The earth pressure calculation should include the maximum water level expected in Pitopiko River.

In case a temporary shoring or roadway protection system is required, it should be designed and constructed to meet a Performance Level of 2 according to OPSS 539. The soil parameters given in Table 14.2 may be used for the design of the shoring systems.

**Table 14.2 – Soil Parameters**

ELEVATION (m)		SOIL TYPE	SOIL PARAMETERS		
FROM	TO		FRICTION ANGLE (°)	UNIT WEIGHT ( $\gamma$ ) kN/m <sup>3</sup>	C <sub>u</sub> , (kPa)
247.5	246	Silty Sand to Sandy Silt Fill	30	18	-
246	241.8	Compact to Very Dense Sandy Silt Till	32	20	-

**Note:** Submerged unit weight should be used below the water level



### **14.3 Groundwater Control**

For work in the dry, the Pitopiko River may have to be temporarily diverted and a cofferdam made up of sheet pile walls may be constructed. Alternatively, a cofferdam consisting of sand bags and clay puddle may be built by damming the culvert on upstream and downstream sides. Dewatering may be carried out by pumping from sumps located along the periphery of the cofferdam.

The contractor should be responsible for selection, performance and detailed design of the dewatering system including the cofferdam. The dewatering system should be designed to conform to the requirement of OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation) and OPSS 518 (Construction Specification for Control of Water from Dewatering Operations).

## **15. SOIL CORROSIVITY**

A sample of the sandy silt was tested for soil corrosivity and potential exposure of concrete to sulphate attack. A summary of the chemical test results are provided in Table 9 of Part A of this report. As shown in this table, the sulphate content obtained for the sandy silt sample is 62 µg/g or 0.006%. According to Clause 4.1.1.6 of the Canadian Standards Association (CSA), A23.1-14, soluble sulphate concentrations less than 1000 µg/g or 0.1% generally indicate a low degree of sulphate attack when concrete is in contact with soil or groundwater.

In Table 8, the chloride content (16 µg/g) is low and the resistivity value (4630 ohm-cm) is relatively high, indicating a non-corrosive environment for buried metal. For non-corrosive environment, it is generally recognised that chloride concentrations should be below 250 µg/g for steel. A resistivity value of less than 2000 ohm-cm is also considered as corrosive for soil in contact with steel. The pH value in Table 8 (8.44) is within the normal range expected for soil pH.



## 16. CLOSURE

This report was prepared by Mr. L. Yimam, PhD. P.Eng., and reviewed by Mr. M. Vasavithasan, M.Sc. Eng., P. Eng. An independent review of the report was conducted by Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact.

Yours very truly

Peto MacCallum Ltd.



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## **APPENDIX E**

List of Ontario Provincial Standard Documents Recommended in the Report



**LIST OF ONTARIO PROVINCIAL STANDARD SPECIFICATIONS (OPSS) AND ONTARIO  
PROVINCIAL STANDARD DRAWINGS (OPSD) RECOMMENDED IN THE REPORT**

DOCUMENT	TITLE
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 518	Construction Specification for Control of Water from Dewatering Operations
OPSS 539	Construction Specification For Temporary Protection Systems
OPSS Prov. 1004	Material Specification for Aggregates
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Depth for Northern Ontario