Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION INVESTIGATION REPORT
for
MEATBIRD CREEK CULVERT REPLACEMENT
HIGHWAY 17
1.2 KM WEST OF HIGHWAY 17/ REGIONAL ROAD 55 INTERCHANGE
AT SUDBURY WESTERLY
GREATER SUDBURY AREA, ONTARIO
SITE NO. 46-571
AGREEMENT NO. 5010-E-0027
G.W.P. 5146-09-00

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FOUNDATION INVESTIGATION REPORT
for
Meatbird Creek Culvert Replacement
Highway 17
1.2 km West of Highway 17/Regional Road 55 Interchange
At Sudbury Westerly
Greater Sudbury Area, Ontario
GWP 5146-09-00

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1. INTRODUCTION

This report summarizes the results of the foundation investigations carried out for the proposed Meatbird Creek culvert replacement on Highway 17, located approximately 1.2 km west of Regional Road 55 in the Township of Waters, as part of the detail design for the Highway 17 resurfacing project, which extends from 0.8 km east of the Highway 17/Regional Road 55 interchange at Sudbury westerly 21.8 km. The investigation was carried out by Peto MacCallum Ltd. (PML) for AECOM Canada Ltd (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The elevations in this report are expressed in meters, unless otherwise noted.

2. SOURCES OF INFORMATION

The following reports, including drawings, were available for the Meatbird Creek Culvert. Reference 1 is the original report for the site and Reference 2 is a subsequent foundation investigation report.

REFERENCE 1:

Soil Design Report, Highway 17, from 12.7 km east of Sec. Hwy 658 easterly (9.8 km), W.P. 62-74-01, District 17, Sudbury, by Material and Testing Office, Ministry of Transportation and Commutations, Northern Region – dated November,1975, GEOCRES 41I-104.

REFERENCE 2:

Foundation Investigation and Stability Analysis, Highway 17 Crossing of Meatbird Creek Valley, W.P. 62-74-01, District 17, Sudbury, by William Trow and Associates Ltd. – dated February 23, 1976, GEOCRES 41I-104.

Borehole Locations and Soil Strata, Drawing No. 1, Highway 17, Proposed Culvert Meatbird Creek, W.P. 62-74-01, District 17, Sudbury, by William Trow and Associates Ltd. – dated April, 1975, GEOCRES 41I-104.

Borehole Locations and Soil Strata, Drawing No. 1A, Highway 17, Proposed Culvert Meatbird Creek, W.P. 62-74-01, District 17, Sudbury, by William Trow and Associates Ltd. – dated October, 1975, GEOCRES 41I-104

In addition to the above GEOCRES reports, the following documents were also reviewed:

Ministry of Northern Development and Mines. 1991. Bedrock Geology of Ontario – Southern Sheet, Map 2544, Scale 1:1,000,000.

Chapman and Putnam. 1984. The Physiography of Southern Ontario, 3rd Edition.

Ontario Geological Survey. 1984. Physiography of Southern Ontario, Map 2715, Scale 1:600,000.

3. SITE DESCRIPTION AND GEOLOGY

The culvert is located within the Regional Municipality of Greater Sudbury within the Geographic Township of Waters. Photographs P1 and P2 (Appendix A) illustrate the site and surface conditions at the time of the investigation.

The Highway 17 corridor within the project limits is generally flanked by open water bodies, marsh areas and rock outcrops. The culvert is located south east of Lively, approximately 0.7 km east of Regional Road 24 and approximately 1.2 km west of Regional Road 55. There are no land use developments at the culvert location.

The project site is located within the Huronian Supergroup of the Canadian Shield. The typical rock types in the project area are argillite, siltstone and greywacke of the McKim Formation. The soil/bedrock interface is encountered at variable depths, but generally close to the surface.

The existing culvert was built within the rockfill embankment which carries the Highway 17 platform with side slopes in the order of 2.5H:1V. The rockfill embankment is up to 12 to 14 m high at the culvert location. At the east of the culvert, the east embankment was cut into a rock outcrop.

Meatbird Creek flows in the north to south direction and the creek water level was at a depth of 0.7 m (Elevation 244.0) at the time of the investigation.

4. INVESTIGATION PROCEDURES

Fourteen (14) boreholes were drilled at / near this site in 1975 and are presented in the Geocres report No.: 41I-104. Based on the previous Geocres report, old contract drawings and satellite photos of the area, this area has been modified since the previous boreholes were drilled with the construction of the existing 12 to 14 m high embankment.

The new fieldwork for the foundation investigation involved a total of 4 boreholes (numbered 101-1 to 101-4) that were carried out during the period from December 1 to 3, 2014. The boreholes were drilled to depths of 1.1 to 13.4 m at the approximate locations shown on Drawings MBC-1 and MBC-2. Boreholes were terminated by refusal on probable bedrock.

Two hand auger probes were also conducted at the north and south ends of the culvert near boreholes 101-1 and 101-4. The auger probes penetrated through silty/sandy soils and met refusal on probable boulder/bedrock at approximate depths of 0.6 to 1.8 m.

The boreholes were advanced using various methods including sonic drilling and manually operated continuous sampling equipment, supplied and operated by specialist drilling contractors working under the full-time supervision of a PML field supervisor. Where site conditions dictated the use of a tripod system, a 70-pound hammer was used and a correction factor was applied to penetration test values obtained.

The following table, Table Section 4, summarizes the subsurface investigation program at the culvert location.

