



March 15, 2016

FOUNDATION INVESTIGATION REPORT

HIGHWAY 542 BLUE JAY CREEK CULVERT, SITE 49-63/C
TOWNSHIP OF TEHKUMMAH, MANITOULIN ISLAND, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5465-09-00, WP 5066-07-01

Submitted to:

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REPORT





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**FOUNDATION REPORT
HIGHWAY 542 BLUE JAY CREEK CULVERT SITE 49-63/C**

PART A

**FOUNDATION INVESTIGATION REPORT
HIGHWAY 542 BLUE JAY CREEK CULVERT, SITE 49-63/C
TOWNSHIP OF TEHKUMMAH, MANITOULIN ISLAND, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5090-13-00, WP 5066-07-01**



FOUNDATION REPORT HIGHWAY 542 BLUE JAY CREEK CULVERT SITE 49-63/C

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Highway 542 Blue Jay Creek culvert at Station 11+597 (Site # 49-63/C), in the Township of Tehkummah on Manitoulin Island, Ontario. The Key Plan showing the general location of this section of Highway 542 and the location of the investigated area are shown on Drawing 1. The orientation (i.e., north, south, east, and west) stated in the text of the report is referenced up-chainage along the existing Highway 542 alignment. For purposes of this report, Highway 542 is oriented north-south.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed culvert by borehole drilling, in situ testing and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The Blue Jay Creek culvert is located in the Township of Tehkummah on Highway 542, approximately 1.9 km north of Highway 6. The land use in the area is generally rural with a few residences and commercial buildings in the vicinity of the site.

In general, the topography in the area of the overall project limits is generally flat with gently rolling hills separated by the Blue Jay Creek which meanders along and below Highway 542 in this area. The creek banks are vegetated with grass and small trees. The creek flows from east to west and is approximately 4 m wide at the culvert location.

The existing highway grade at the culvert is at about Elevations 209.2 m. with the Blue Jay Creek located about 2.6 m below the existing highway grade. The existing culvert, which was constructed in 1985, is a 3.9 m span by 2.4 m high by 20 m long (on the skew with beveled ends) Structural Plate Corrugated Steel Pipe Arch (SPCSPA) under approximately 0.14 m of fill. The existing inlet and outlet inverts are at Elevation 206.6 m. A 2010 structural inspection indicated significant deterioration of the culvert barrel with bolt line cracking and breakdown of the structural steel coating. Photographs taken at the site are included following the text of the report.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out on September 20 and 21, 2012, during which time a total of three boreholes (BJW-1 to BJW-3) were advanced at the culvert location. The locations of the boreholes are shown on Drawing 1.

The field investigation was carried out using a track-mounted CME-850 drill rig supplied and operated by Landcore Drilling (Landcore) of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained at intervals of depth of about 0.75 m to 1.5 m, using a 50 mm outer diameter split-spoon sampler, operated by an automatic hammer on the drill rig, in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). Samples of the bedrock were obtained using NW casing and 'NQ' size rock core barrels in Boreholes BJW-1 and BJW-2. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).



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The boreholes were advanced to depths ranging between 0.6 m and 6.0 m below existing ground surface. In Boreholes BJW-1 and BJW-2, a total of 3.0 m and 2.9 m of bedrock was cored, respectively. Borehole BJW-3 was advanced to split-spoon refusal (i.e., hammer bouncing) on the inferred bedrock surface. The pavement borehole advanced near the east end of the culvert in the vicinity of Borehole BJW-3 encountered refusal on inferred bedrock at a similar depth below ground surface and a copy of the pavement log is included in Appendix A. A Dynamic Cone Penetration Test (DCPT) was advanced adjacent to each borehole to refusal at depths ranging from 0.6 m to 2.9 m below the existing ground surface.

The fieldwork was supervised throughout by members of our technical staff who: located the boreholes; arranged for the clearance of underground services; supervised the drilling, sampling operations; logged the boreholes; and examined and cared for the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water contents and grain size distribution) was carried out on selected soil samples. The results of the laboratory testing are included on the Record of Borehole Sheets in Appendix A and in Appendix B.

