REPORT

JANUARY 28, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

BEKANON ROAD SBL OVERPASS STRUCTURE, SITE NO.44-459/2
HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529 NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5404-05-00; WP 5142-08-01

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PART A

FOUNDATION INVESTIGATION REPORT

BEKANON ROAD SBL OVERPASS STRUCTURE, SITE NO. 44-459/2

HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529

NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5404-05-00; WP 5142-08-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the proposed Highway 69 southbound lane (SBL) structure over Bekanon Road (Site No. 44-459/2), which is within the Contract 3 limits of the new Highway 69 alignment. The proposed work in Contract 3 is part of the four-laning of Highway 69 from 1.7 km north of Highway 529 northerly to 3.9 km north of Highway 522, for a total distance of 19.7 km, which includes: high fill embankments and embankments over swamps; the Canadian National Railway (CNR) re-alignment; the Bekanon Road and Highway 522 interchanges and structures; the Still River, Straight Lake and Key River structures; the Canadian Pacific Railway (CPR) and Canadian National Railway (CNR) overpass structures; as well as culvert crossings. The Bekanon Road SBL Overpass structure is to be located approximately 0.5 km east of the existing Highway 69. The general location of this proposed bridge along the new Highway 69 four-laning alignment is shown on the Site Location Plan on Drawing 1.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated December 2008. Golder's proposal for foundation engineering services associated with the Contract 3 Bekanon Road SBL Overpass structure is contained in Section 6.8 of URS's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated April 19, 2010.

This report addresses the investigation carried out for the Bekanon Road SBL Overpass structure and the associated approach embankments only. Separate reports address the foundation investigations for the related swamp crossings and high fill areas, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed bridge structure location, including the associated approach embankments, by borehole drilling, rock coring, in situ testing and laboratory testing on selected soil and rock core samples. The foundation units/limits for this investigation were located in the field by Callon Dietz Inc. (Callon Dietz), a professional surveying company retained by URS. The investigation area is shown in plan on Drawing 2.

2.0 SITE DESCRIPTION

The proposed Highway 69 alignment is oriented generally in a south-north direction spanning the Township of Wallbridge to the south, the Township of Henvey, and the Township of Mowat to the north. The Contract 3 section of the new four-lane Highway 69 alignment is also oriented generally in a south-north direction within the overall project limits, for a total distance of 5.5 km in the Township of Henvey. The proposed Bekanon Road SBL Overpass structure is located within the Contract 3 highway alignment and is located approximately 3.9 km from the southern limit of Contract 3, corresponding to approximately 0.5 km east of the existing Highway 69 alignment and about 5.5 km northeast of the junction between existing Highway 69 and Highway 526.

In general, the topography of this section of the overall project limits consists of rolling terrain, including sparsely or densely populated tree covered areas and numerous bedrock outcrops separated by valleys and swamps containing areas of standing water and various types of vegetation and organic soils. The proposed overpass structure and associated approach embankments are to be situated on a relatively flat, sparsely to densely treed area. The existing ground surface within the limits of the proposed structure and approach embankments is between about Elevation 194.6 m and 192.4 m, referenced to Geodetic datum, and is gently sloping downward from north to south.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the proposed Bekanon Road SBL Overpass structure was carried out on January 18 and 19, and between January 28 and February 1, 2012 during which time a total of twelve (12) boreholes, and one (1) hand excavation were advanced at the locations of the structure foundation footprints and approach embankments. A summary of the respective boreholes and hand excavation advanced at each foundation element and approach embankment is presented below.

Foundation Element/Approach Embankment	Investigation Type	
	Borehole No.	Hand Excavation
South Approach Embankment	B301-11	--
South Abutment	B301-01 B301-02 B301-03 B301-04 B301-04A B301-05	--
North Abutment	B301-06 B301-07 B301-08 B301-09 B301-10	--
North Approach Embankment	--	B301-12

The Record of Borehole/Drillhole sheets and the results of the laboratory testing are presented in Appendix A and Appendix B, respectively. The locations of the boreholes and hand excavation are shown in plan on Drawing 2.

The field borehole investigation was carried out using a track-mounted Diedrich D-25 drill rig supplied and operated by Walker Drilling Co. Ltd. of Utopia, Ontario. Hand excavation methods were used as appropriate depending on the terrain to confirm refusal conditions at shallow borehole locations. The boreholes were advanced through the overburden using 163 mm outer diameter (O.D.) solid-stem augers or NW casing. Where possible, soil samples were obtained at ground surface and at intervals of depth of about 0.75 m, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by an automatic hammer on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). Samples of the bedrock were obtained using an 'NQ' size rock core barrel.

