DRAFT REPORT

**March 17, 2016**

# DRAFT DETAIL FOUNDATION INVESTIGATION REPORT

## KABITOTIKWIA RIVER CULVERT
## SITE NO. 48W-196/C HIGHWAY 811, DISTRICT OF THUNDER BAY
## UNSURVEYED TERRITORY
## MINISTRY OF TRANSPORTATION, ONTARIO
## G.W.P 6302-14-00, W.P. 6302-14-01

**Submitted to:**
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**GEOCRES No.:**

**Report Number: 1411523-D6**

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1 PDF Copy: Ministry of Transportation, Ontario, Downsview, ON (Foundations Section)
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1 Copy: Golder Associates Ltd., Sudbury, ON

Golder Associates

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# PART A

## DETAIL FOUNDATION INVESTIGATION REPORT
## KABITOTIKWIA RIVER CULVERT – SITE NO. 48W-196/C
## HIGHWAY 811, DISTRICT OF THUNDER BAY
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# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Mott MacDonald (HMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Kabitotikwia River culvert (Site No. 48W-196/C). The Kabitotikwia River culvert is located in the District of Thunder Bay on Highway 811 at STA 10+040, approximately 9.8 km west of Highway 527. The key plan showing the general location of this section of Highway 811 and the location of the investigated area are shown on Drawing 1.

# 2.0 SITE DESCRIPTION

The Kabitotikwia River culverts consist of three Structural Plate Corrugated Steel Pipe (SP CSP) structures, the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in this area is relatively flat with moderate to dense tree cover along the highway right-of-way. At the culvert location, the Kabitotikwia River flows in a northerly direction, the highway grade is at Elevation 432.8 m and the existing culvert invert is at Elevations 429.7 m and 429.5 m at the inlet (south) and outlet (north) ends, respectively. The water level measured by others on October 29, 2013, was Elevation 428.8 m at the outlet and the river ice was measured at Elevation 429.8 m by Golder on December 7, 2014, at the inlet. The existing outlet is perched approximately 1 m above the river water level on the north side. Surface conditions in the culvert area in October 2013 and December 2015 are shown on Photographs 1 to 3.

# 3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between December 6 and 8, 2014, during which time four (4) boreholes (Boreholes KB-1 to KB-4) were advanced at approximately the locations shown on Drawing 1. Boreholes KB-1 to KB-4 were advanced using a track or truck-mounted CME-55 drill rigs were supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

The boreholes were advanced using a combination of hollow stem augers, NW casing, wash boring techniques and NQ coring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). 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 upon completion in accordance with Ontario Regulation 903 (Wells) (as amended).

The field work was supervised on a full-time basis by members of Golder's technical staff who, located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined and cared for the soil and bedrock samples. The soil and bedrock samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, Atterberg limits and grain size distributions were carried out on selected soil samples. In addition, unconfined compressive strength tests were carried out on selected

specimens of the bedrock core recovered from the boreholes. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the river 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, including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline and existing culvert and converted into Northing/Easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing, provided by MTO in January 2015 (Drawing E4928928111.dwg). The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole locations are presented on the Record of Borehole sheets in Appendix A and summarized below.

| Borehole Number | MTM NAD83 Northing (m) | MTM NAD83 Easting (m) | Ground Surface Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|
| KB-1 | 5472758.2 | 341068.7 | 430.4 | 3.0 |
| KB-2 | 5472742.2 | 341082.4 | 432.7 | 5.2 |
| KB-3 | 5472745.2 | 341067.1 | 432.8 | 5.3 |
| KB-4 | 5472731.7 | 341080.7 | 432.4 | 5.0 |

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

## 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)[1] mapping, the subsoils in the vicinity of the Kabitotikwia River culvert site generally consist of esker complex deposits comprised of primarily of gravel and sand, bordered closely to the west by a ground moraine deposit comprised mainly of till.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)[2], the site is underlain by bedrocks of the Archean Era, comprised of foliated tonalite suite rocks consisting of foliated to massive tonalite to granodiorite rocks.

## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole and Record of Drillhole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N'-values) as presented on the Record of Borehole sheets and in Section 4 are

[1] Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52HSW.

