March 17, 2016

DRAFT DETAIL FOUNDATION INVESTIGATION AND DESIGN 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

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DRAFT REPORT

Golder Associates

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DETAIL FOUNDATION INVESTIGATION REPORT
KABITOTIKWIA RIVER CULVERT – SITE NO. 48W-196/C
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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) 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] **Compact to Dense**	w = 4% – 25 % 2 – MH, 1 – M (Fig. B1) 2 – AL NP
Silt, some sand some gravel, trace clay, trace organics, brown, wet	KB-4	0.7	430.2	N = 13 **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.

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PART B

DETAIL FOUNDATION DESIGN REPORT
KABITOTIKWIA RIVER CULVERT – SITE NO. 48W-196/C
HIGHWAY 811, DISTRICT OF THUNDER BAY
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides detail foundation design recommendations for the proposed replacement of the Kabitotikwia River culverts. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. Where comments are made on construction, they are provided to highlight those aspects that could affect the current detail design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

The existing Kabitotikwia River culverts are located on Highway 811 at STA 10+040, approximately 9.8 km west of the Highway 527 junction. The highway embankment is constructed of granular fill material (with cobble sized particles) and is approximately 3.2 m high. The existing culverts consist of three SP CSP structures, the details of which (i.e., width, height, length, etc.) are summarized in Table 1.

As part of the preliminary design phase of the project, alternative culvert types were considered for replacement of the existing structures, as reported in the "Preliminary Foundation Investigation and Design Report, Kabitotikwia River Culvert – Site No. 48W-196/C, Highway 811, District of Thunder Bay, Unsurveyed Territory, G.W.P. 6302-14-00, GEOCRES No. 52H-28 dated May 21, 2015", by Golder Associates Ltd.

Based on the General Arrangement (GA) drawing provided by HMM on December 15, 2015, the existing SP CSP culverts are to be replaced with a 16 m wide segmented corrugated structural plate metal arch supported on a cast-in-place concrete footings. The cast-in-place concrete footings are proposed to be founded on bedrock at Elevation 428.2 m at the both the inlet and outlet with the top of footings at Elevation 428.7 m. This founding depth of the footings is required to allow for the placement of the segmented structural plate metal arch and the pavement structure above the culvert such that an embankment grade raise or widening is not required in the area of the culvert as part of the Highway 811 reinstatement.

6.2 Foundation Conditions and Frost Protection

The subsoils encountered at the proposed culvert location consist of embankment granular fill underlain by thin, granular deposits of silty sand, silt, gravel and cobbles in places, which are underlain by diorite bedrock. Based on the proposed invert elevations, as required to accommodate the metal arch segments, the open footing culvert will be founded below the surface of the bedrock. Bedrock excavation will be required to achieve the proposed invert elevations, as follows:

Borehole No.	Depth to Bedrock (below ground surface) (m)	Bedrock Surface Elevation (m)	Proposed Invert Elevation (m)	Bedrock Excavation Required (m)
KB-1	0.2	430.2	428.2	2.0*
KB-2	3.6	429.1		0.9
KB-3	3.7	429.1		0.9
KB-4	3.6	428.8		0.6

*Borehole KB-1 is located between an exposed rock outcrop and the existing/proposed culvert outlet end and it is inferred that the nearest existing culvert pipe was likely founded on or near the surface of the bedrock (current invert Elevation 429.5 m). Therefore the actual depth of bedrock excavation for the northern portion of the proposed western footing may be as low as 1.3 m.

For open footings for the metal arch culvert placed on a level and properly cleaned and prepared excavated bedrock surface, the factored geotechnical axial resistance at ULS may be taken as 1,000 kPa. The geotechnical reaction at SLS for 25 mm of settlement will be greater than the factored geotechnical axial resistance at ULS, since the bedrock is considered to be an unyielding material; as such, ULS conditions will govern for an open footing culvert design.

Strip footings for the open footing culvert founded directly on bedrock do not require soil cover for protection from frost penetration.

6.2.1 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the base of the concrete open footings and the bedrock should be calculated in accordance with Section 6.7.5 of the CHBDC. The coefficient of friction (tan δ) between the base of the cast-in-place concrete footing and the bedrock interface should be taken as 0.7.

Dowels should be incorporated into the design where bedrock is found to be sloping at greater than 10 degrees. The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. Where the rock mass is stronger than the concrete, the design of the dowels into the rock may be handled in the same way as the dowel embedment into the concrete for uniaxial compressive strength of the grout is similar to that of the concrete. The dowels should have a minimum embankment length within the very strong bedrock of 1 m, and the structural strength of the grout should not be exceeded. An example NSSP for dowels (anchors) into bedrock is provided in Appendix C, if required.