The boreholes at the locations of the foundation elements were typically advanced to auger/casing and/or sampler refusal (i.e. inferred bedrock) and bedrock was confirmed by coring in selected boreholes. Refusal condition at the borehole at the north approach embankment was confirmed by hand excavation. The boreholes were advanced to depths of up to about 6.1 m below existing ground surface, including coring of bedrock for core lengths between about 3.6 m and 6.1 m in Boreholes B301-02 to B301-09 and B301-04A. Photographs of the recovered rock samples are provided in Appendix B.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations. Within the limits of the south and north abutments, a piezometer was installed in each of Boreholes B301-04A, B301-06 and B301-08 to monitor the ground water levels at these locations. The piezometers consist of 35 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled to the surface with bentonite pellets. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendix A. All boreholes in which standpipe piezometers are not installed were backfilled with bentonite upon completion in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil and rock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content and grain size distribution) was carried out on selected samples. Strength testing, such as uniaxial (unconfined) compression and point load index, was carried out on selected specimens of the rock core. The results of the laboratory testing are included in Appendix B.

The perimeter limits of each foundation unit were located in the field by Callon Dietz prior to drilling. The as-drilled borehole locations and ground surface elevations were surveyed by a member of our technical staff, referenced to the survey stakes put down by Callon Dietz. The locations given in the Record of Borehole/Drillhole sheets and shown on Drawing 2 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations and ground surface elevations are summarized below.

Borehole No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B301-01	5079652.3	222828.1	193.1	1.0
B301-02	5079649.4	222836.3	192.9	5.3
B301-03	5079651.3	222845.3	192.7	5.0
B301-04	5079647.3	222853.4	192.9	5.9
B301-04A	5079647.5	222852.4	192.9	5.7
B301-05	5079648.4	222861.3	193.1	5.7
B301-06	5079666.0	222832.3	193.8	6.1
B301-07	5079667.2	222838.9	193.8	6.1
B301-08	5079663.2	222847.4	193.4	6.0
B301-09	5079665.1	222856.8	193.5	5.6
B301-10	5079662.4	222863.8	193.6	1.7
B301-11	5079630.6	222841.4	192.4	1.9
B301-12[1]	5079683.9	222851.0	194.6	0.1

Note: 1. Borehole B301-12 refers to a shovel excavation carried out at the centre of the north approach embankment to expose the bedrock surface.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in The Physiography of Southern Ontario[1], this section of the new Highway 69 lies within the physiographic region known as the Georgian Bay Fringe, which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of very shallow deposits of sand, silt and clay underlain by metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localized low-lying swampy areas, containing peat and/or organic soils overlying soft/loose native soils, sometimes to significant depth, are present in valleys between the bedrock knobs and ridges.

The bedrock in the area consists typically of crystalline gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in Geology of Ontario, OGS Special Volume 4[2]. Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil and bedrock core samples, are presented on the attached Record of Borehole and Drillhole sheets and the laboratory test figures provided in Appendix A and Appendix B, respectively. The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profile and cross-sections on Drawing No. 2 are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations. It should be noted that the interpreted stratigraphy shown on Drawing 2 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the Bekanon Road SBL Overpass structure consist of a layer of topsoil, underlain by a thin, discontinuous non-cohesive deposit of silty sand to sandy silt, sand and gravel/sand and silt, underlain by bedrock. The overburden thickness at the boreholes advanced for the proposed bridge structure ranges from less than 0.1 m at the north-west area of the north abutment to about 2.0 m at the east corner of the south abutment.

A detailed description of the subsurface conditions encountered in the boreholes at the abutments and approach embankments is provided in the following sections.

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

[2] Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.

4.2.1 Topsoil

A layer of topsoil up to about 0.2 m thick, was encountered at the ground surface at all boreholes advanced at the site.

4.2.2 Silty Sand to Sandy Silt to Sand and Silt

A deposit of brown and grey cohesionless material grading from sands to silts was encountered below the topsoil in all borehole locations except for Boreholes B301-06 and B301-07 and the hand excavation B301-12. The top of this deposit was encountered between about Elevation 193.4 m and 192.2 m and the thicknesses of the deposit ranges between about 0.4 m and 1.8 m. The composition of the deposit is variable, consisting of silty sand to sandy silt to sand and silt to silt to sand.

An up to 0.2 m thick layer of sand and gravel was encountered below this deposit and overlying the bedrock at Elevation 191.2 m and 191.1 m in Boreholes 301-04 and 301-04A, respectively. A cobble was encounter at about Elevation 191.6 m in Borehole B301-02.