[2] Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.

uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

## *Subsoil Conditions*

In summary, the subsoil conditions encountered at the site consist of embankment granular fill underlain by thin, non-cohesive deposits of silty sand, silt, gravel and cobbles in places, which are underlain by diorite bedrock. A more detailed description of the soil deposits, bedrock and groundwater conditions encountered in the boreholes is below.

| Deposit/Layer Description | Boreholes | Deposit Thickness (m) | Deposit Elevation (m) | N Values (blows)<br>Consistency or Relative Density | Laboratory Testing |
|---|---|---|---|---|---|
| **(FILL)** [1] Sand to Sandy Gravel, trace to some silt, trace clay, trace organics, trace wood, brown, moist to wet | KB-1 to KB-4 | 0.2 – 3.6 | 432.8 – 430.4 | N = 15 – 40 [1,2]<br>**Compact to Dense** | w = 4% – 25 %<br>2 – MH, 1 – M (Fig. B1)<br>2 – AL NP |
| **Silt**, some sand some gravel, trace clay, trace organics, brown, wet | KB-4 | 0.7 | 430.2 | N = 13<br>**Compact** | - |
| **Gravel and Cobbles** | KB-4 | 0.7 | 429.5 | - | - |
| **Silty Sand (TILL)**, trace gravel, grey, wet | KB-3 | 0.1 | 429.2 | - | - |

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = Natural Moisture Content (%)
MH = Combined Sieve and Hydrometer analysis
M = Sieve analysis for particle size
AL = Atterberg limits test
NP = Non-Plastic test results

Note:

[1] Within the fill in Borehole KB-3, a 230 mm cobble was encountered at a depth of 0.5 m below ground surface, requiring NW casing and NQ coring techniques to advance the borehole through that portion of the deposit. In Borehole KB-4, the augers were noted to be grinding from ground surface to a depth of 1.5 m below ground surface.

[2] Within the fill in Boreholes KB-2 and KB-3, two 'N'-values of 100 blows for 0.15 m of penetration were recorded, inferred indicative of the presence of cobbles within the fill deposit.

## Bedrock

Bedrock was cored in Boreholes KB-1 to KB-4 and the depth to the bedrock surface and bedrock surface elevations are presented below.

| Borehole No. | Depth to Bedrock (below ground surface) (m) | Bedrock Surface Elevation (m) | Core Thickness (m) |
|---|---|---|---|
| KB-1 | 0.2 | 430.2 | 2.8 |
| KB-2 | 3.6 | 429.1 | 1.6 |
| KB-3 | 3.7 | 429.1 | 1.6 |
| KB-4 | 3.6 | 428.8 | 1.4 |

The retrieved bedrock core is described as black and white, medium to coarse grained, fresh, diorite, as presented on the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B2. A more detailed description of the bedrock properties encountered in the boreholes is provided in the following table.

| Borehole No. | Total Core Recovery | Rock Quality Designation | Quality Classification Table 3.10 of CFEM 2006[3] | Uniaxial Compressive Strength (MPa) | Strength Classification Table 3.5 of CFEM 2006[3] |
|---|---|---|---|---|---|
| KB-1 | 100% | 93% - 100% | Excellent | 235 | (R5) Very Strong |
| KB-2 | 100% | 85% - 87% | Good | - | - |
| KB-3 | 100% | 75% - 100% | Good to Excellent | 176 | (R5) Very Strong |
| KB-4 | 100% | 100% | Excellent | - | - |

## Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river ice level was measured at Elevation 429.8 m on December 7, 2014. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

3 Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

| Borehole No. | Depth to Groundwater Level (m) | Groundwater Elevation (m) |
|---|---|---|
| KB-1 | 1.6 | 428.8 |
| KB-2 | Dry to 1.4 m[1] | 431.3 |
| KB-3 | Dry to 1.6 m[1] | 431.2 |
| KB-4 | Dry to 0.6 m[1] | 431.8 |

Note:

[1] Boreholes KB-2 to KB-4 caved at depths ranging from 0.6 m to 1.6 m (inferred depths to water level) upon completion of drilling and boreholes were noted to be dry to the caved depth.

## 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Cody Walter and Mr. Mathew Riopelle, under the overall direction of Mr. David Muldowney, P.Eng. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Ms. Sarah E. M. Poot, P.Eng., an Associate of Golder, provided a technical review of the report. Mr. Jorge M.A. Costa P.Eng., the Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review of this report.

# Report Signature Page

**GOLDER ASSOCIATES LTD.**

Adam Core, P.Eng.
Geotechnical Engineer

Sarah E.M. Poot, P.Eng.
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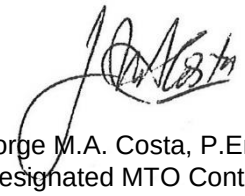