6.3 Stability, Settlement and Horizontal Strain

For the subsurface conditions encountered at this site, a proposed reconstructed embankment height up to about 3 m above the existing ground surface adjacent to the culvert and no grade raise or platform widening at the culvert site, the granular fill reconstructed embankment at this site will be stable at side slopes inclined at 2 Horizontal to 1 Vertical (2H:1V) or flatter. Further, the existing native soils immediately adjacent to the culvert foundation will not experience additional load, and the bedrock is considered an unyielding foundation, such that settlement of the culvert is estimated to be less than 25 mm.

Horizontal strain along the length of the culvert is not expected to occur as we understand that the open footing culvert will be founded directly on the unyielding bedrock surface.

6.4 Lateral Earth Pressures

The lateral earth pressures acting on the side walls of the culvert will depend on the type and method of placement of backfill materials, the nature of soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following geotechnical recommendations are made concerning the design of the metal arch culvert. It should be noted that these design recommendations and parameters are applicable to level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III, should be used as backfill behind the culvert walls, and on top of the culvert for a thickness of up to 300 mm. Backfill should be placed in a maximum of 200 mm loose lift thickness. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting).
- Granular fill should be placed in the zone of greatest width resulting from the width equal to the equivalent depth of frost penetration (as per OPSD 3090.100 [Foundation Frost Penetration Depths for Northern Ontario]), which for this site is 2.6 m behind the back of the walls as for a restrained wall (see Figure C6.20(a) of the Commentary to the CHBDC) or in a zone similar to that shown on OPSD 802.020 (Flexible Pipe Arch Embedment) where the bedding grade is actually the top of footing grade, the minimum thickness of cover is 300 mm, the truncated top width of the zone is equal to the culvert span and the side slopes of the zone are not steeper than 1.5H:1V extending to the excavation side slopes. The lateral earth pressures acting against the culvert are based on the proposed backfill materials against the walls and the following parameters (unfactored) may be used:

Fill Type	Internal Angle of Friction (ϕ, degrees)	Unit Weight	Coefficients of Static Lateral Earth Pressure	
			At-Rest, K_o	Active, K_a
Granular 'A'	35	22 kN/m^3	0.43	0.27
Granular 'B' Type II	35	21 kN/m^3	0.43	0.27
Granular 'B' Type I or III	32	21 kN/m^3	0.47	0.30

If the structures allow for lateral yielding, active earth pressures may be used in the design of the structure(s). If the structures do not allow lateral yielding, at-rest earth pressures should be assumed for design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as presented in Table C6.6 of the Commentary to the CHBDC.

6.5 Construction Considerations

6.5.1 Construction Staging and Temporary Roadway Protection

The temporary excavation for the culvert replacement will be made through the existing embankment granular fill comprised of compact to dense sand to sandy gravel and through native soils comprised of compact silts, gravels and cobbles. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). The granular fills and native soils are considered to be Type 3 soil above the groundwater table and Type 4 soil below. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are formed no stepper than 1 Horizontal to 1 Vertical (1H:1V). In Type 4 soils, the side sloes should be formed no steeper than 3H:1V.

Based on the GA drawing provided by HMM, a temporary protection support systems is required along the highway to facilitate construction staging and maintain traffic during culvert replacement work. At this site due to the relatively shallow depth to bedrock, a temporary support system comprised of sheet piling will not be feasible. Soldier piles and lagging (with the piles socketted into bedrock or supported by tiebacks or rakers) may be used for support of the excavation along the structure, as well as along the roadway. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways.

The support systems may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Cohesion	Coefficient of Earth Pressure		
	(γ, kN/m^3)	(ϕ, degrees)	(kPa)	Active, K_a	At Rest, K_o	Passive, K_p
Existing Sand to Sandy Gravel (Fill) (Compact to Dense)	20	32	-	0.31	0.47	3.25
Silt (Compact)	18	28	-	0.36	0.53	2.77
Gravel and Cobbles	20	35	-	0.27	0.43	3.69
Silty Sand (Till)	20	35	-	0.27	0.43	3.69