Table Section 4 - Details of Subsurface Investigation Program

Borehole No.	Location	Drilling Method	Depth (m)
101-1	Proposed Culvert Inlet	Tripod Continuous Sampling	4.1
AP-1		Hand Augering	1.8
101-2	Existing Highway 17 Embankment, WBL	Sonic and Casing	13.4
101-3	Existing Highway 17 Embankment, EBL	Sonic and Casing	11.7
101-4	Proposed Culvert Outlet	Tripod Continuous Sampling	1.1
AP-2		Hand Augering	0.6 (Boulder)

Representative samples of the soils were recovered at frequent depth intervals using a conventional split spoon sampler. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. The results of the field tests and observations are reported on the Record of Borehole sheets.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil and the sampler as the samples were retrieved. No groundwater observations could be made in the boreholes completed using the Sonic drilling, where casing was advanced by washboring techniques, as the drilling method continuously introduced outside water into the boreholes.

The boreholes were backfilled with a bentonite/cement mixture where required in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment.

The coordinates including ground surface elevations at the borehole locations were established by exp Geomatics.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. The soil samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determination. The minimum soil recovery required to carry out laboratory tests including moisture content determinations was not obtainable from the SPT tests in the rockfill using tripod drilling. As a result, grain size distribution analyses (2) and moisture content determinations (3) were performed only on selected soil samples with sufficient soil available.

5. SUMMARIZED SUBSURFACE CONDITIONS

5.1 General

Refer to the attached Appendix A, Image 1 and 2 for general and detailed aerial view of the site and two photographs of the site. Refer to the attached Record of Borehole sheets for the details of the subsurface conditions including soil classifications, groundwater observations and inferred

stratigraphy. The laboratory grain size distribution charts are presented in Figures GS-MB-1 and GS-MB-2. The test results are summarized on the attached Record of Borehole sheets.

Borehole locations and the stratigraphic profile and cross-sections prepared from the current borehole data are shown on Drawings MBC-1 and MBC-2. The boundaries between soil strata are transitional and have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

The culvert is located under an approximately 12 to 14 m high rockfill embankment overlying natural ground. In summary, the subsurface stratigraphy revealed in boreholes located at the inlet and outlet of the culvert (boreholes 101-1 and 101-4 respectively) comprised a 100 mm thick topsoil layer underlain by an approximately 4.0 m thick non-cohesive deposit of silty/sandy soils at the inlet and an approximately 1.0 m thick cohesive clayey silt layer at the outlet. Probable bedrock was inferred at a depth of 1.1 m (Elevation 244.3) at the culvert outlet and at a depth of 4.1 m (Elevation 240.6) at the culvert inlet.

The subsurface stratigraphy revealed in the median boreholes 101-2 (Highway 17, westbound lane shoulder) and 101-3 (Highway 17, eastbound lane shoulder) generally consisted of pavement fill underlain by 9.5 and 11.0 m thick rockfill and 2.0 m thick non-cohesive sand layer. Boulders or rock fill up to 2 m in diameter were contacted at depths of 1.5 m and 3.9 m at approximately 1.5 to 2.0 m west of Borehole 101-3 and may exist throughout the rock fill. Probable bedrock was inferred by refusal at depths of 11.7 m (Elevation 241.9) in borehole 101-2 and 13.4 m (Elevation 241.0) in borehole 101-3.

The strata encountered are summarised below:

5.2 Topsoil

A 100 mm thick topsoil layer was encountered surficially in boreholes 101-1 and 101-4 (inlet and outlet of the culvert) and extended to Elevation 244.6 and 245.3, respectively.

5.3 Pavement Structure

Shoulder pavements of 100 mm asphaltic concrete with approximately 500 to 600 mm of sand and gravel courses were encountered surficially in boreholes 101-2 and 101-3 (WBL and EBL shoulders) that extended to depths of 0.7 and 0.6 m (Elevation 253.7 and 253.0), respectively.

5.4 Fill Material

A 1.4 m thick fill unit was encountered below the topsoil at a depth of 0.1 m (Elevation 244.6) in borehole 101-1 (culvert inlet) and extended to a depth of 1.5 m (Elevation 243.2). The fill was composed of silty sand mixed with organic materials. This unit was compact in relative density (SPT-'N' values of 14 and 16).

5.5 Rockfill

A 9.5 and 11.0 m thick rockfill unit was encountered below the pavement structure at depths of 0.7 and 0.6 m (Elevation 253.7 and 253.0) in boreholes 101-2 and 101-3 (WBL and EBL shoulders), respectively and was penetrated at depths of 10.2 and 11.6 m (Elevation 244.2 and 242.0).

Borehole 101-3 had to be relocated due to presence of a 1.0 to 2.0 m thick boulder that was contacted at depths of 1.5 m and 3.9 m at approximately 1.5 to 2.0 m west of borehole 101-3 (drilled on Highway 17, eastbound lane).

5.6 Sand

A 2.0 and 2.6 m thick deposit of non-cohesive sand was contacted below the fill units at depths of 1.5 and 10.2 m (Elevation 243.2 and 244.2) in boreholes 101-1 (culvert inlet) and 101-2 (WBL shoulder) and extended to the probable bedrock/boulder at depths of 4.1 to 12.2 m (Elevation 240.6 and 242.2). SPT-'N' values ranged from 9 to 41 within the sand deposit indicating a variable loose to dense relative density.

The results of grain size distribution analyses of a sand sample is included in Figure GS-MB-1. This deposit was moist to wet.