Jorge M.A. Costa, P.Eng
Designated MTO Contact, Principal

AC/SEMP/JMAC/kp



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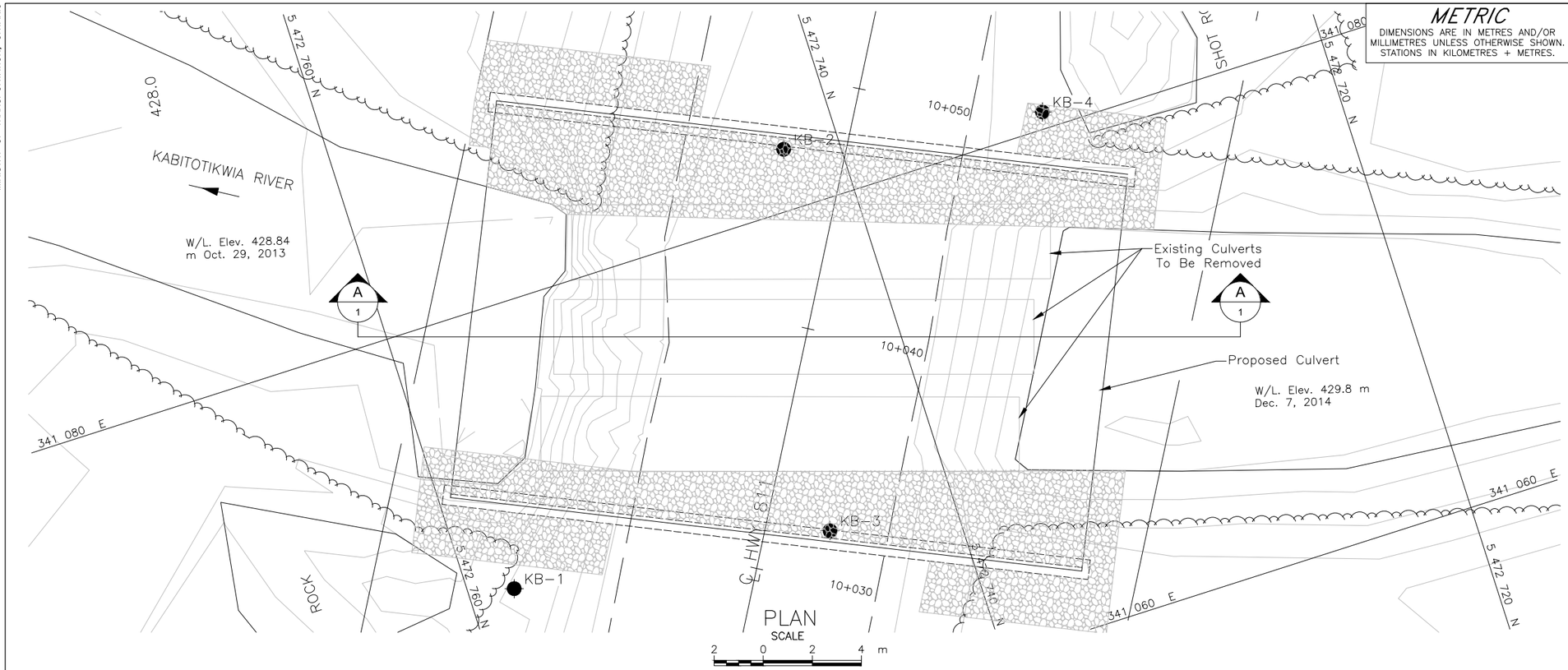
**Table 1: Summary Details of Existing Culvert**

| Culvert Location | Site # | Approximate Height of Embankment [1] | Existing Culvert | | | Approximate Existing Invert Elevation[2] | |
|---|---|---|---|---|---|---|---|
| | | | Type | Approximate Dimension[2] | Approximate Length | North End of Culvert (Outlet) | South End of Culvert (Inlet) |
| Hwy 811 STA 10+040 | 48W-196/C | 3.2 m | 3 – SP CSPs | 3 – 3.05 m x 2.13 m | 20 m | 429.5 m | 429.7 m |

Notes: 1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the culvert.
2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (Drawing E4928298111.dwg).

Prepared by: AC
Checked by: SEMP
Reviewed by: JMAC

MINISTRY OF TRANSPORTATION, ONTARIO



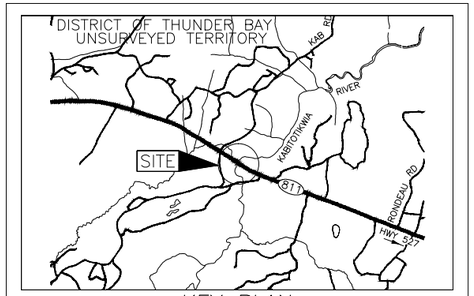

*METRIC*
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 6302-14-01

HIGHWAY 811
KABITOTIKWIA RIVER CULVERTS STA 10+040
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates