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

6.5.2 Excavation Below Culvert

The bedrock surface elevation is relatively consistent between boreholes, as described in Section 6.2, except at the northwest corner of the site where the proposed footings are close to an exposed rock outcrop. Given the proposed invert required to allow for construction of the footings and the segmented structural metal plate arch culvert, an area of bedrock excavation will be required to allow for concrete placement for the footings. Further, we understand that it may be required to sub-excavate the overburden to bedrock within the river channel to accommodate flow considerations. For bedrock excavation for footing construction, the bedrock is classified as very strong and pre-drilling and hoe ramming techniques alone may not be adequate at this site and consideration could be given to controlled blasting excavation techniques as per OPSS.PROV 120 (Explosives) and OPSS.PROV 202 (Rock Removal - Manual or Blasting) in order to preserve the integrity of the rock mass in the area of the footing excavation. Pre-shearing, line-drilling or other specialized techniques may be required to maintain the excavation lines and preserve the integrity of the rock mass along the footprint of the footings. The effect of blasting on the existing roadway and temporary protection systems should be considered by the designer and by the blasting contractor. The contractor should be alerted that levelling of bedrock will be required at this site; a sample NSSP has been included in Appendix C to be included in the contract.

The culvert subgrade (excavated bedrock surface) should be inspected by a Quality Verification Engineer (QVE) following sub-excavation to ensure that the rock mass integrity was preserved during excavation and that the bedrock surface is properly cleaned, scaled and loosened debris removed prior to placing the concrete for footings in accordance with OPSS 902 (Excavating and Backfilling Structures) for an open footing culvert. .

6.5.3 Culvert Backfill and Cover

The backfill requirements for the cast-in-place open footing culvert replacement should be in accordance with OPSS 902 (Excavating and Backfilling – Structures) and of a similar configuration to that shown on OPSD 802.020 (Flexible Pipe Arch Embedment and Backfill), as described in Section 6.4. The backfill should be placed in maximum 200 mm thick loose lifts and be compacted to at least 95 per cent of the SPMDD of the materials as specified in OPSS.PROV 501 (Compacting).

Backfill material to be placed around the metal arches of the culvert should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III. The granular backfill should be placed and compacted in accordance with OPSS.PROV 501 (Compacting). The fill should also be placed concurrently on both sides of the culvert, ensuring that the backfill depth on one side does not exceed the other side by more than 500 mm as per OPSS 902.

Backfill placement for reconstruction of the roadway embankments over the culvert should be carried out as per OPSD 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and new fill along the cut faces.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

Given the granular composition of the existing embankment fill in the area of the existing culvert at this site, a frost taper is not considered necessary.

6.5.4 Erosion Protection

Provision should be made for scour and erosion protection at the culvert location. In order to prevent surface/river water infiltration from flowing through the granular backfill along the culvert walls, a clay seal should be provided on the embankment slope at the upstream end of the culvert. The clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should be a minimum thickness of 1 m, if constructed of natural clay or soil bentonite mix. The clay seal should extend to a depth of 1 m below the scour level or to bedrock whichever is encountered first and also to a minimum vertical height equivalent to the high water level, and should extend a minimum horizontal distance of 2 m on either side of the culvert inlet opening or across the full width of the face of the new granular culvert backfill zone, whichever is greater. If a geosynthetic clay liner (GCL) is utilized in lieu of the 1 m thick clay seal than the GCL should be positioned within the embankment slope to allow for 0.3 m of granular (embankment) fill cover to be placed over the GCL and covered with the requisite erosion protection material.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. Given that the bedrock is to be exposed within the culvert span, for greater flow capacity, rip rap treatment for the outlet of the culvert should be provided on the embankment toe of slope and on the banks of the river at the culvert ends on both sides of the culvert consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment). Erosion protection for the inlet of the culvert should also follow the standard presented in OPSD 810.010 (Rip Rap Treatment) similar to the outlet but with the rip rap placed up to the toe of slope level, in combination with the clay seal cut-off measures noted above. Providing Rip Rap for erosion protection along the river bed as shown in OPSD 810.010, is not practical at this site given the river bed is to be excavated to bedrock.

6.5.5 Control of Groundwater and Surface Water

Excavation along the culvert alignment will be required to remove embankment fill, overburden soils to bedrock within the culvert footprint and bedrock for footing construction. As a result of the excavation, groundwater flow into the excavation can be expected due to the relatively permeable nature of the fill and native coarse grained soils, as well as along the soil/bedrock interface. Therefore, control of groundwater will be necessary to allow for construction to be carried out in dry conditions for the footings. Surface water should be directed away from the excavation areas to prevent ponding of water that could result obstruct the placement of concrete for strip footings.

Depending on the river flow, surface water flow conditions and groundwater level at the time of construction, water flow could be passed through the area by means of a temporary culvert, using one of the existing CSPs or diverted by pumping from behind temporary sand bag cofferdams placed on the bedrock surface (as a sheet-pile cofferdam is not feasible at this location).