A sample of the creek water was obtained during the field investigation using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters. The results of the analytical testing are summarized in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to stations on the highway. The MTM NAD 83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and are summarized below.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BJW-1	5058819.2	344664.3	209.3	6.0
BJW-2	5058818.7	344654.3	207.2	3.7
BJW-3	5058827.9	344678.1	207.0	0.6

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Physiography of Southern Ontario (Ministry of Northern Development and Mines)¹, the site is located within clay plains, which are interrupted by drumlin formations of till and/or rock.

¹ Chapman, L.J. and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.



Based on geological mapping in the area (Ministry of Northern Development and Mines)², the bedrock in the area consists typically of sandstone, shale, dolostone and siltstone from the Amabel Formation from the Silurian Period of the Paleozoic Era.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced for this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory testing are provided in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown in profile on Drawing 1.

In general, the subsurface conditions encountered at the site generally consist of embankment fill overlying bedrock at the midpoint of the culvert and a surficial layer of sand or peat underlain by a relatively thin layer of clayey silt to silt overlying bedrock near the ends of the culvert. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Surface Treatment

A 50 mm thick layer of surface treatment was encountered at ground surface (Elevation 209.3 m) in Borehole BJW-1, which was advanced through the existing roadway.

4.2.2 Fill

Underlying the surface treatment in Borehole BJW-1, embankment fill material consisting of brown, moist sand and gravel to gravelly sand, trace to some silt, was encountered. The granular fill is about 2.9 m thick and extends to the bedrock surface. The augers were noted to be grinding likely on cobbles within the fill at depths of 2.4 m and 2.9 m below the existing ground surface.

Standard Penetration Test (SPT) 'N'-values in the granular fill are 14 blows and 25 blows per 0.3 m of penetration. One split-spoon drive at a depth of about 2.4 m, did not penetrate the full sampling depth indicative of the likely presence of cobbles.

A grain size distribution test was carried out on one sample of the gravelly sand fill and the result is shown on Figure B1 in Appendix B.

The natural water content measured on one sample of the gravelly sand fill is 5 per cent.

² Ministry of Northern Development and Mines, 1991. *Bedrock Geology of Ontario*, Southern Sheet, Map 2544.



4.2.3 Peat

A 0.5 m thick deposit of black, wet amorphous peat, some sand and trace gravel was encountered from ground surface (Elevation 207.0 m) in Borehole BJW-3.

The SPT 'N'-value within the peat is 0 blows (i.e., weight of hammer) per 0.3 m penetration, suggesting a very soft consistency.

The natural moisture content measured on one sample of the peat is 94 per cent.

4.2.4 Sand

A 0.6 m thick deposit of grey, wet sand, trace gravel and trace to some organics, was encountered at ground surface (Elevation 207.2 m) in Borehole BJW-2.

The SPT 'N'-value within the sand deposit is 2 blows per 0.3 m penetration, indicating a very loose relative density.

4.2.5 Clayey Silt to Silt

A 0.1 m to 0.2 m thick layer of grey, wet clayey silt to silt, some sand and some gravel, was encountered underlying the sand in Borehole BJW-2 and the peat in Borehole BJW-3 at Elevation 206.6 m and 206.5 m. The bottom of the deposit is defined by bedrock coring in Borehole BJW-2 and refusal to further auger advancement in Borehole BJW-3.

4.2.6 Bedrock/ Refusal

Bedrock was cored in Boreholes BJW-1 and BJW-2. Refusal to further auger penetration was encountered in Borehole BJW-3 with a generally consistent refusal depth in the adjacent pavement borehole. The bedrock surface/refusal depths and elevations are presented below.

Borehole No.	Depth to Bedrock/Refusal Surface (m)	Bedrock/Refusal Surface Elevation (m)	Refusal Type
BJW-1	3.0	206.3	Bedrock Cored (3.0m)
BJW-2	0.8	206.4	Bedrock Cored (2.9 m)
BJW-3	0.6	206.4	Auger Refusal
Pavement Borehole	0.5	N/A	NFP

The retrieved bedrock core is described as a fine to medium grained, slightly weathered, grey to brown, dolomitic limestone, as presented in the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B2 in Appendix B.