## LEGEND

| | |
|---|---|
| ● | Borehole |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow) |
| 100% | Rock Quality Designation (RQD) |
| REC | Recovery |
| ▽ | WL upon completion of drilling |

BOREHOLE CO-ORDINATES

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| KB-1 | 430.4 | 5472758.2 | 341068.7 |
| KB-2 | 432.7 | 5472742.2 | 341082.4 |
| KB-3 | 432.8 | 5472745.2 | 341067.1 |
| KB-4 | 432.4 | 5472731.7 | 341080.7 |

## NOTES

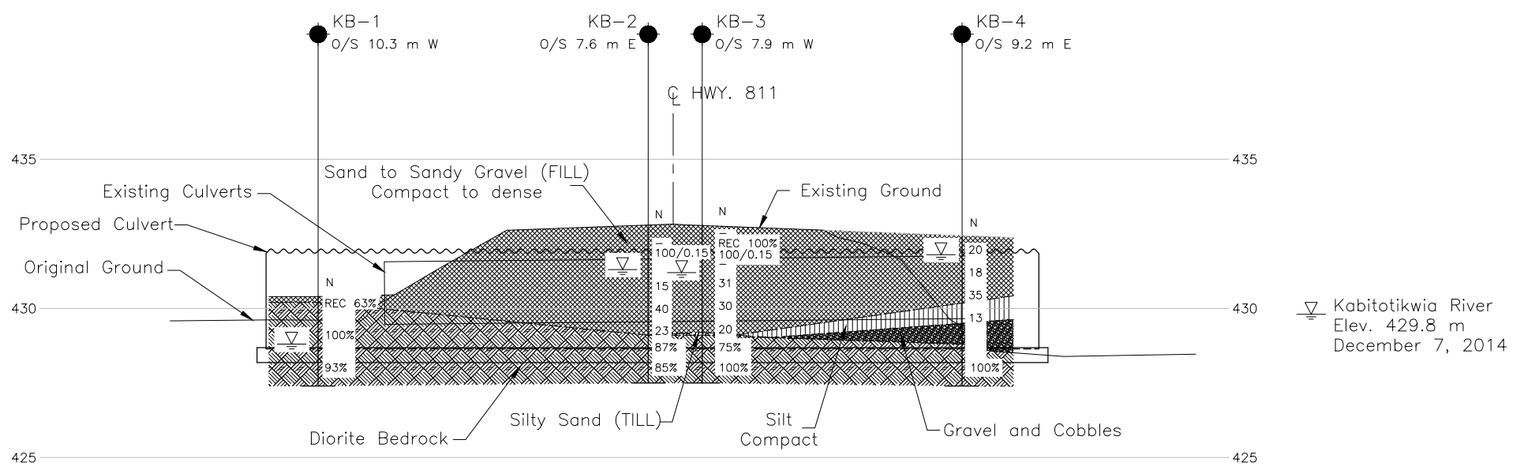
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 MTO, drawing file no. E4928928111, dated DEC 2013, received JAN 27, 2015. Culvert GA drawing no. ST-343033-KABITOTIKWIA RIVER CULVERTS-01-GA.dwg, received DEC 15, 2015.




▽ Kabitotikwia River
Elev. 429.8 m
December 7, 2014

A-A'
1
PROFILE
HORIZONTAL SCALE
2 0 2 4 m
2 0 2 4 m
VERTICAL SCALE

DRAFT

| NO. | DATE | BY | REVISION |
|---|---|---|---|
| . | . | . | . |

Geocres No. .

| | | | |
|---|---|---|---|
| HWY. 811 | PROJECT NO. 1411523 | | DIST. . |
| SUBM'D. AC | CHKD. . | DATE: 3/15/2016 | SITE:48W-196/C |
| DRAWN: TB | CHKD. SEMP | APPD. JMAC | DWG. 1 |

PLOT DATE: March 15, 2016
FILENAME: R:\Projects\2014\1411523 hmm 26 culverts thunder bay\Ohk_3D\1411523_KabitotikwiaRiver (KB).dwg

**Photograph 1: Kabitotikwia River Culverts**
**South Inlet (Taken from MTO, OSIM 16-Oct-13)**

**Photograph 2: Kabitotikwia River Culverts**
**North Outlet (Taken from MTO, OSIM 16-Oct-13)**

**Photograph 3: Kabitotikwia River Culverts**
**South Inlet (Golder – December 7, 2014)**

# APPENDIX A

## Record of Boreholes

# LIST OF SYMBOLS

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

## I. GENERAL

| | |
|---|---|
| $\pi$ | 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

| | |
|---|---|
| $\gamma$ | shear strain |
| $\Delta$ | change in, e.g. in stress: $\Delta\sigma$ |
| $\varepsilon$ | linear strain |
| $\varepsilon_v$ | volumetric strain |
| $\eta$ | coefficient of viscosity |
| $\upsilon$ | Poisson's ratio |
| $\sigma$ | total stress |
| $\sigma'$ | effective stress ($\sigma' = \sigma - u$) |
| $\sigma'_{vo}$ | initial effective overburden stress |
| $\sigma_1, \sigma_2, \sigma_3$ | principal stress (major, intermediate, minor) |
| $\sigma_{oct}$ | mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$ |
| $\tau$ | 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 |
| $\gamma'$ | 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 |