It is likely that standard pumping from sumps will not be adequate at this site and careful consideration should be given to the dewatering and channel diversion to allow for the bedrock/founding level to be exposed, allow for bedrock excavation for footing construction and placement of concrete in-the-dry. Unwatering of all excavations should be carried out in accordance with OPSS 517 (Dewatering). Consideration should be given to including an NSSP in the Contract to address unwatering at this site; a sample NSSP is included in Appendix C.

An accurate prediction of the groundwater pumping volumes cannot be made, as the flow rate would be dependent on construction methods adopted by the contractor. However, it is considered that groundwater pumping volumes could exceed 50 m^3/day during initial drawdown stages and/or during periods of heavy precipitation. For this pumping volume, a Permit to Take Water (PTTW) would be required. We understand that a PTTW has been obtained by HMM for this culvert site.

6.5.6 Analytical Testing for Construction Materials

The results of an analytical test on a sample of river water taken at the culvert site are presented in Table B1 in Appendix B. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

7.0 CLOSURE

This Detail Foundation Design Report was prepared by Mr. Adam Core, P.Eng., and the technical aspects were reviewed by Ms. Sarah E. M. Poot, P.Eng and Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review of this report.

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n:\active\2014\1190 sudbury\1191\1411523 - hmm 26 culverts thunder bay\reporting\detail design\d6 - kabitotikwia river\draft\1411523 dft rpt d6 16mar17 fidr kabitotikwia river fidr.docx

REFERENCES

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

Canadian Standards Association (CSA), 2006. Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06. CSA Special Publication, S6.1 06.

Occupational Health and Safety Act and Regulation for Construction Projects, January 2006.

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

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

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

Ontario Provincial Standard Specifications (OPSS)

OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 902	Construction Specification for Excavating and Backfilling – Structures
OPSS 1205	Material Specification for Clay Seal

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 120	General Specification for the use of Explosives
OPSS.PROV 202	Construction Specification for Rock Removal by Manual Scaling, Machine Scaling, Trim Blasting, or Controlled Blasting
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 802.020	Flexible Pipe Arch Embedment and Backfill, Earth Excavation
OPSD 810.010	Rip-Rap Treatments for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario

Ontario Water Resource Act:

Regulation 903	Wells (as amended)

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

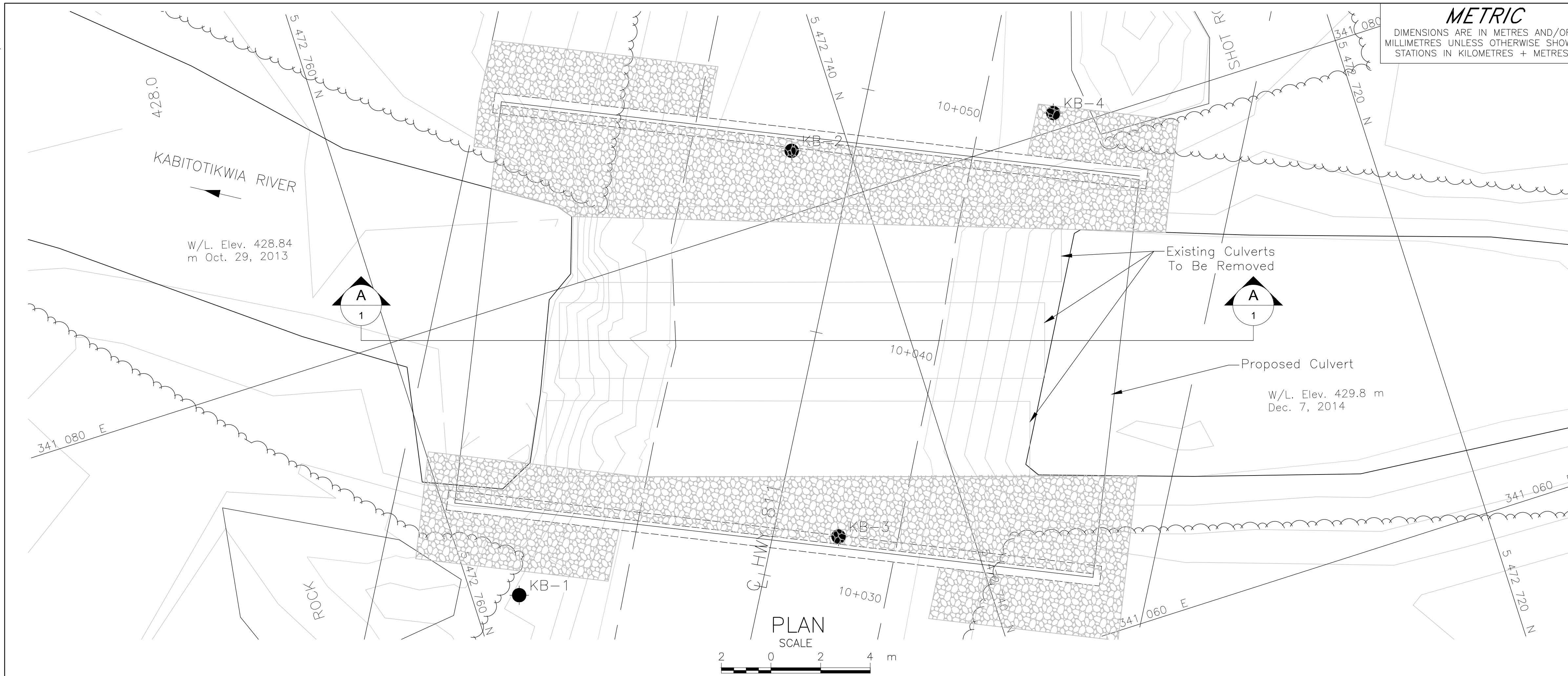
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 6302-14-01