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The Total Core Recovery during bedrock coring was 100 per cent. The Rock Quality Designation measured on the core samples ranges from 67 per cent to 98 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

4.2.7 Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized in the table below.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
BJW-1	3.6	205.7
BJW-2	1.7	205.5
BJW-3	Dry	Dry

Groundwater levels encountered in the boreholes shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. The water in the creek at the time of the investigation in September 2012 was at about Elevation 206.7 m, just above the culvert invert. Groundwater levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

5.0 CLOSURE

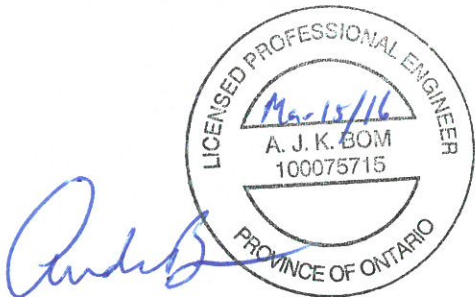
The field personnel supervising the drilling program was Mr. Ed Savard. This report was prepared by Ms. Michelle He and Mr. David Muldowney, P.Eng., and the technical aspects were reviewed by Mr. André Bom, P.Eng. Mr. Fintan Heffernan, P.Eng., Golder's Designated MTO Contact for this project, carried out a quality control review and reviewed the technical aspects of the report.



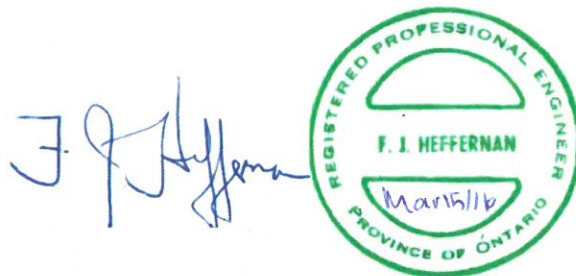
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Report Signature Page

GOLDER ASSOCIATES LTD.



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Senior Geotechnical Engineer, Associate