The SPT ‘N’-values measured within the sand to silt deposit range from 2 blows to 24 blows per 0.3 m of penetration indicating a very loose to compact relative density. Higher SPT ‘N’-values and/or lower penetrations associated with the split-spoon sampler refusing on bedrock were measured at some locations, but are not representative of the relative density of this deposit. The grain size distributions of eight (8) samples from the sand to silt deposit are presented on Figure B1-1 and B1-2 in Appendix B.

The natural water content measured on eighteen (18) samples of the sand to silt deposit ranges between about 21 per cent and 36 per cent.

4.2.3 Bedrock/Refusal

Bedrock was encountered and core samples were recovered from Boreholes B301-02 to B301-09 and B301-04A. Bedrock outcrops were observed in the area of the proposed structure and the bedrock is exposed at ground surface around the location of Borehole B301-12. The bedrock surface was inferred from hand excavation, split-spoon and auger refusal in Boreholes B301-01, B301-10 to B301-12. The depths to bedrock below ground surface and the corresponding bedrock surface elevation are summarized below.

Foundation Element / Approach Embankment	Borehole	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
South Approach Embankment	B301-11	1.9	190.5	Split-Spoon and Auger Refusal
South Abutment	B301-01	1.0	192.1	Split-Spoon and Auger Refusal
	B301-02	1.7	191.2	Bedrock Cored
	B301-03	0.7	192.0	Bedrock Cored
	B301-04	2.0	190.9	Bedrock Cored
	B301-04A	1.8	191.1	Bedrock Cored

Foundation Element / Approach Embankment	Borehole	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
	B301-05	0.5	192.6	Bedrock Cored
North Abutment	B301-06	<0.1	193.8	Bedrock Cored
	B301-07	0.1	193.7	Bedrock Cored
	B301-08	0.7	192.7	Bedrock Cored
	B301-09	1.8	191.7	Bedrock Cored
	B301-10	1.7	191.9	Split-Spoon and Auger Refusal
North Approach Embankment	B301-12	0.1	194.5	Hand Excavation Refusal

In general, the bedrock surface in the area of the Bekanon Road SBL Overpass structure slopes downward from north to south, with the bedrock surface elevation changing by as much as about 4.0 m at the borehole locations.

Based on a review of the bedrock core samples, the bedrock consists of granite gneiss. In general, the bedrock samples are described as fresh to slightly weathered, foliated, medium crystalline, slightly porous, strong to very strong, pink, grey and black, as presented in the Record of Drillhole sheets in Appendix A, and shown on the photographs of the recovered core samples on Figures B2 to B4 in Appendix B. The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W2), and the strength classification of the intact rock mass based on field identification (i.e. strong to very strong – R4 to R5) are described in accordance with the International Society for Rock Mechanics (ISRM[3]) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 79 per cent to 100 per cent, indicating a rock mass of good to excellent quality as per Table 3.10 of CFEM (2006). However, portions of core recovered from Boreholes B301-04 and B301-05 contain fractured rock with RQD values as low as about 0 per cent and 34 per cent, indicating a rock mass of very poor to poor quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 26 per cent and 100 per cent and between 0 per cent and 100 per cent, respectively.

Point load strength index tests (ASTM D5731 – Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification) were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. The axial tests carried out on sixteen (16) samples of the granite gneiss bedrock core measured Is_{50} values ranging from about 6.2 MPa to 10.0 MPa and the diametral tests carried out on fourteen (14) samples of the granite gneiss bedrock core measured Is_{50} values ranging from about 2.8 MPa to 9.3 MPa.

Two (2) Unconfined Compression (UC) tests (ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens) were carried out on selected core samples of the granite

[3] International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

gneiss bedrock obtained in Boreholes B301-02 and B301-07 and measured compressive strengths of about 129 MPa and 147 MPa, respectively, as summarized in Table B2-1 and detailed in Tables B2-2 and B2-3 in Appendix B.

Also presented in Table B1 are the estimated Uniaxial Compressive Strength (UCS) values for each sample tested for point load strength index based on a relationship between Is_{50} and UCS, which is given by a correlation factor (K) which varies depending on the size of the core sample and the strength of the rock. For this site, the UCS values are based on an estimated average correlation factor (K) of 15.

Based on the laboratory UC test and the point load index test results, in accordance with Table 3.5 in CFEM (2006), the granite gneiss bedrock is classified as medium strong to very strong (R3, 25 MPa $<$ UCS $<$ 50 MPa to R5, 100 MPa $<$ UCS $<$ 250 MPa).