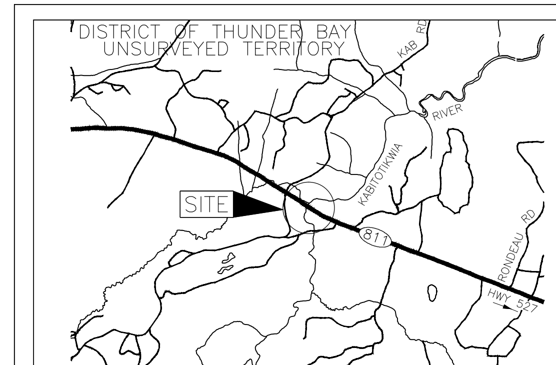
SHEET

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

Golder Associates



PLAN
SCALE
2 0 2 4 m



KEY PLAN
1 0 1 2 km
1:50,000 m

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

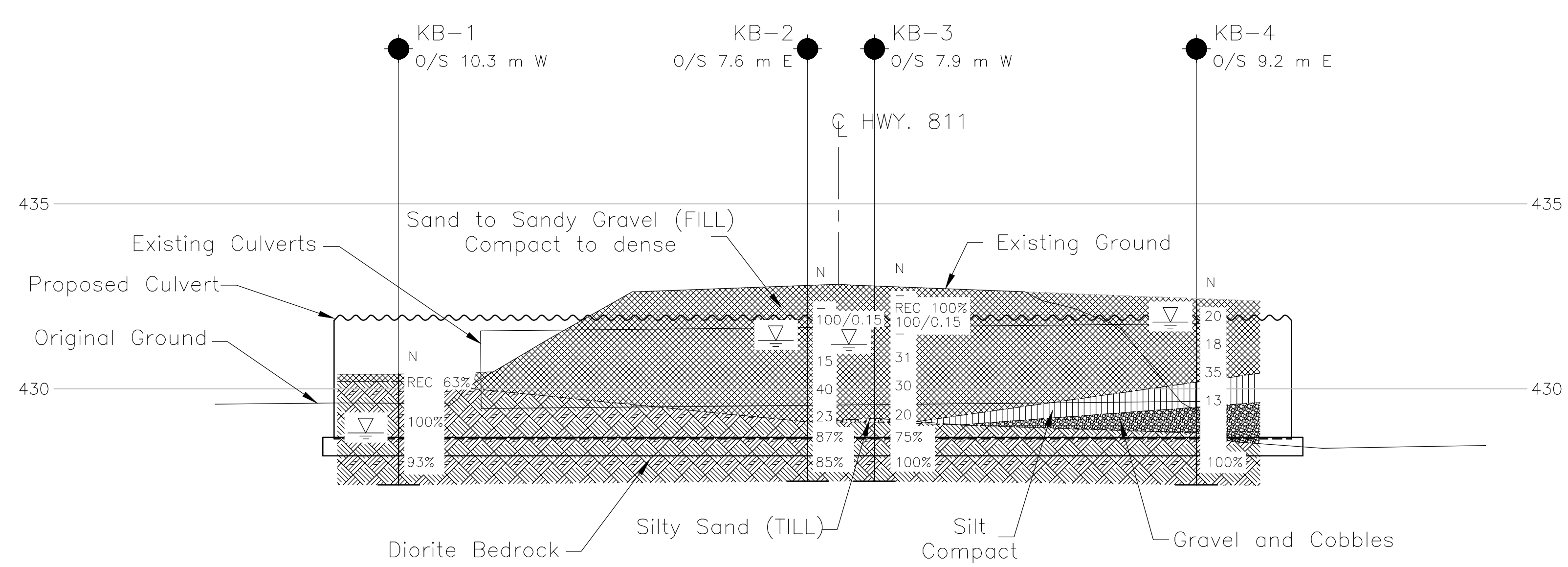
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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: H:\Projects\2014\1411523 hmm 26 culverts thunder bay\CIVIL 3D\1411523_Kabitotikwia River (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