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

### (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 |
| $C_\alpha$ | 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 |
| $\sigma'_p$ | pre-consolidation stress |
| OCR | over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$ |

### (d) Shear Strength

| | |
|---|---|
| $\tau_p, \tau_r$ | peak and residual shear strength |
| $\phi'$ | effective angle of internal friction |
| $\delta$ | angle of interface friction |
| $\mu$ | 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 |

**Notes:** 1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (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, 60º 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 $cm^2$ 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 / Relative Density | N 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 | $c_u$, $s_u$ 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) |
| $\gamma$ | 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 $90^{o}$ 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
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

Golder Associates

# RECORD OF BOREHOLE No KB-1

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6302-14-00 | LOCATION N 5472758.2; E 341068.7 | ORIGINATED BY CW

DIST _____ HWY 811 | BOREHOLE TYPE NQ Coring | COMPILED BY AC

DATUM GEODETIC | DATE December 7, 2014 | CHECKED BY SEMP

| 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, × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 430.4 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | Sandy gravel, some silt (FILL) | | 1 | RC | REC 63% | | | | | | |
| 0.2 | Brown<br>Wet<br>DIORITE BEDROCK<br><br>Bedrock cored from 0.2 m to 3.0 m depth.<br><br>For coring details see Record of Drillhole KB-1. | | 1 | RC | REC 100% | ▽ | 430 | | | | RQD = 100% |
| | | | | | | | 429 | | | | |
| | | | 2 | RC | REC 100% | | | | | | RQD = 93% |
| | | | | | | | 428 | | | | |
| 427.4 | | | | | | | | | | | |
| 3.0 | END OF BOREHOLE<br><br>Note:<br><br>1. Water level at a depth of 1.6 m below ground surface (Elev. 428.8 m) upon completion of drilling. | | | | | | | | | | |

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1411523

# RECORD OF DRILLHOLE: KB-1

SHEET 1 OF 1

LOCATION: N 5472758.2 ;E 341068.7

DRILLING DATE: December 7, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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; BR - Broken Rock

**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DEPTH (m) | RUN No. | COLOUR, % RETURN / FLUSH | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX METRES | DISCONTINUITY DATA: B Angle | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | DISCONTINUITY DATA: Jr | DISCONTINUITY DATA: Ja | DISCONTINUITY DATA: Jn | HYDRAULIC CONDUCTIVITY k, cm/s | Diametral Point Load Index (MPa) | RMC -Q' AVG. | NOTES WATER LEVELS INSTRUMENTATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Refer to Previous Page | | 430.2 | | | | | | | | | | | | | | | | |
| 1 | CME 55-Track NQ Coring | DIORITE<br>Medium to coarse grained<br>Fresh<br>Black-white<br>Very strong | | 0.2 | 1 | GREY 100 | | | | | | | | | | | | | | UCS=235 MPa |
| 2 | | | | | 2 | GREY 10 | | | | | | | JNIRRo<br>JNIRRo<br>JNIRRo<br>JNIRRo | | | | | | | |
| 3 | | END OF DRILLHOLE | | 427.4<br>3.0 | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50

LOGGED: CW

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 20/05/15 DATA INPUT:

Golder Associates

# RECORD OF BOREHOLE No KB-2

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6302-14-00 | LOCATION N 5472742.2; E 341082.4 | ORIGINATED BY MR

DIST | HWY 811 | BOREHOLE TYPE NW Casing, NQ Coring and Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE December 7 and 8, 2014 | CHECKED BY SEMP