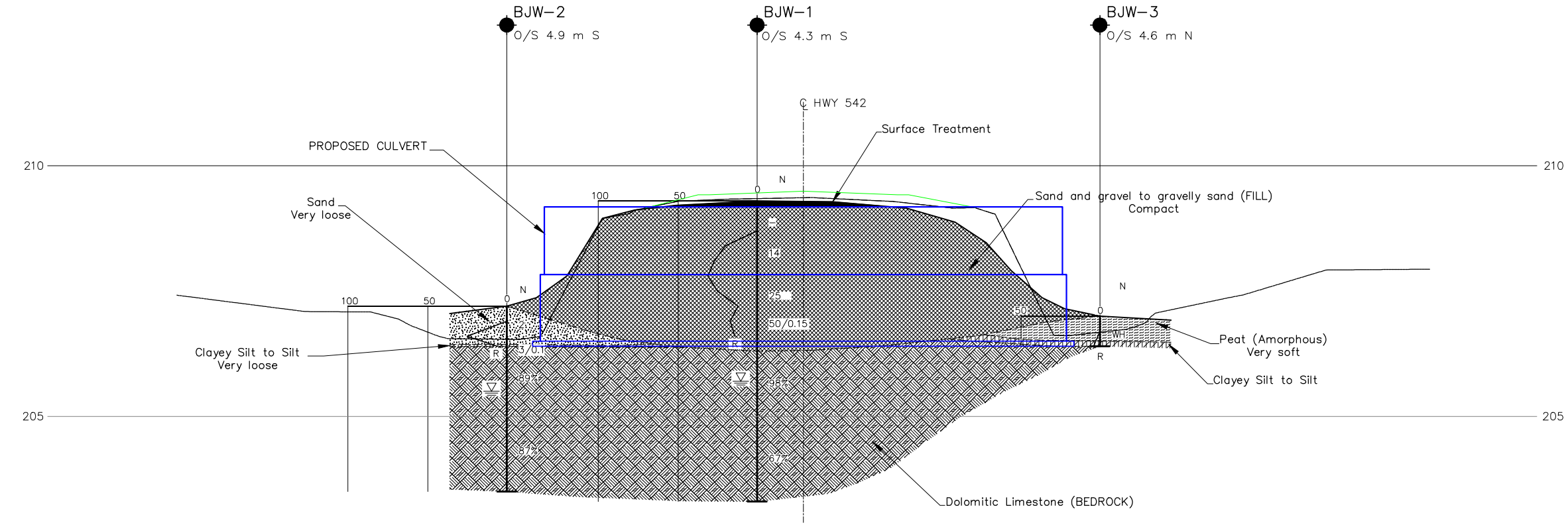
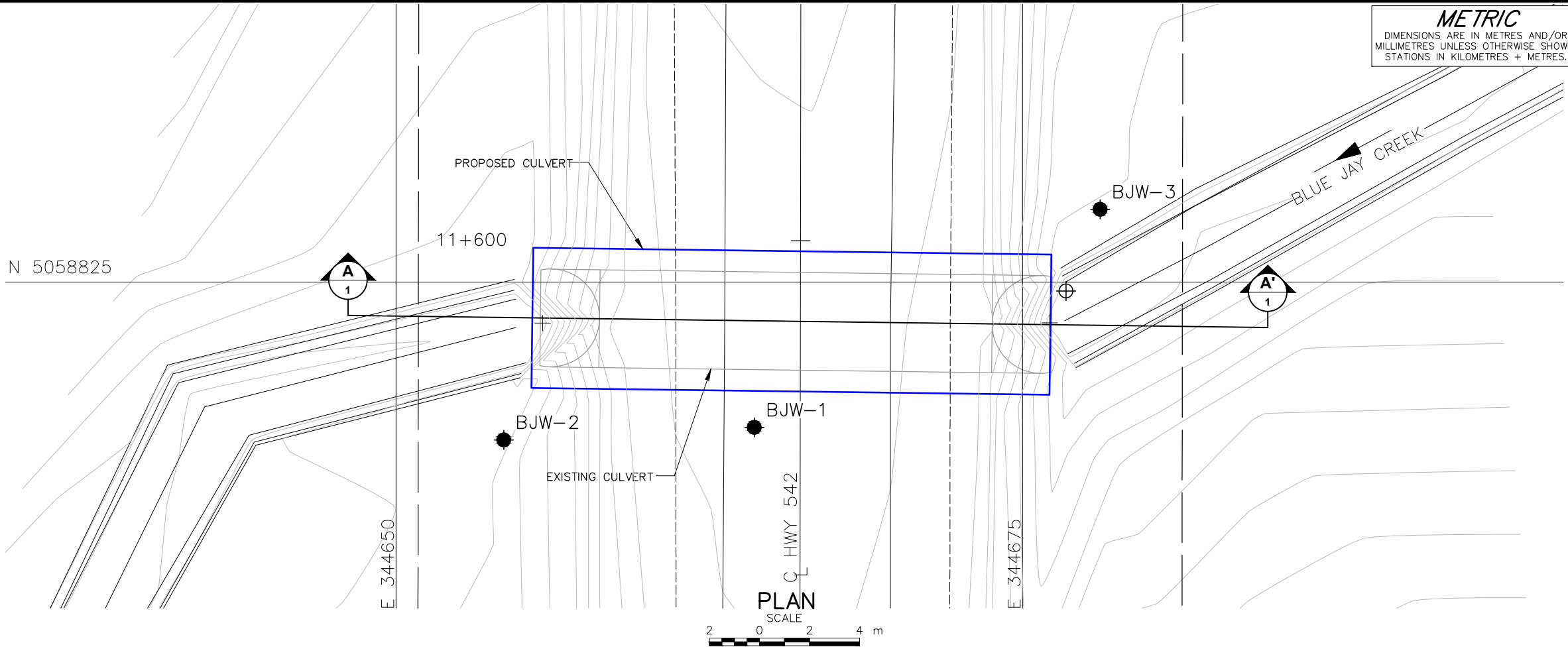