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
υ	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

* Density symbol is ρ. Unit weight symbol is γ 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_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 $= \sigma'_p / \sigma'_{vo}$

(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 δ
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)
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

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	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		

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	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
430.4	GROUND SURFACE										
0.0	Sandy gravel, some silt (FILL) Brown Wet		1	RC	REC 63%		430				
0.2	DIORITE BEDROCK Bedrock cored from 0.2 m to 3.0 m depth. For coring details see Record of Drillhole KB-1.		1	RC	REC 100%						RQD = 100%
			2	RC	REC 100%	∇	429 428				RQD = 93%
427.4 3.0	END OF BOREHOLE Note: 1. Water level at a depth of 1.6 m below ground surface (Elev. 428.8 m) upon completion of drilling.										

Plot legend: DCPT scale 20, 40, 60, 80, 100; Shear strength: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100. Water content: PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; 20, 40, 60.

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

RECORD OF DRILLHOLE: KB-1

PROJECT: 1411523

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.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER METRES	DISCONTINUITY DATA B Angle	DIP w.r.t. CORE AXIS	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																		
	CME 55-Track NQ Coring	DIORITE Medium to coarse grained Fresh Black-white Very strong		430.2 0.2	1	GREY 100														UCS=235 MPa
1																				
2					2	GREY 10							JNIRRo JNIRRo JNIRRo JNIRRo							
3		END OF DRILLHOLE		427.4 3.0																
4																				
5																				
6																				
7																				
8																				
9																				
10																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CW

CHECKED: SEMP

Golder Associates

RECORD OF BOREHOLE No KB-2

 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	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ 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) Compact to dense Grey Wet		1	WS	-					
			2	SS	100/0.15		432			
						∇				
			3	SS	15		431	○		
			4	SS	40		430	○	NP	0 82 15 3
429.1			5	SS	23					
3.6	DIORITE BEDROCK Bedrock cored from 3.6 m to 5.2 m depth. 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 Note: 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)									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

+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-2

LOCATION: N 5472742.2 ;E 341082.4

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 7 and 8, 2014

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DATUM: GEODETIC

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	B Angle	DIP w.r.t. CORE AXIS	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 Medium to coarse grained Fresh Black-white		3.6	1	GREY 100							JNIRRo							
					2	GREY 100							JNIRRo JNIRRo JNIRRo JNIRRo							
5				427.5 5.2																
		END OF DRILLHOLE																		

Depth scale marks: 6, 7, 8, 9, 10, 11, 12, 13

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: SEMP

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	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
432.8	GROUND SURFACE					
0.0	Sand to sandy gravel, trace to some silt (FILL) Compact to dense Brown to grey Wet A 230 mm diameter cobble was encountered at 0.5 m depth.	1	WS	-	○	
		-	RC	REC 100%		
		2	SS	100/0.15		
		3	WS	-	○	0 94 (6)
		4	SS	31	○	
		5	SS	30		
		6	SS	20	○	
429.2 3.7	Silty SAND, trace gravel (TILL) Grey Wet					
	DIORITE BEDROCK Bedrock cored from 3.7 m to 5.3 m depth. For coring details see Record of Drillhole KB-3.	1	RC	REC 100%		RQD = 75%
427.5		2	RC	REC 100%		RQD = 100%
5.3	END OF BOREHOLE Note: 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).					

Ground water level symbol (▽) shown at approx. elevation 431.2.

Elevation scale: 432, 431, 430, 429, 428

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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 γ kN/m³

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

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

DRILL RIG: CME 55-Track

INCLINATION: -90° AZIMUTH: ---

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.	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	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 Medium to coarse grained Fresh Black-white Very strong		3.7	1		GREY 100														
5					2		GREY 100														UCS=176 MPa
		END OF DRILLHOLE		427.5 5.3																	

Depth scale: 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: SEMP

Golder Associates

RECORD OF BOREHOLE No KB-4

 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	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
432.4	GROUND SURFACE								
0.0	Sand, some gravel, some silt, trace clay (FILL) Compact to dense Brown Moist Augers grinding from ground surface to 1.5 m depth.	1	SS	20	▽	432	○	NP	18 64 15 3
		2	SS	18		431	○		
430.2		3	SS	35					
2.2	SILT, some sand, some gravel, trace organics, trace clay Compact Brown Wet	4	SS	13		430	○		
429.5 / 2.9	GRAVEL and COBBLES	-	RC			429			
428.8 / 3.6	DIORITE BEDROCK Bedrock cored from 3.6 m to 5.0 m depth. For coring details see Record of Drillhole KB-4.	1	RC	REC 100%		428			RQD = 100%
427.4 / 5.0	END OF BOREHOLE								

Note:

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).