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "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 × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 432.7 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | Sand to gravelly sand, some silt, trace clay, trace organics (wood) (FILL)<br>Compact to dense<br>Grey<br>Wet | | 1 | WS | - | | 432 | | | | |
| | | | 2 | SS | 100/0.15 | ▽ | | | | | |
| | | | 3 | SS | 15 | | 431 | | ○ | | |
| | | | 4 | SS | 40 | | 430 | | ○ | NP | 0 82 15 3 |
| 429.1 | | | 5 | SS | 23 | | | | | | |
| 3.6 | DIORITE BEDROCK<br><br>Bedrock cored from 3.6 m to 5.2 m depth.<br><br>For coring details see Record of Drillhole KB-2. | | 1 | RC | REC 100% | | 429 | | | | RQD = 87% |
| 427.5 | | | 2 | RC | REC 100% | | 428 | | | | RQD = 85% |
| 5.2 | END OF BOREHOLE<br><br>Note:<br><br>1. Borehole caved at 1.4 m depth upon completion. Borehole dry to 1.4 m depth upon completion of drilling (Inferred depth to water level Elevation 431.3 m) | | | | | | | | | | |

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

PROJECT: 1411523

# RECORD OF DRILLHOLE: KB-2

SHEET 1 OF 1

LOCATION: N 5472742.2 ;E 341082.4

DRILLING DATE: December 7 and 8, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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; BR - Broken Rock

**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DEPTH (m) | RUN No. | COLOUR / % RETURN / FLUSH | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX METRES | DISCONTINUITY DATA: B Angle | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | Jr | Ja | Jn | HYDRAULIC CONDUCTIVITY k, cm/s | Diametral Point Load Index (MPa) | RMC -Q' AVG. | NOTES WATER LEVELS INSTRUMENTATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Refer to Previous Page | | 429.1 | | | | | | | | | | | | | | | | |
| 4 | CME 55-Track NW / NQ Coring | DIORITE<br>Medium to coarse grained<br>Fresh<br>Black-white | | 3.6 | 1 | GREY 100 | | | | | | | JNIRRo | | | | | | | |
| 5 | | | | | 2 | GREY 100 | | | | | | | JNIRRo<br>JNIRRo<br>JNIRRo<br>JNIRRo | | | | | | | |
| | | END OF DRILLHOLE | | 427.5<br>5.2 | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
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| 11 | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50

LOGGED: MR

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 20/05/15 DATA INPUT:

Golder Associates

# RECORD OF BOREHOLE No KB-3

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6302-14-00 | LOCATION N 5472745.2; E 341067.1 | ORIGINATED BY MR

DIST | HWY 811 | BOREHOLE TYPE NW Casing, NQ Coring and Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE December 7, 2014 | CHECKED BY SEMP

| 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 × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 432.8 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | Sand to sandy gravel, trace to some silt (FILL)<br>Compact to dense<br>Brown to grey<br>Wet<br><br>A 230 mm diameter cobble was encountered at 0.5 m depth. | | 1 | WS | - | | 432 | | | | 0 94 (6) |
| | | | - | RC | REC 100% | | | | | | |
| | | | 2 | SS | 100/0.16 | | | | | | |
| | | | 3 | WS | - | ▽ | | | | | |
| | | | 4 | SS | 31 | | 431 | | | | |
| | | | 5 | SS | 30 | | 430 | | | | |
| 429.2 | | | 6 | SS | 20 | | | | | | |
| 3.7 | Silty SAND, trace gravel (TILL)<br>Grey<br>Wet | | 1 | RC | REC 100% | | 429 | | | | RQD = 75% |
| | DIORITE BEDROCK<br><br>Bedrock cored from 3.7 m to 5.3 m depth.<br><br>For coring details see Record of Drillhole KB-3. | | 2 | RC | REC 100% | | 428 | | | | RQD = 100% |
| 427.5<br>5.3 | END OF BOREHOLE<br><br>Note:<br><br>1. Borehole caved at 1.6 m depth upon completion. Borehole dry to 1.6 m depth upon completion of drilling (Inferred depth to water level Elevation 431.2 m). | | | | | | | | | | |

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 07/05/15 DATA INPUT:

PROJECT: 1411523

# RECORD OF DRILLHOLE: KB-3

SHEET 1 OF 1

LOCATION: N 5472745.2 ;E 341067.1

DRILLING DATE: December 7, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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; BR - Broken Rock

**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DEPTH (m) | RUN No. | COLOUR / % RETURN / FLUSH | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX METRES | DISCONTINUITY DATA: B Angle | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | Jr | Ja | Jn | HYDRAULIC CONDUCTIVITY k, cm/s | Diametral Point Load Index (MPa) | RMC -Q' AVG. | NOTES WATER LEVELS INSTRUMENTATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Refer to Previous Page | | 429.1 | | | | | | | | | | | | | | | | |
| 4 | CME 55-Track NW | DIORITE<br>Medium to coarse grained<br>Fresh<br>Black-white<br>Very strong | | 3.7 | 1 | GREY 100 | | | | | | | | | | | | | | |
| 5 | NQ Coring | | | | 2 | GREY 100 | | | | | | | | | | | | | | UCS=176 MPa |
| | | | | 427.5 | | | | | | | | | | | | | | | | |
| | | END OF DRILLHOLE | | 5.3 | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | |
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| 13 | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 20/05/15 DATA INPUT:

Golder Associates

# RECORD OF BOREHOLE No KB-4

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6302-14-00 | LOCATION N 5472731.7; E 341080.7 | ORIGINATED BY CW

DIST _____ HWY 811 | BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers, NW Casing, NQ Coring and Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE December 6 and 7, 2014 | CHECKED BY SEMP

| 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 × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) 20 40 60 | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 432.4 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | Sand, some gravel, some silt, trace clay (FILL)<br>Compact to dense<br>Brown<br>Moist<br><br>Augers grinding from ground surface to 1.5 m depth. | | 1 | SS | 20 | ▽ | 432 | | ○ | NP | 18 64 15 3 |
| | | | 2 | SS | 18 | | | | ○ | | |
| | | | 3 | SS | 35 | | 431 | | | | |
| 430.2 | | | | | | | | | | | |
| 2.2 | SILT, some sand, some gravel, trace organics, trace clay<br>Compact<br>Brown | | 4 | SS | 13 | | 430 | | ○ | | |
| 429.5 | | | | | | | | | | | |
| 2.9 | Wet<br>GRAVEL and COBBLES | | - | RC | | | 429 | | | | |
| 428.8 | | | | | | | | | | | |
| 3.6 | DIORITE BEDROCK<br><br>Bedrock cored from 3.6 m to 5.0 m depth.<br><br>For coring details see Record of Drillhole KB-4. | | 1 | RC | REC 100% | | 428 | | | | RQD = 100% |
| 427.4 | | | | | | | | | | | |
| 5.0 | END OF BOREHOLE<br><br>Note:<br><br>1. Borehole caved at 0.6 m depth upon completion. Borehole dry to 0.6 m depth upon completion of drilling (Inferred depth to water level Elevation 431.8 m). | | | | | | | | | | |

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 07/05/15 DATA INPUT:

PROJECT: 1411523

# RECORD OF DRILLHOLE: KB-4

SHEET 1 OF 1

LOCATION: N 5472731.7 ;E 341080.7

DRILLING DATE: December 6 and 7, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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; BR - Broken Rock

**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DEPTH (m) | RUN No. | COLOUR & % RETURN / FLUSH | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX METRES | DISCONTINUITY DATA: B Angle | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | Jr | Ja | Jn | HYDRAULIC CONDUCTIVITY k, cm/s | Diametral Point Load Index (MPa) | RMC -Q' AVG. | NOTES WATER LEVELS INSTRUMENTATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | GROUND SURFACE | | 428.8 | | | | | | | | | | | | | | | | |
| 4 | CME 55-Track NQ Coring | DIORITE<br>Medium to coarse grained<br>Fresh<br>Black-white | | 3.6 | 1 | GREY 100 | | | | | | | | | | | | | | |
| 5 | | END OF DRILLHOLE | | 427.4<br>5.0 | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
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| 13 | | | | | | | | | | | | | | | | | | | | |

SUD-RCK 1411523.GPJ GAL-MISS.GDT 20/05/15 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CW