5.7 Clayey Silt

A 1.0 m thick cohesive clayey silt was encountered below the topsoil at a depth of 0.1 m (Elevation 245.3) in borehole 101-4 (culvert outlet) and extended to probable bedrock at a depth of 1.1 m (Elevation 244.3). The clayey silt was very soft to soft in consistency (SPT-'N' values of 1 and 5).

The results of grain size distribution analyses conducted on a clayey silt sample are included in Figure GS-MB-2. The minimum soil recovery required to carry out the Atterberg Limits test for this sample was not obtained. This moisture content of the clayey silt was about 27%.

5.8 Bedrock

Based on the previous GEOCRES reports (identified in Section 2 under References), satellite photos of the area, geological maps, visual inspections and previous rock samples, the typical rock types in the project area are argillite, siltstone and greywacke of the McKim Formation.

Although the bedrock interface was not verified by coring and the borehole refusal could be on bedrock or boulders, the inferred bedrock interface was encountered at variable depths along the culvert alignment. The probable bedrock/boulder surfaces were inferred by refusal at depths 4.1 and 1.1 (Elevation 240.6 and 244.3) in boreholes 101-1 and 101-4, near the inlet and outlet of the culvert, respectively. Below the highway rockfill, the probable bedrock was inferred by refusal at depths of 13.4 and 11.7 m (Elevation 241.0 and 241.9) in boreholes 101-2 and 101-3, respectively. A 1.2 m thick layer of cobbles and boulders was contacted in borehole 101-2.

5.9 Groundwater

The Meatbird Creek is about 4.5 to 5.0 m wide at the culvert location. The water level in the creek flows from north to south and was at Elevation 244.0 at the time of the current investigation. The water level in the creek governs the water level at the site.

In the process of augering and upon completion of drilling, water was at depths of 0.7 and 0.6 m (Elevation 244.0 and 244.8) in boreholes 101-1 and 101-4, respectively. The groundwater in borehole 101-4 was likely perched water above the local bedrock. No groundwater observations could be made in boreholes 101-2 and 101-3 as drilling water was continuously introduced into the boreholes as a result of the Rotosonic drilling.

The groundwater level of the creek is subject to seasonal fluctuations and rainfall patterns.

6. CLOSURE

Mr. A. Lo and Mr. S. Aziz carried out the field investigations under the supervision of Mr. K. Daly, BEng, Project Supervisor, EIT and Mr. C. M. P. Nascimento, P. Eng., Project Manager. LandCore Drilling Ltd. and Underground Sonic Drilling Services Inc. supplied the drill equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Ms. Marzieh Kamranzadeh, MSc, Project Supervisor, EIT and reviewed by Mr. David Dundas, P.Eng, Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

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Project Supervisor, Geotechnical Services

David Dundas, P.Eng.
Senior Engineer, Geotechnical Services

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MK/DD/CN:mk-mi-jk

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:

RQD (%)	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
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ontario

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Foundation Design

RECORD OF BOREHOLE No 101-1 1 of 1 METRIC

G.W.P. 5146-09-00 LOCATION Coords: 5 143 321.2 N; 294 370.9 E ORIGINATED BY S.A.

DIST Sudbury HWY 17 BOREHOLE TYPE Tripod and Continuous Sampling COMPILED BY M.K.

DATUM Geodetic DATE December 02, 2014 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
244.7	Ground Surface										
244.6	Topsoil										
0.1	Silty sand organics		1	SS	14	▽* ▼*	244				
	Compact Grey/ Wet dark brown (FILL)		2	SS	16				○		
243.2			3	SS	21		243				
1.5	Sand some silt, some gravel, trace clay		4	SS	22						16 66 16 2
	Compact to dense Grey Wet		5	SS	32		242				
			6	SS	36						
240.6			7	SS	41		241				
4.1	End of borehole										
	Refusal on probable boulder										

* 2014 12 02

▽ Water level observed during drilling

▼ Water level measured after drilling

Auger probe was carried out at the culvert end and 1.2 to 1.8m thick silty/sandy soils were encountered and auger probe met refusal on probable boulder at 1.8m depth.

Borehole was drilled using 70lb hammer and 'N' values were adjusted accordingly.

+7, ×5: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ontario

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Foundation Design

RECORD OF BOREHOLE No 101-2 1 of 1 METRIC

G.W.P. 5146-09-00 LOCATION Coords: 5 143 290.1 N; 294 360.9 E ORIGINATED BY A.L.

DIST Sudbury HWY 17 BOREHOLE TYPE Sonic Drilling and Casings COMPILED BY M.K.

DATUM Geodetic DATE December 02, 2014 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.4	Ground Surface										
0.0	100mm asphalt over 60mm base-course over sand and gravel		1	GS		*	254				
253.7	(PAVEMENT FILL)										
0.7	Rockfill						253				
							252				
							251				
							250				
							249				
							248				
							247				
							246				
							245				
244.2											
10.2	Sand trace to some gravel trace silt Loose to compact Brown Wet		2	SS	9		244		○		
							243				
242.2			3	SS	11						
12.2	cobbles and boulders		4	SS	17		242				
241.0							241				
13.4	End of borehole Refusal on probable bedrock										Borehole was drilled using 70lb hammer and 'N' values were adjusted accordingly.

* Borehole charged with drilling water

+7, ×5 : Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No 101-3 1 of 1 METRIC

G.W.P. 5146-09-00 LOCATION Coords: 5 143 232.1 N; 294 356.9 E ORIGINATED BY A.L.