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60)

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

PROJECT: 1411523

RECORD OF DRILLHOLE: KB-4

SHEET 1 OF 1

LOCATION: N 5472731.7 ;E 341080.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 6 and 7, 2014

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DATUM: GEODETIC

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.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	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 Medium to coarse grained Fresh Black-white		3.6	1	GREY 100														
5				427.4 5.0																
		END OF DRILLHOLE																		

Depth scale marks: 6, 7, 8, 9, 10, 11, 12, 13

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CW

CHECKED: SEMP

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

APPENDIX B

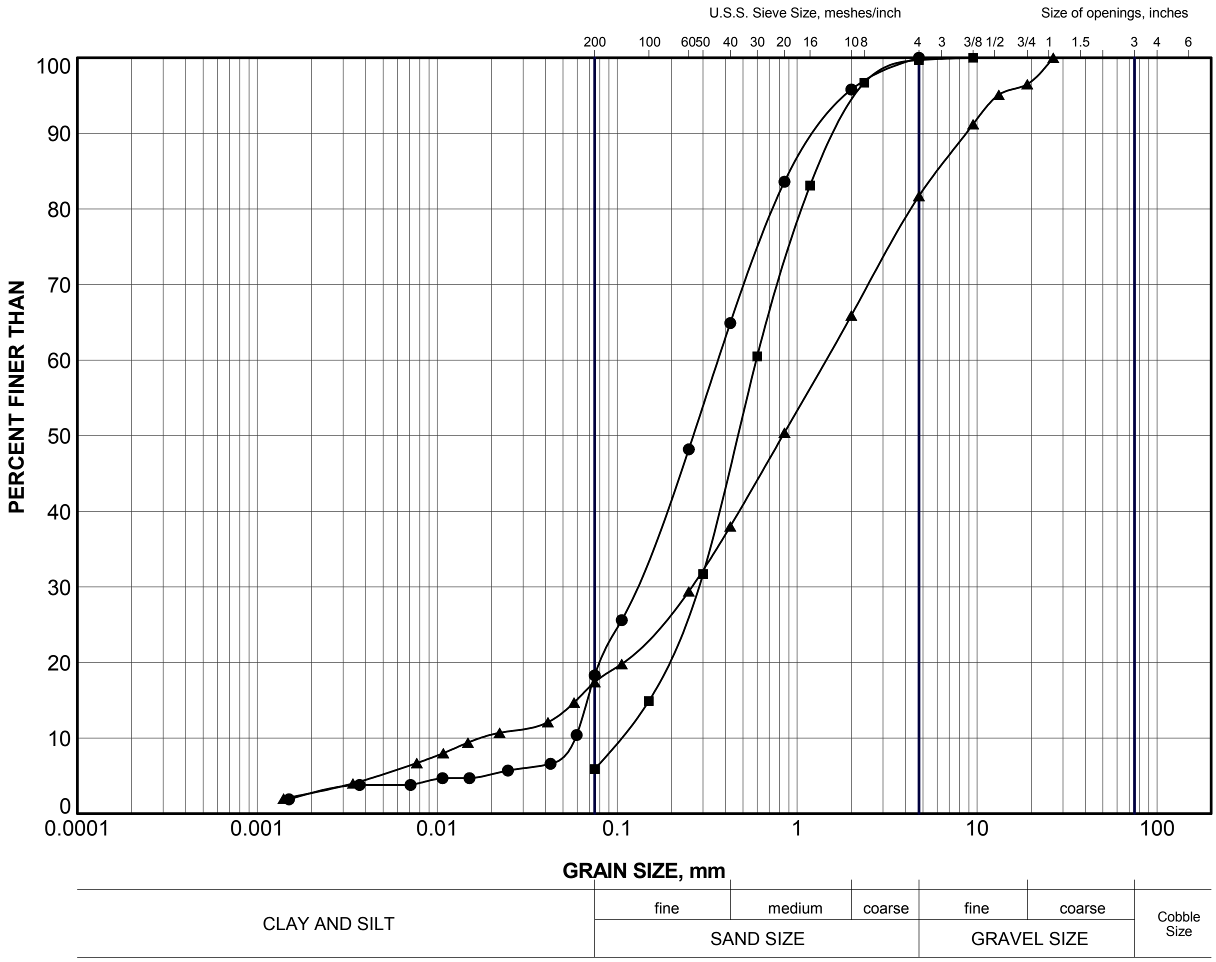
Laboratory Test Results

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

0 m 0.3 m 0.6 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	

APPENDIX C

Non-Standard Special Provisions

DOWELS INTO ROCK - Item No.