4.2.4 Groundwater Conditions

In general, the overburden samples taken in the boreholes were moist to wet. The water level observed in boreholes upon completion of drilling varied between about Elevation 191.6 m and 193.3 m, measured between about 0.2 m and 0.9 m below ground surface. Borehole B301-12 was dry upon completion of hand excavation.

A standpipe piezometer was installed in Borehole B301-04A, B301-06 and B301-08 to allow monitoring of the groundwater level at the site. Details of the piezometer installation are shown on the Record of Borehole sheet in Appendix A. The groundwater level measured in the piezometer installation is summarized below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
South Abutment	B301-04A	192.9	192.9 192.5	January 31, 2012 March 11, 2012
North Abutment	B301-06	193.8	193.6 193.2	January 29, 2012 March 11, 2012
North Abutment	B301-08	193.4	193.4 192.9	January 29, 2012 March 11, 2012

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

Mr. Matt Rhody, senior technician with Golder, directed the drilling program. This report was prepared by Mr. Matt Soderman, E.I.T., and reviewed by Ms. T. Veronica Ayetan, P.Eng., a geotechnical engineer with Golder. Mr. Jorge M. A. Costa, P.Eng. Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

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https://capws.golder.com/sites/0911116014highway69fourlaning/contract 3/reporting/final/bekanon road overpass sbl/09-1111-6014-3523 rpt 14jan28 bekanon road sbl overpass.docx

PART B

FOUNDATION DESIGN REPORT

BEKANON ROAD SBL OVERPASS STRUCTURE, SITE NO. 44-459/2

HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529

NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5404-05-00; WP 5142-08-01

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides engineering design recommendations for the proposed Bekanon Road SBL Overpass structure. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the design of the structure foundation and approach embankments. Where comments are made on construction, they are provided in order to highlight those aspects which could affect the design of the project. 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

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide recommendations on foundation aspects for the detail design of the Bekanon Road SBL Overpass structure within Contract 3 along the proposed section of four-laning of Highway 69 in the Township of Henvey. It is understood that the Bekanon Road SBL Overpass structure will consist of a single span, rigid frame structure with a span length of 14 m and abutments located north and south of Bekanon Road.

Based on the General Arrangement (GA) Drawing provided by URS on December 12, 2011, the grade of the proposed Bekanon Road SBL overpass bridge deck will vary between about Elevation 199.5 m and 199.6 m, about 5.4 m to 7.0 m above the existing ground surface. In comparison, the proposed grade for the new Bekanon Road in the area of the proposed SBL Overpass is at about Elevation 193.1 m, up to about 0.7 m below the existing ground surface near the north abutment and up to about 0.4 m above the existing ground surface near the south abutment. The proposed north and south approach embankments will be up to about 6 m and 7 m high, respectively.

6.2 Foundation Options

Given the proximity of the bedrock to the existing ground surface (i.e. less than about 1.9 m deep), the topography of the bedrock surface and considering the proximity of the proposed grade for the Bekanon Road alignment to the bedrock surface, shallow foundations comprised of spread footings founded directly on bedrock is considered the preferred foundation alternative to support the SBL Overpass structure.

Due to the shallow nature of the overburden deposits at the site, pile foundations would not be practical and a significant amount of excavation/trenching or socketing into the medium strong to very strong bedrock would be required to achieve the minimum required pile lengths for deep foundation and integral abutments, which would likely be cost prohibitive.

The following sections provide recommendations for shallow foundations (spread footings) to support the structure. From a foundations perspective, a shallow foundation is considered most practical for construction at this site and is the preferred alternative.

The advantages, disadvantages, relative costs and risks/consequences for the foundation options are summarized in Table 1.

6.3 Spread Footings

At this site, shallow foundations comprised of spread footings founded directly on bedrock is the preferred alternative for support of the structure.

6.3.1 Geotechnical Axial Resistance and Reaction

Based on the GA Drawing provided by URS, the underside of the abutment footings are currently proposed to be founded at approximately Elevation 191.2 m. Given this proposed founding level, up to about 2.6 m of bedrock excavation will be required to construct the spread footing on properly prepared granite gneiss bedrock at the north abutment. At the south abutment, up to about 1.4 m of bedrock excavation and up to about 0.3 m of filling with mass concrete will be required to construct the footing. Alternatively, the elevation of the underside of the footing at the south abutment could be lowered by 0.3 m to Elevation 190.9 m to avoid the use of mass concrete.