DIST Sudbury HWY 17 BOREHOLE TYPE Sonic Drilling and Casings COMPILED BY M.K.

DATUM Geodetic DATE December 1 and 3, 2014 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
253.6	Ground Surface										
0.0	100mm asphalt over 50mm base-course over sand and gravel										
253.0 0.6	(PAVEMENT FILL) Rockfill						253				
							252				
251.2 2.4	probable boulder						251				
							250				
248.8 4.8	layers of silty/sand soils						249				
							248				
246.3 7.3	layers of dense gravelly soils						247				
							246				
							245				
							244				
241.9 11.7	End of borehole Refusal on probable bedrock Note: 1.0m to 2.0m thick boulder contacted at 1.5m and 3.9m depth in nearby boreholes, first and second trial)(at approximately 1.5 to 2.0m west of BH 101-3. * Borehole charged with drilling water						243				Borehole was drilled using 70lb hammer and 'N' values were adjusted accordingly.
							242				

ON MTO_VER3 NEW LOGO 12KF053.GPJ ON_MOT.GDT 21/08/2015 2:20:10 PM

+7, ×5 : Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No 101-4 1 of 1 METRIC

G.W.P. 5146-09-00 LOCATION Coords: 5 143 214.1 N; 294 344.9 E ORIGINATED BY A.L.

DIST Sudbury HWY 17 BOREHOLE TYPE Tripod and Continuous Sampling COMPILED BY M.K.

DATUM Geodetic DATE December 01, 2014 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
245.4	Ground Surface										
245.3 / 0.1	Topsoil										
	Clayey silt some to with sand, trace gravel		1	SS	1	▽* ▼*	245				
244.3 / 1.1	Very soft Brown Moist to soft		2	SS	5				○		9 20 55 16
	End of borehole										
	Refusal on probable bedrock										

* 2014 12 010

▽ Water level observed during drilling

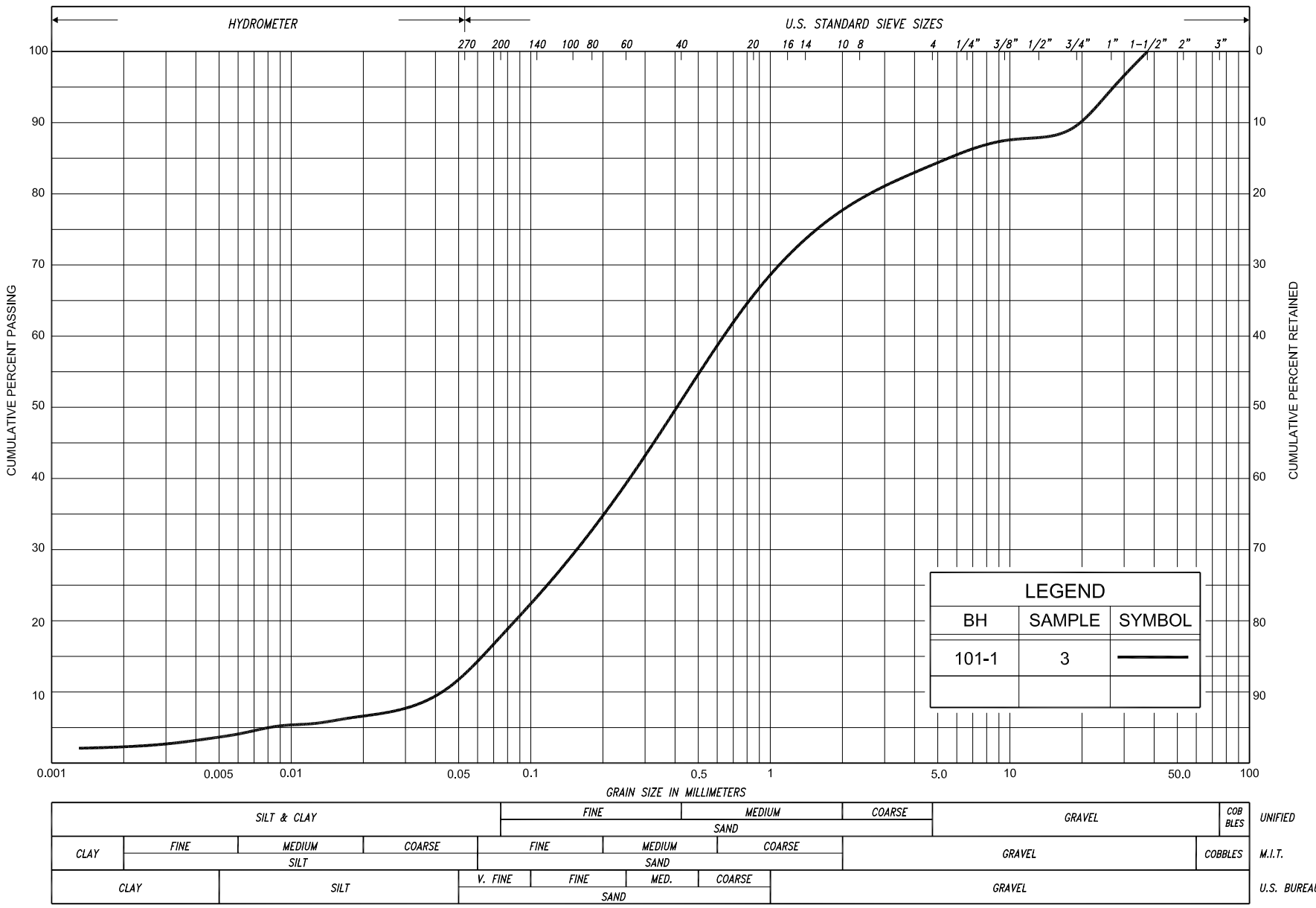
▼ Water level measured after drilling

Auger probe was carried out at the culvert end and 0.6m thick silty/sand soild were encountered auger probe met refusal on probable bedrock at 0.6m depth.