Fintan J. Heffernan, P.Eng.
Designated MTO Contact

DAM/AB/FJH/kp

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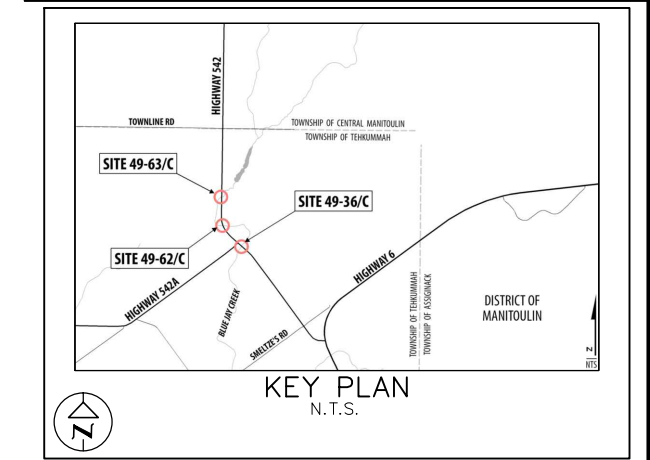


CONT No.
GWP No. 5090-13-00

HIGHWAY 542
BLUE JAY CREEK CULVERT STA. 11+597
BOREHOLE LOCATIONS AND
SOIL STRATA

SHEET

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - Pavement
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- R Refusal
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BJW-1	209.3	5058819.2	344664.3
BJW-2	207.2	5058818.7	344654.3
BJW-3	207.0	5058827.9	344678.1

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by McIntosh Perry, drawing file nos. 11-684-Bluejay (all 3) - XREF.dwg, received OCT 19, 2012. Cross-sections drawing file nos. Blue Jay and Jocko Cross-Sections.dwg, received NOV 22, 2012. Keyplan received August 24, 2012 file nos. KM11684-49-63, 49-62 and 49-36 Location Map - June 26, 2012.jpg. Proposed culvert drawing file nos. OKM-11-684-Blue Jay Creek Site 49-63 Plan and Profile.dwg and KM-11-684 BlueJay Site 62 & 63 Elevation.dwg, received MAR 2, 2016.



NO.	DATE	BY	REVISION
Geocres No. 41H-127			
HWY. 542	PROJECT NO. 12-1191-0014		DIST.
SUBM'D. DAM	CHKD. AB	DATE: MAR 2016	SITE: 49-63/C
DRAWN: JJJ	CHKD.	APPD: FJH	DWG. 1



SITE PHOTOGRAPHS (Site # 49-63)

Photograph 1: Looking northeast at culvert outlet (September 2012)



Photograph 2: Looking northeast from culvert inlet (November 2012)





APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis



The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT 12-1191-0014		RECORD OF BOREHOLE No BJW-1				1 OF 2 METRIC										
G.W.P. 5465-09-00		LOCATION N 5058819.2; E 344664.3				ORIGINATED BY EHS										
DIST _____ HWY 542		BOREHOLE TYPE 108 mm I.D. Continuous Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY MH										
DATUM GEODETIC		DATE September 20, 2012				CHECKED BY DAM										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
209.3	GROUND SURFACE						20	40	60	80	100	20	40	60		
0.0	Surface Treatment (50 mm)		1	AS	-	209										
	Sand and gravel to gravelly sand, trace to some silt (FILL)		2	SS	14	208										
	Compact to very dense Brown Moist		3	SS	25	207										
	Augers grinding on cobbles at 2.4 m and 2.9 m depth.		4	SS	50/0.15	206										
206.3	DOLOMITIC LIMESTONE (BEDROCK)		1	RC	REC 100%	206										
3.0	Bedrock cored from 3.0 m depth to 6.0 m depth.		2	RC	REC 100%	205										
	For coring details see Record of Drillhole BJW-1.		204													
203.3	END OF BOREHOLE															
6.0	Note: 1. Water level at a depth of 3.6 m below ground surface (Elev. 205.7 m) upon completion of drilling. 2. Advanced DCPT 1.5 m south of Borehole BJW-1. Augered to 1.0 m depth prior to start of DCPT. DCPT refusal (hammer bouncing) at 2.9 m depth (Elev. 206.4 m).															