Given that there is no minimum requirement for soil cover for frost protection at this location (as discussed in Section 6.3.3) consideration could be given to raising the footing elevation in order to decrease the amount of bedrock excavation required at the north abutment. However, the elevation of the underside of the footings should not be above the base of the adjacent cut of the bedrock for the proposed Bekanon Road alignment where required (Elevation 193.1 m minus pavements structure / cushion thickness).

The following summarizes the factored geotechnical axial resistance at Ultimate Limit States (ULS) for spread footings on properly prepared bedrock. For footings founded on the granite gneiss bedrock, the geotechnical reaction at Serviceability Limit States (SLS) for 25 mm of settlement will be greater than the factored geotechnical resistance at ULS at this site and as a result the SLS condition does not apply.

Foundation Option	Factored Geotechnical Axial Resistance at Ultimate Limit States (ULS)	Geotechnical Reaction at Serviceability Limit States (SLS) for 25 mm of Settlement
Spread footing on properly prepared granite gneiss bedrock or on mass concrete overlying bedrock	10,000 kPa	N/A[1]

Note: 1. The geotechnical reaction at SLS for 25 mm of settlement will be greater than the factored geotechnical resistance at ULS for spread footings on bedrock and as a result the SLS condition does not apply.

The geotechnical resistance provided above is given for loads applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Sections 6.7.2 and 6.7.4 of the *Canadian Highway Bridge Design Code* (*CHBDC*) and its *Commentary*.

For footings placed on mass concrete, the factored geotechnical axial resistance at ULS is as given above for bedrock assuming that the compressive strength of the concrete used to form the pad is at least 25 MPa.

Following excavation of the overburden and excess bedrock and prior to placing any concrete, it will be necessary to clean, scale and remove all loose, shattered and/or fractured rock within the footprint of the footings to ensure a proper bond of the mass concrete/concrete footing to the bedrock. A provision should be included in the Contract Documents to address the requirements for field inspection. In order to carry out this inspection, the excavation should be dry. In addition, a check on the sliding resistance between the mass concrete/concrete footing and the bedrock should be carried out (in accordance with the recommendations provided in Section 6.3.2). A Non-Standard Special Provision (NSSP) should be included in the Contract Documents for mass concrete placement to accommodate variations in the bedrock surface; an example is included in Appendix D.

6.3.2 Resistance to Lateral Loads

The resistance to lateral forces/sliding resistance between the mass concrete/concrete footings and the bedrock, should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The following summarizes the coefficient of friction, tan δ, for the interface between the mass concrete / concrete footing and bedrock.

Interface Material(s)	Coefficient of Friction (tan δ)
Mass Concrete or Concrete Footing on Bedrock	0.70

The value presented above represents an unfactored value.

If necessary, the sliding resistance between the mass concrete/concrete footings and the bedrock can be supplemented by dowelling into the bedrock. The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. For this site, where the rock mass is essentially as strong or stronger than concrete, the design of the dowels into the rock may be handled in the same way as the dowels embedment into the concrete. This assumes that the unconfined compressive strength of the grout will be similar to that of the concrete. The dowels should have a minimum embedded length within the bedrock of 1 m, and the structural strength of the dowels and compressive strength of the grout should not be exceeded. If dowelling into bedrock is adopted at this site, a NSSP should be included in the Contract Documents to specify the installation, materials and testing of the dowels (an example NSSP is included in Appendix C).

6.3.3 Frost Protection

For spread footings founded directly on the properly prepared granite gneiss bedrock or on mass concrete over the bedrock at this site, a minimum soil cover for frost protection is not required.

6.4 Seismic Site Consideration

6.4.1 Site Coefficient

For seismic design purposes, the Site Coefficient, S, for this site, based on experience and considering the guidelines in Section 4.4.6 of the CHBDC (2006) may be taken as 1.0, consistent with Soil Profile Type I.

6.4.2 Seismic Analysis Coefficient

According to the National Building Code of Canada (1995) seismic hazard values (as referenced in the CHBDC and its Commentary), the site specific peak horizontal ground acceleration for Sudbury and Parry Sound area is 0.051 (for a probability of exceedance of 10 per cent in 50 years). For the thicknesses and type of overburden soils at the site, an amplification factor of 1.0 of the ground motion is recommended for design. As such, the ground surface acceleration would be about 0.05.

Given that the proposed CPR Overhead NBL structure is a single-span bridge, and in accordance with Sections 4.4.5.2 of the CHBDC, seismic analysis is not required for this structure.