Borehole was drilled using 70lb hammer and 'N' values were adjusted accordingly.

+7, ×5: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

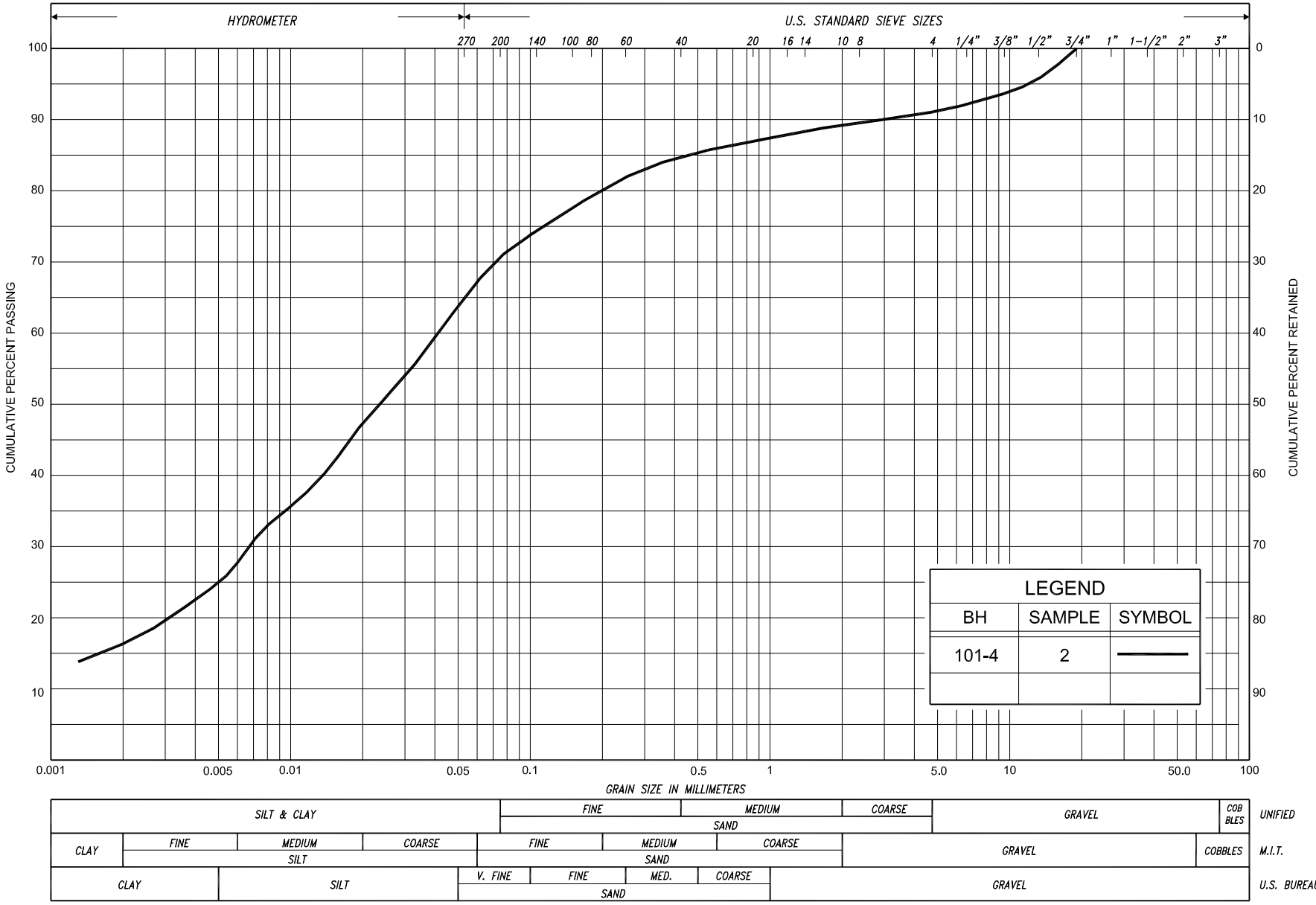


Ontario

GRAIN SIZE DISTRIBUTION

SAND, some silt, some gravel, trace clay

FIG No.	GS-MB-1
HWY:	17
G.W.P. No.	5146-09-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some to with sand, trace gravel