CHECKED: SEMP

# APPENDIX B

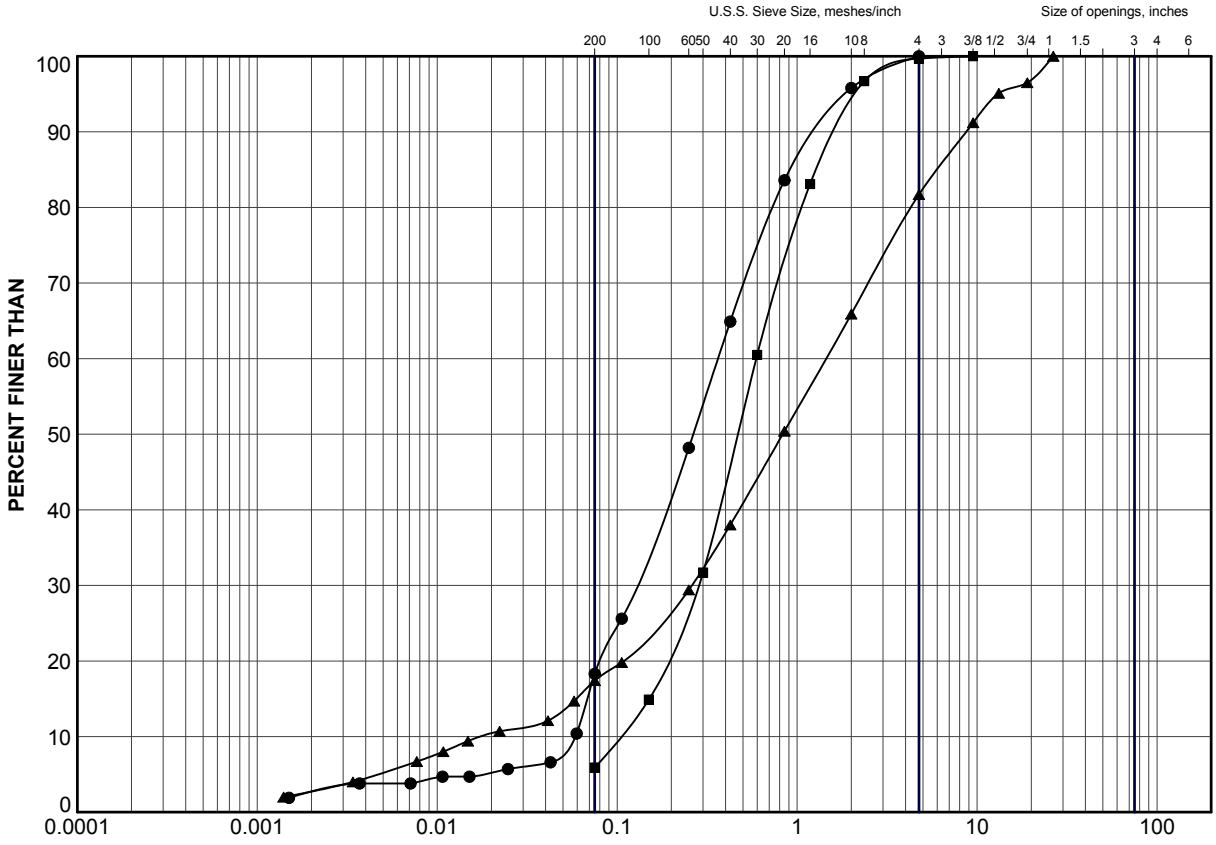
## Laboratory Test Results

**Table B1: Summary of Analytical Testing of Kabitotikwia River Water Sample**

| Parameter | Units | Result |
|---|---|---|
| Chloride (CL) | mg/L | 0.43 |
| Sulphate (SO4) | mg/L | 1.50 |
| Conductivity (EC) | µS/cm | 80.7 |
| Resistivity | µohm-cm | 12,392 |
| pH | n/a | 7.22 |

Notes:
1. Sample obtained on February 6, 2015.
2. Analytical testing carried out by ALS Canada Ltd.

Prepared by: AC
Checked by: SEMP
Reviewed by: JMAC




## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEV (m) |
|---|---|---|---|
| ● | KB-2 | 4 | 430.1 |
| ■ | KB-3 | 3 | 431.6 |
| ▲ | KB-4 | 1 | 432.1 |

PROJECT

HIGHWAY 811
KABITOTIKWIA RIVER CULVERTS STA 10+040

TITLE

# GRAIN SIZE DISTRIBUTION

SAND (FILL)

Golder Associates
SUDBURY, ONTARIO

| | | | | |
|---|---|---|---|---|
| PROJECT No. | 1411523 | | FILE No. | 1411523.GPJ |
| DRAWN | JJL | Mar 2015 | SCALE N/A | REV. |
| CHECK | SEMP | Mar 2015 | | |
| APPR | JMAC | Mar 2015 | **FIGURE B1** | |

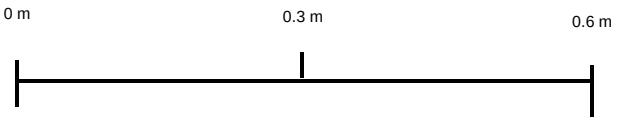
SUD-MTO GSD (NEW) GLDR_LDN.GDT

Borehole KB-1
Elevation 430.2 m to 427.4 m

Borehole KB-2
Elevation 429.1 m to 427.5 m

Borehole KB-3
Elevation 429.1 m to 427.5 m

Borehole KB-4
Elevation 428.8 m to 427.4 m




PROJECT
HIGHWAY 811
KABITOTIKWIA RIVER CULVERTS STA 10+040

TITLE
**BEDROCK CORE PHOTOGRAPHS**

Golder Associates

| | | | |
|---|---|---|---|
| PROJECT No. 1411523 | | | FILE No. ---- |
| DESIGN | AC | Mar. 2015 | SCALE AS SHOWN REV. |
| CADD | -- | | **FIGURE B2** |
| CHECK | SEMP | Mar. 2015 | |
| REVIEW | JMAC | Mar. 2015 | |

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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