6.5 Lateral Earth Pressures

The lateral earth pressures acting on the abutment stems and any associated wing walls/retaining walls will depend on the type and method of placement of the backfill material, the nature of the soils 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. Seismic (earthquake) loading must also be taken into account in design, if required.

The following recommendations are made concerning the design of walls. 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 specifications of Special Provision 110S13 Aggregates Granular ‘A’ or Granular ‘B’ Type II, but with less than 5 per cent passing the No. 200 sieve, should be used as backfill behind the walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with Special Provision 105S21 Compacting. Other aspects of the granular backfill requirements with respect to sub drains and frost taper should be in accordance with OPSD 3121.150 Walls, Retaining, Backfill, Minimum Granular Requirement.

- For structures that are not comprised of integral or semi-integral abutments, rock fill may be used as backfill behind the walls and the material should meet the specification as outlined in the Northeastern Region Directive (2002) for backfill of structures adjacent to rock embankments. Other aspects of rock backfill requirements should be in accordance with OPSD 3101.200 Walls, Abutment, Backfill, Rock.

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with *CHBDC* Section 6.9.3 and Figure 6.6. Other surcharge loadings should be accounted for in the design as required.

- For the proposed rigid frame bridge structure at this site, granular fill should be placed in a zone with the width equal to at least 1.9 m behind the back of the abutment (in accordance with Figure C6.20(a) of the *Commentary* to the *CHBDC* for restrained walls). For the wing walls and retaining walls, fill should be placed within a wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (in accordance with Figure C6.20(b) of the *Commentary* to the *CHBDC* for unrestrained walls). The lateral pressures are based on the fill as placed and the following parameters (unfactored) may be assumed:

Fill Type	Soil Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular ‘A’	22 kN/m^3	0.43	0.27
Granular ‘B’ Type II	21 kN/m^3	0.43	0.27
Rock Fill	19 kN/m^3	0.36	0.22

If the bridge structure and/or wing/retaining walls allow lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the bridge structure and/or wing/retaining walls do not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design. The movement required to allow active pressure to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the Commentary to the *CHBDC*.

Given the proposed overpass structure is a single-span bridge, in accordance with Section 4.4.5.2 of the *CHBDC*, seismic analysis is not required.

6.6 Retained Soil System (RSS) Walls

Based on the GA Drawing provided by URS, it is understood that mechanically-reinforced retaining soil systems (Retained Soil System walls or RSS walls) are proposed on both ends of the north and south abutments between the SBL and NBL structures and on the west sides of the SBL structure to retain the Highway 69 approach embankment fill. It is also understood that the underside of the strip footings for the RSS wall facings is to be founded at the same elevation as the abutment footings (i.e. currently proposed at Elevation 191.2 m). As such, refer to Section 6.3 for geotechnical axial resistance/reaction, resistance to lateral loads and frost protection requirements for the design of the RSS Wall facing strip footings.

6.7 Approach Embankment Design

Based on the GA Drawing provided by URS, the proposed road grade for the new Highway 69 SBL approaches to the Bekanon Road Overpass structure will be at about Elevation 199.6 m, requiring placement of up to about 6 m and 7 m of fill within the limits of the north and south approach embankments, respectively. In addition, the grade of the proposed new Bekanon Road in the area of the proposed overpass is to be at about Elevation 193.1 m, requiring up to about 0.7 m of soil excavation/rock cut near the north abutment and up to about 0.4 m of fill near the south abutment.

Based on the investigated locations at this site, the approach embankments will be founded directly on either the overburden soils comprised mainly of very loose to compact sand, silty sand, sandy silt and silt deposits or on the bedrock. All topsoil should be stripped from below the approach embankment areas.

The results of stability and settlement analysis for the new approach embankments are presented in the following sections.

6.7.1 Stability

6.7.1.1 Methodology

Stability analyses were carried out for the critical sections of the proposed approach embankments, which correspond to the greatest embankment height at 7 m. The Factor of Safety (FoS) is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum FoS of 1.3 is normally used in the design of embankment slopes under static conditions. This FoS is considered adequate for the embankments at this site considering the design requirements and the field data available. Based on the subsoils encountered at this site which consisted of non-cohesive soils at shallow depth, the stability of the proposed embankment section was assessed based on precedent experience in similar soil conditions to check that the target minimum FoS was achieved for the proposed embankment heights and geometries.

The stability assessment assumes that the organic soils encounter at/below ground surface have been removed prior to approach embankment fill placement.