FIG No.	GS-MB-2
HWY:	17
G.W.P. No.	5146-09-00

CONT No
GWP No 5146-09-00
WP No

MEATBIRD CREEK CULVERT
HIGHWAY 17
BOREHOLE LOCATIONS & SOIL STRATA

SHEET

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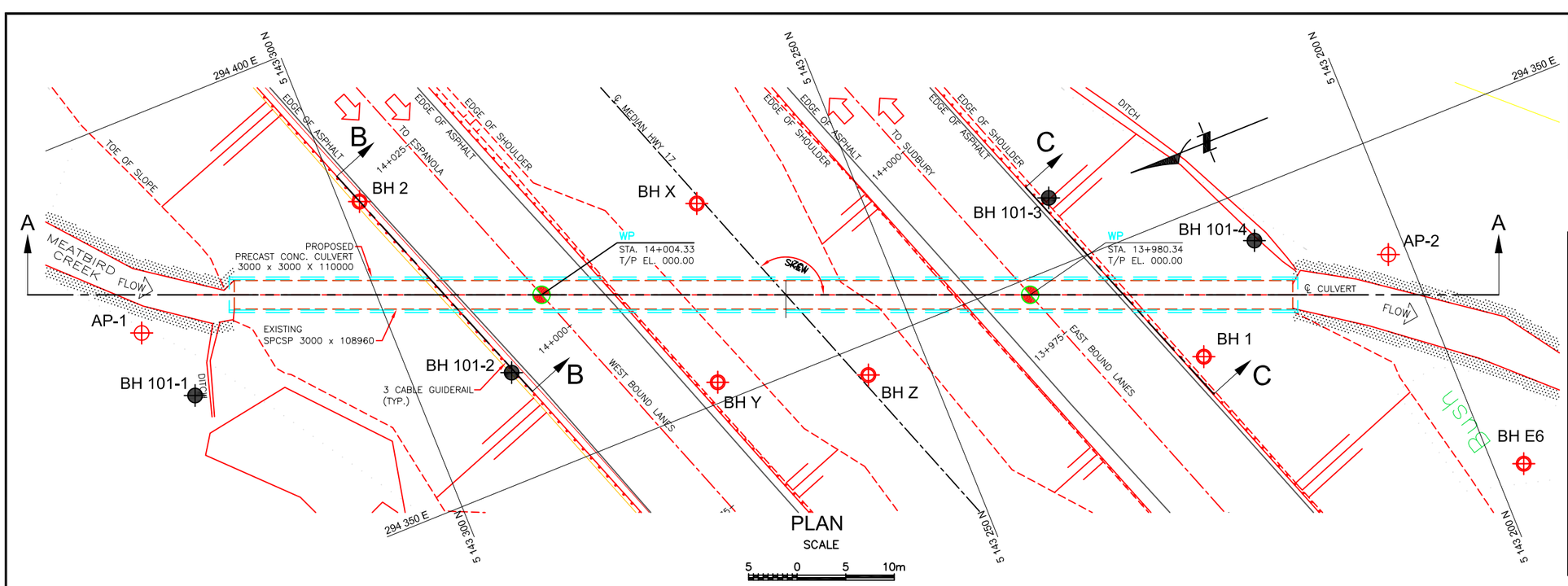
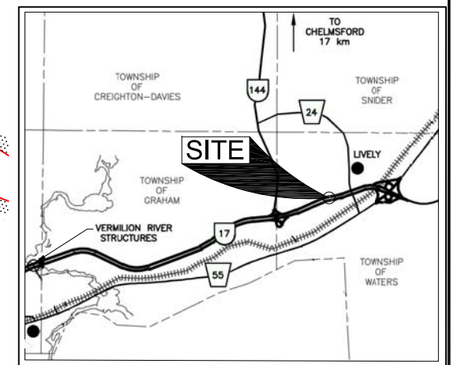
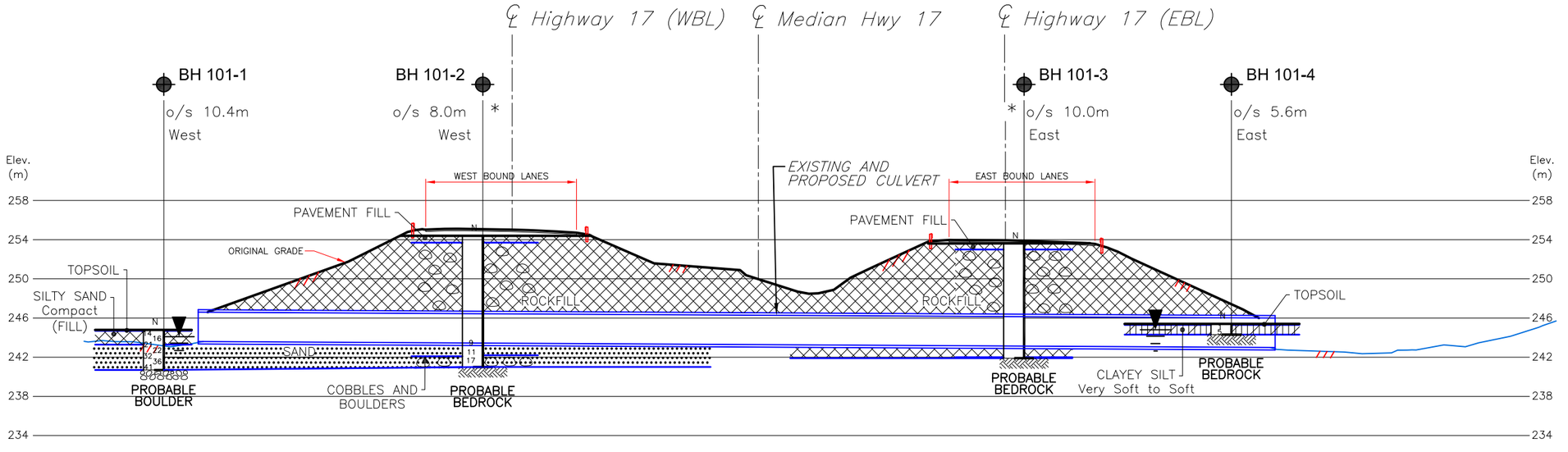
CONSULTING ENGINEERS