PROJECT: 12-1191-0014

RECORD OF DRILLHOLE: BJW-1

SHEET 2 OF 2

LOCATION: N 5058819.2 ; E 344664.3

DRILLING DATE: September 20, 2012

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	CORING LOG														NOTES WATER LEVELS INSTRUMENTATION																																																																																																																				
							COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)					RMC -Q' AVG.																																																																																																																
								FLUSH	TOTAL CORE %			SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION				k, cm/s																																																																																																																						
									JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate			BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage			PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break	Jr	Ja								Jn																																																																																																															
3	NW September 20, 2012 NQ Coring	~SEE PREVIOUS PAGE~		206.3	3.0	1	GREY 100%																																																																																																																																		

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: DAM

SUD-RCK 1211910014.GPJ GAL-MISS.GDT 19/12/12 DATA INPUT:

PROJECT		RECORD OF BOREHOLE No B JW-2				1 OF 2 METRIC							
12-1191-0014													
G.W.P. 5465-09-00		LOCATION N 5058818.7; E 344654.3				ORIGINATED BY EHS							
DIST _____ HWY 542		BOREHOLE TYPE 108 mm I.D. Continuous Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY MH							
DATUM GEODETIC		DATE September 21, 2012				CHECKED BY DAM							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL	
207.2	GROUND SURFACE												
0.0	SAND, trace gravel, trace to some organics		1	SS	2		207						
206.6	Very loose		2	SS	3/0.1		206						
0.8	Grey Wet		1	RC	REC 100%		205						
	Augers grinding on cobbles at 0.5 m depth.		2	RC	REC 100%		204						
	CLAYEY SILT to SILT, some sand, some gravel												
	Very loose												
	Grey Wet												
	DOLOMITIC LIMESTONE (BEDROCK)												
	Bedrock cored from 0.8 m depth to 3.7 m depth.												
203.5	For coring details see Record of Drillhole B JW-2.												
3.7	END OF BOREHOLE												
	Note:												
	1. Water level at a depth of 1.7 m below ground surface (Elev. 205.5 m) upon completion of drilling.												
	2. Advanced DCPT 1.0 m south of Borehole B JW-2. DCPT refusal (hammer bouncing) at 0.8 m depth (Elev. 206.4 m).												

SHEET 2 OF 2

DATUM: GEODETIC

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: DAM

PROJECT 12-1191-0014		RECORD OF BOREHOLE No BJW-3				1 OF 1 METRIC						
G.W.P. 5465-09-00		LOCATION N 5058827.9; E 344678.1				ORIGINATED BY EHS						
DIST _____ HWY 542		BOREHOLE TYPE 108 mm I.D. Continuous Hollow Stem Augers				COMPILED BY MH						
DATUM GEODETIC		DATE September 21, 2012				CHECKED BY DAM						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa				W _p W W _L
207.0	GROUND SURFACE							20 40 60 80 100				
0.0	PEAT, some sand, trace gravel (Amorphous)		1	SS	WH							
206.5	Very soft											
	Black											
0.6	Wet											
	CLAYEY SILT to SILT, some sand, some gravel											
	Grey											
	Wet											
	END OF BOREHOLE											
	AUGER REFUSAL											
	Notes:											
	1. Borehole dry upon completion of drilling.											
	2. Advanced DCPT 1.0 m north of Borehole BJW-3. DCPT refusal (hammer bouncing) at 0.6 m depth (Elev. 206.4 m).											

Culvert Replacement (Site 49-63C, on Hwy 542; W.P. 5066-07-01)

12-1184-0051

Station 11+575 to 11+625, Referenced to C/L

March, 2013

11+598 10.60 Rt C/L D-2.00 HA

0 - 300 Wat
300 - 500 Gry Si Sa W Gr Occ Cob, Sat, Comp
- 500 NFP BR

11+600 2.00 Rt C/L D-0 PA

0 - 090 PST
090 - 270 Br Cr Gran
270 - 2.90 Br Gr(y) Sa Tr Si Occ Cob Occ Blds,
Moist, Wet @ 2.20, Comp
- 2.90 NFP BR