Non-Standard Special Provision

Scope of Work

This special provision covers the requirements for the placement and field testing of dowels into rock.

Construction

Dowels into rock shall be constructed in accordance with OPSS.PROV 904 Concrete Structures[i]. All reinforcing steel supplied shall be in accordance with OPSS.PROV 1440 Steel Reinforcement for Concrete[ii] (dowel bars conforming to CAN/CSA G30.18, Grade 400).

Where dowels are to be placed in rock, hole shall be drilled to the required depth and size. Hole diameter shall be two times the nominal diameter of the dowel. Each hole shall be cleaned out, grouted and the dowel set in place. Grout shall be of the same strength as the footing concrete or at least 30 MPa at 28 days.

If the dowel hole contains water, the Contractor shall remove the water, otherwise a tremie procedure shall be used to completely fill the hole with grout. The dowel shall be forced into the hole after the grout has been placed and while it is still fresh.

Rock Dowel Testing

All proposed testing procedures shall be in general conformance with ASTM D3689, ASTM D1143/D1143M and ASTM D4435. Field testing must be carried out in the presence of, and the results reviewed and approved by, the Contract Administrator.

Performance Tests

The following table summarizes the number of rock dowels where performance testing shall be carried out to confirm that the design load of the rock dowels can be achieved. The Contract Administrator will select the rock dowels to be tested.

Culvert	Foundation	Number of Dowels for Performance Testing
Kabitotikwia River Culvert	West and East Footings	2 per footing

Performance test shall be by axial tensioning using a hydraulic jack with a capacity of at least 1.5 times the ultimate strength of the dowels.

Rock dowels shall be loaded and unloaded in 3 cycles and measurements of the displacement of the dowel shall be carried out at each load increment (step) in accordance with the following schedule:

Cycle-Step	1-1	1-2	1-3	2-1	2-2	2-3	2-4
% Design Load	50	75	25	50	75	100	25

Cycle-Step	3-1	3-2	3-3	3-4	3-5
% Design Load	50	75	100	110	25

The design load shall be taken as 360 kN for 35M dowels, 252 kN for 30M dowels, 180 kN, for 25M dowels, and 108 kN for 20M dowels.

Displacement measurements shall be carried out at each load increment using calibrated displacement gauges capable of measuring movements of 0.0025 cm. Measurements shall be referenced to an independent fixed referenced pint.

Rock dowels which fail to meet the acceptance criteria shall be replaced at the Contractor's expense and re-tested. If a rock dowel fails, three (3) additional rock dowels shall be tested at the same footing as directed by the Contract Administrator.

Acceptance criteria for the rock dowels will be in accordance with the Post-Tensioning Institute (1985) as follows:

- The dowels are acceptable if the total elastic movement is greater than 80 percent of the theoretical elastic elongation of the free stressing length and is less than the theoretical elongation of the free stressing length plus 50 percent of the bond length.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

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[i] OPSS.PROV 904 Construction Specification for Concrete Structures
[ii] OPSS.PROV 1440 Material Specification for Steel Reinforcement for Concrete

GROUNDWATER CONTROL - Item No.

Non-Standard Special Provision

Foundations for the Kabitotikwia River culvert replacement will require excavations to extend below the groundwater level at the site. The granular embankment fill and native granular soils at this site will slough, run or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate groundwater control system for the culvert site to enable installation of the culvert (including construction of the footings) in dry conditions.

Basis of Payment

Payment at the lump sum contract price for this Tender Item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

LEVELLING BEDROCK SURFACE - Item No.

Non-Standard Special Provision

Scope of Work

Foundations for the Kabitotikwia River culvert replacement will require bedrock excavation to reach the founding surface of the footings.

Construction

Prior to placing concrete for the footings, the bedrock shall be levelled by hydraulic hammer or line drilling and blasting such that the surface of the bedrock is sloping less than 10 degrees throughout the footprint of the footings, and steel dowels should be grouted into bedrock as may be necessary, to satisfy lateral resistance requirements. The exposed bedrock must be cleaned by removing loose debris and rock shatter. The QVE shall review the footing subgrade prior to placing concrete.

Basis of Payment

Payment at the Contract Price for the above tender item includes full compensation for all labour, equipment and material to do the required work.

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