PROFILE A - A ALONG MEATBIRD CREEK CULVERT

SCALE
5 0 5 10m

LEGEND

- Borehole
- Borehole and Cone
- Geocres Borehole (41I–104)
- Auger Probe (AP)
- N — Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation (Dec. 2014)
- ∗ Borehole Charged With Drilling Water

BH No	ELEVATION	NORTHINGS	EASTINGS
101–1	244.7	5 143 321.2	294 370.9
101–2	254.4	5 143 290.1	294 360.9
101–3	253.6	5 143 232.1	294 356.9
101–4	245.4	5 143 214.1	294 344.9

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. REFER TO DRAWING MBC–2 FOR SECTIONS B–B AND C–C.
4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

LICENSED PROFESSIONAL ENGINEER — D. H. DUNDAS — Nov 12, 2015 — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — C M P Nascimento — Nov. 12, 15 — PROVINCE OF ONTARIO

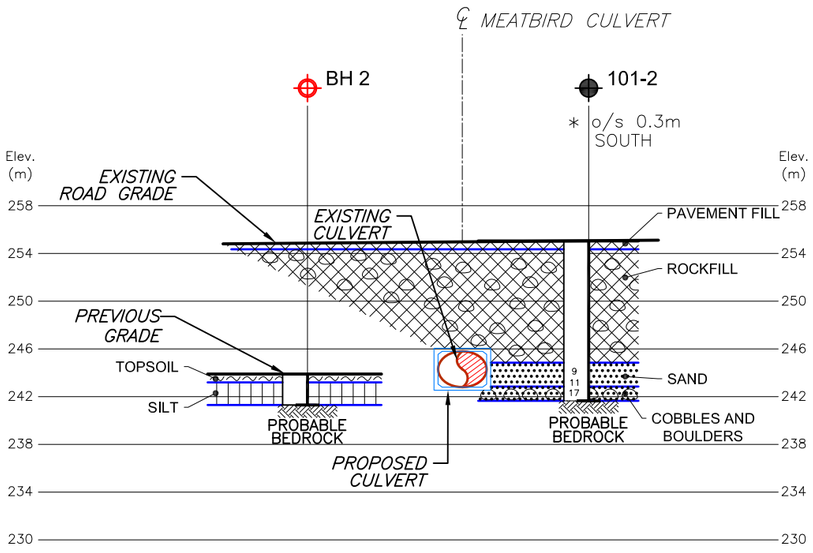
REF AECOM Drawing: 6027641–P1 Geotech.dwg, undated

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

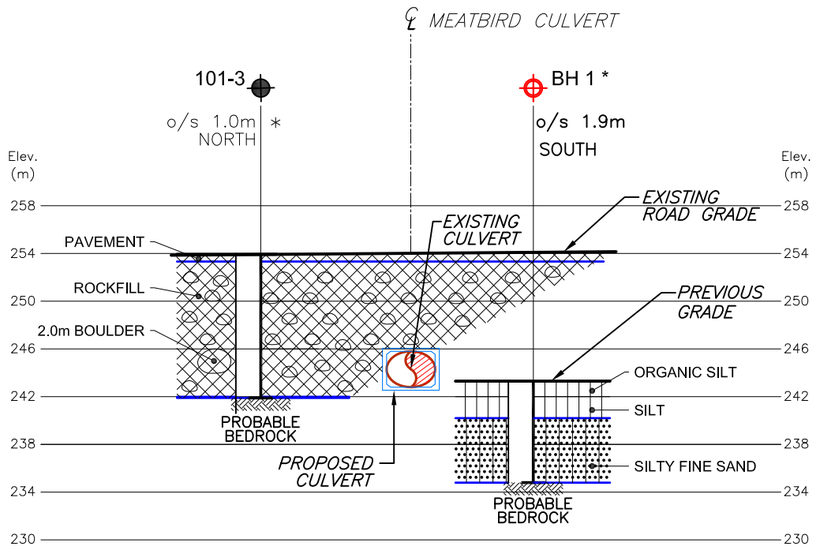
REVISIONS			
DATE	BY	DESCRIPTION	

Geocres No. 41I-340

HWY No	17			DIST	SUDBURY
SUBM'D	NA	CHECKED	MK	DATE	NOV. 12, 2015
DRAWN	NL	CHECKED	DD	APPROVED	CN
SITE	30–334/1			DWG	MBC–1



SECTION B - B



SECTION C - C

SCALE

5 0 5 10m

NOTE: TYPE OF CULVERT SHOWN FOR ILLUSTRATION ONLY

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. REFER TO DRAWING MBC–1 FOR BOREHOLE LOCATIONS AND PROFILE A–A
4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

CONT No GWP No 5146-09-00 WP No	
MEATBIRD CREEK CULVERT HIGHWAY 17 SOIL STRATA	SHEET

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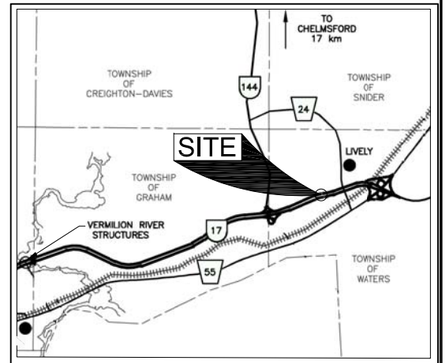