11+601 4.40 Rt C/L D-0 PA

0 - 180 Br Cr Gran
180 - 1.30 Br F-Co Sa Tr Si Tr Gr Occ Cob Occ
Blds, Moist, Comp
- 1.30 NFP Blds

11+605 4.20 Lt C/L D-0 PA

0 - 200 Br Cr Gran
200 - 590 Br Gr(y) Sa W Si Occ Cob, Moist,
Comp
590 - 1.50 Gry Sa Si Tr Cl Tr Gr, Wet, Comp
1.50 - 2.00 Gry Cl Si Tr Sa Tr Gr, Moist, Firm
2.00 - 2.90 Dk Gry-Blk Cl Si Tr Sa W Org M,
Moist, Firm
- 2.90 NFP BR

11+605 4.10 Rt C/L D-0 PA

0 - 270 Br Cr Gran
270 - 2.00 Br Gr(y) Sa W Si Occ Cob, Moist,
Comp
- 2.00 NFP BR

11+609 4.10 Lt C/L D-0 PA

0 - 180 Br Cr Gran
180 - 1.40 Br Gr(y) Sa Tr Si Occ Cob Occ Blds,
Moist, Comp
1.40 - 1.60 Gry Si Sa W Gr Occ Cob Occ Blds,
Moist, Comp
- 1.60 NFP Blds

11+609 4.30 Rt C/L D-0 PA

0 - 320 Br Cr Gran
320 - 1.20 Br Gr(y) Sa W Si Occ Cob, Moist,
Comp
1.20 - 1.80 Dk Br-Gry Cl Si W Sa Tr Gr Tr Org M,
Wet, Firm
- 1.80 NFP BR

11+625 9.00 Lt C/L D-1.40 HA

0 - 090 Dk Br Si Tps
090 - 1.80 Br Cl Si Tr Sa Tr Gr, Moist, Fr Wat @
700, Sat, Firm
- 1.80 NFP BR



APPENDIX B

Laboratory Test Results



FOUNDATION REPORT HIGHWAY 542 BLUE JAY CREEK CULVERT SITE 49-63/C

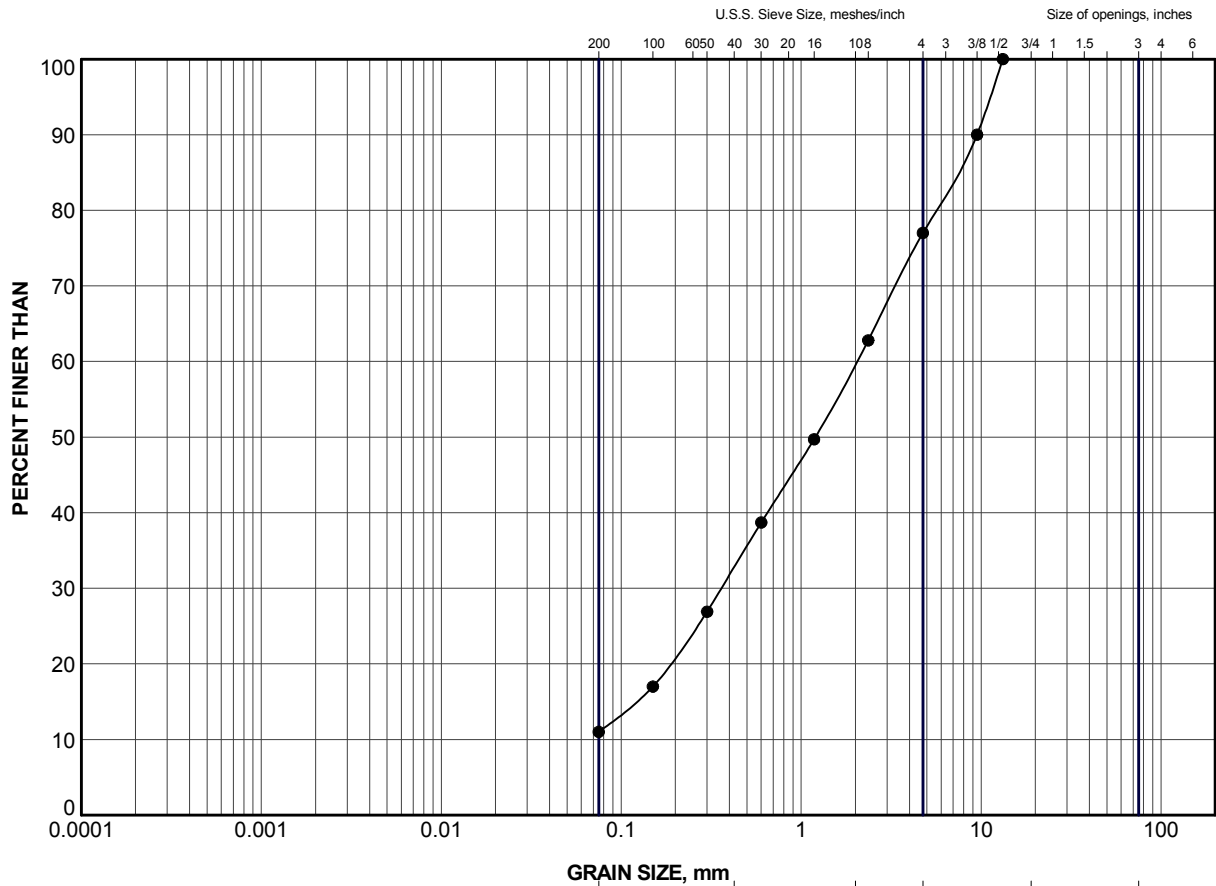
Table B1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Method Detection Limit	Result
Resistivity	ohm-cm	n/a	3300
Conductivity	µmho/cm	1	300
pH	n/a	n/a	8.00
Sulphate	mg/L	1	14
Chloride	mg/L	1	4