6.7.1.2 Parameter Selection

The soils encountered below the proposed approach embankments consist primarily of a thin deposit of topsoil underlain by relatively localized deposits of silty sand to sandy silt to sand and silt, underlain by bedrock at shallow depth. It is recommended that the embankment fills be placed on the localized non-cohesive deposit or directly on the granite gneiss bedrock for construction of the approach embankments.

For the non-cohesive overburden soils, the effective stress parameters employed in the analysis were estimated from empirical correlations based on the results of the in situ Standard Penetration Tests (SPT). The correlations proposed by Peck et al (1974) and US Navy (1986) were employed and the results were tempered by engineering judgment based on precedent experience in similar soils.

Although the groundwater level measured in the piezometer installations is up to 0.6 m below the existing ground surface, for the purpose of the stability assessment, the groundwater table is conservatively assumed to be located at the existing ground surface.

The following summarize the simplified stratigraphy and the associated strengths and unit weights employed for the fill material and the silty sand to sandy silt to sand and silt deposits in the approach embankment areas. Based on the GA Drawing provided by URS, the proposed approach embankments are to be constructed with rock fill with 1.5H:1V side slopes. Considerations could be given to constructing the embankment with 1.25H:1V side slopes as noted in Section 6.8.2.

Embankment	Soil Type	Unit Weight	Undrained Shear Strength	Cohesion, c’	Angle of Internal Friction, ϕ’
North and South Approach Embankment	Rock Fill	19 kN/m^3	--	--	40°
	Silty Sand to Sandy Silt	19 kN/m^3	--	--	28°

6.7.1.3 Results of Analysis

Given the generally non-cohesive nature of the subsoils and based on precedence experience in similar soil conditions, no stability issues are anticipated for the proposed up to about 7 m high approach embankments, provided that all organic deposits are sub-excavated and replaced prior to filling.

6.7.2 Settlement

6.7.2.1 Methodology

To estimate the magnitude of the expected embankment settlements, analyses were carried out at the critical section of the proposed approach embankments using hand/spreadsheet calculations. For the approach embankments, the critical sections correspond to the greatest embankment height at 7 m.

The settlement analysis assumes that the organic soils encountered at/below ground surface have been removed.

The sources of settlement are considered to include:

- Immediate settlement of the thin native granular soils (where present); and,
- Self-weight compression of the embankment fill materials (long-term).

The thickness of the localized compressible foundation soils is up to about 1.8 m thick, where present, and as such, the settlements along the length of the approach embankment will similarly vary. Given that the analyses were carried out at the critical sections, the settlements generally represent the maximum estimated value along the approach embankments.

6.7.2.2 Parameter Selection

The following summarize the simplified stratigraphy and the associated strengths and unit weights employed for the foundation soils at the approach embankment areas. The immediate compression of the overburden soils (comprised mainly of sand, silty sand, sandy silt and sand) were modelled by estimating an elastic modulus of deformation based on the SPT ‘N’-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990).

Embankment	Soil Type	Thickness	Unit Weight	Elastic Modulus, E’
North and South Approach Embankment	Silty Sand to Sandy Silt to Sand and Silt	Up to 1.8 m (where present)	19 kN/m^3	2 MPa

Although the groundwater level measured in the piezometer installations is up to 0.6 m below the existing ground surface (i.e. within the silty sand/sandy silt deposit), for the purpose of the settlement analysis, the groundwater table is conservatively assumed to be located at the existing ground surface.

6.7.2.3 Settlement of Foundation Soils

The results of the estimated settlement of the foundation soils at the approach embankments are summarized below.

Embankment	Soil Type	Estimated Settlement of Foundation Soils (mm)
North and South Approach Embankment	Silty Sand to Sandy Silt to Sand and Silt (where present)	Up to 120

The settlements are expected to occur rapidly (i.e. during construction) in response to filling based on the non-cohesive and granular nature of the foundation soils.

6.7.2.4 Settlement of Rock Fill Embankment

It is understood that rock fill is to be used for the construction of the approach embankments and as such, there will be settlement due to compression of the rock fill itself under self-weight. The magnitude of settlement of the rock fill depends on the type of rock/strength of particles, size and shape of particles, gradation of rock fill, total height/thickness of fill and the method of construction and sequence of placement. Rock fill should be placed, in a controlled manner (i.e. not end dumped) in accordance with Special Provision 206S03 Grading. According to MTO's Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates (2010), the settlement of rock fill placed in this manner is expected to be nominal and the magnitude is estimated to be up to about 0.75 per cent of the effective height of the rock fill embankment. As such, the estimated settlement of rock fill for the approach embankments is presented below.