LEGEND

- Borehole
- Borehole and Cone
- Geocres Borehole (41I–104)
- Auger Probe (AP)
- N — Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation (Dec. 2014)
- * — Borehole Charged With Drilling Water

BH No	ELEVATION	NORTHINGS	EASTINGS

REFER TO DWGS MBC-1, FOR DETAILS

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

REVISIONS		
DATE	BY	DESCRIPTION

Geocres No. 41I-340

HWY No	17				DIST SUDBURY
SUBM'D	NA	CHECKED MK	DATE NOV. 12, 2015		SITE 30–334/1
DRAWN	NL	CHECKED DD	APPROVED CN		DWG MBC–2

LICENSED PROFESSIONAL ENGINEER D. H. DUNDAS Nov 12, 2015 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento Nov. 12, 15 PROVINCE OF ONTARIO

REF AECOM Drawing: 6027641–P1 Geotech.dwg, undated

APPENDIX A

Image 1– General Aerial View of the Site

Image 2 – Detailed Aerial View of the Site

Site Photographs

IMAGE 1 – GENERAL AERIAL VIEW OF THE SITE

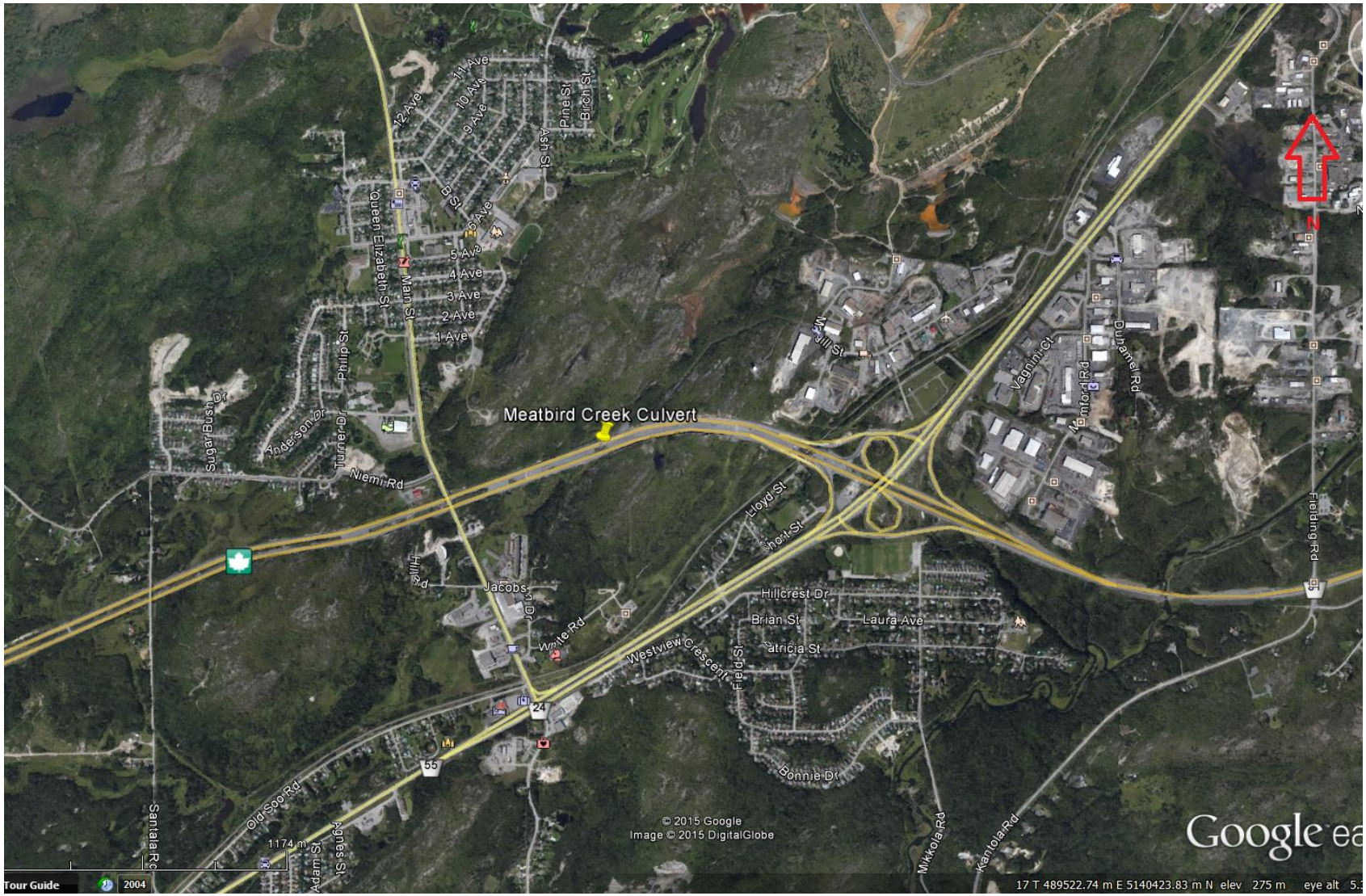

IMAGE 2 – DETAILED AERIAL VIEW OF THE SITE

Photograph P1: Looking north from the existing Highway 17 WBL at the location of the Borehole 101-1 (culvert inlet). Surficial boulders are visible. (December 2, 2014)

Photograph P2: Looking west from the existing Highway 17 median. Borehole 101-2 advanced using the Sonic drilling techniques at this location. (December 1, 2014)