Notes:


1. Sample obtained November 5, 2012.
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: DAM
Reviewed by: AB



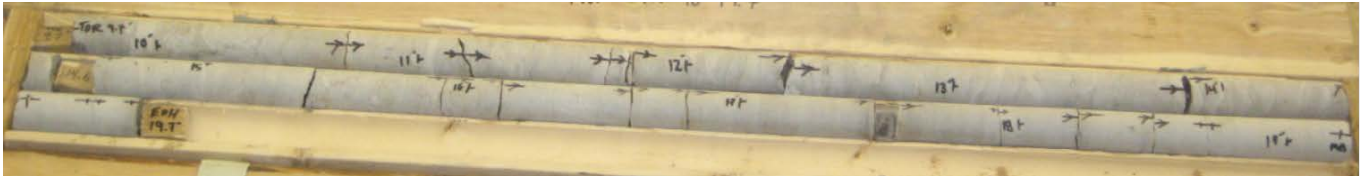
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BJW-1	3	207.5

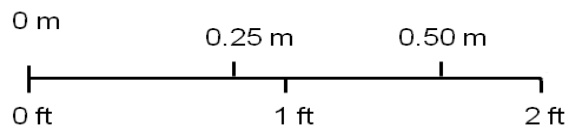
PROJECT					HIGHWAY 542 BLUE JAY CREEK CULVERT				
TITLE					GRAIN SIZE DISTRIBUTION GRAVELLY SAND (FILL)				
PROJECT No.		12-1191-0014		FILE No.		1211910014.GPJ			
DRAWN	JJL	Sep 2013	SCALE	N/A	REV.				
CHECK	AB	Sep 2013							
APPR	FJH	Sep 2013							
 Golder Associates <small>SUDBURY, ONTARIO</small>			FIGURE B1						


SUD-MTO GSD (NEW) GLDR_LDN.GDT

Borehole BJW-1
Elev. 206.3 m to 203.3 m



Borehole BJW-2
Elevation 206.4 m to 203.5 m



PROJECT		<p>HWY 542 Blue Jay Creek Culvert Site # 49-63</p>			
TITLE		<p>BEDROCK CORE</p>			
		PROJECT No. 12-1191-0014		FILE No. ----	
		DESIGN	MH	Feb 2012	SCALE AS SHOWN
		CADD	--		REV.
		CHECK	AB	Feb 2012	
		REVIEW			
<p>FIGURE B2</p>					

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