Embankment	Maximum New Embankment Height[1] (m)	Estimated Settlement of Rock Fill (mm)
North and South Approach Embankments	7.0	55

Note: 1. Includes additional fill required after removal of maximum depth of topsoil

The majority of the settlement of the rock fill as estimated above is expected to occur during construction. However, post-construction time-dependent settlement of the Rockfill embankment will occur. In order to meet the settlement performance criterion of 25 mm of settlement over a 20-year period following the completion of construction in accordance with Section 1.2 of MTO's Embankment Settlement Criteria for Design (2010), a minimum preload period of 100 days is required.

6.7.2.5 Embankment Platform Widening

In accordance with the requirements of MTO Northern Region Engineering Directive NRE 98-200, Northern Region Embankment Design Guidelines (1998), the construction of the approach embankments should include an allowance for platform widening (in 0.5 m increments) to accommodate settlements during construction as well as post-construction settlements so that the minimum standard shoulder widths are maintained if future grade raises on the embankments are required. However, given that the embankment is essentially founded on bedrock (and/or on thin deposits localized sands to silts) and only negligible settlements of the foundation soils are expected to occur, a minimum platform widening is not required at the approach embankments.

6.8 Subgrade Preparation and Embankment Construction

The following sections provide details on the recommendations for subgrade preparation and embankment construction.

6.8.1 Removal of Organic Materials

Prior to the placement of any fill, all organic materials including topsoil should be stripped from the plan limits of the proposed works.

6.8.2 Embankment Fill Placement

Placement of rock fill material for approach embankment construction should be carried out in accordance with the requirements as outlined in the Special Provision 206S03 Grading. The rock fill should not be dumped in final position, but should be deposited on and pushed forward over the end of the layer being constructed. Blading, dozing and 'chinking' the rock fill to form a dense, compact mass will be required to minimize voids and bridging. Side slopes for rock fill embankments should be no steeper than 1.25 horizontal to 1 vertical (1.25H:1V).

6.9 Design and Construction Considerations

6.9.1 Overburden Excavation

In order to construct the bridge foundations on the bedrock at the currently proposed footing elevations, excavations up to about 2.6 m below the existing ground surface will be required and will be made through the overburden and bedrock. The overburden soils are considered Type 3 soils according to Occupational Health and Safety Act and Regulation for Construction Projects (OHSA). Excavations in the overburden soils should be carried out with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V). Excavations within the bedrock may be made with vertical or near vertical cut slopes as discussed in Section 6.10.

All excavations must be carried out in accordance with Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended).

6.9.2 Control of Groundwater and Surface Water

The groundwater level measured at this site is generally between about 0 m (i.e. at existing ground surface) and about 0.9 m below existing ground surface. Foundation construction for the bridge structure will require excavation up to 2.6 m below ground surface, to the proposed base of the footings at Elevation 191.2 m within the bedrock for both the north and south abutments.

Although the water table was measured to be above the proposed footing elevation, given the relatively thin overburden and granite gneiss bedrock of good to excellent quality, it is expected that pumping from within the excavations with adequately sized and properly filtered pumps will be sufficient to control the groundwater inflow. All surface water should be directed away from the excavations.

6.10 Recommendations for Rock Excavation and Blasting

6.10.1 Rock Excavation

It should be noted that the bedrock at the site is classified as medium strong (R3) to very strong (R5) (i.e. estimated unconfined compressive strengths in the range of about 43 MPa to about 150 MPa). As such, bedrock excavation in the vicinity of the proposed structure foundations should be carried out using line drilling and pre-shearing techniques to minimize blast damage to the rock (i.e. shattering and over-break) and provide better control over the configuration of the founding surface. The overall slope of the rock face may be formed vertically, or near vertically (i.e. about 0.25H:1V). In addition, following excavation, it will be necessary to remove all loose, shattered and/or fractured rock within the footprint of the foundations and to ensure that the founding rock is cleaned and protected such that the integrity of the rock is maintained.

6.10.2 Blasting

The use of explosives should follow the specifications outlined in OPSS 120 Use of Explosives. It is recommended that control of all blasting operations be carried out in accordance with Special Provision 299F06 Rock Excavation (Controlled Blasting).

It is recommended that all new rock cut faces in the area of the proposed structure foundations be inspected by a Quality Verification Engineer (QVE) soon after blasting to assess if the blasting operations have affected the integrity of the rock mass that will ultimately be supporting the new abutment footings.

7.0 CLOSURE

This report was prepared by Mr. Matt Soderman, E.I.T., and Ms. T. Veronica Ayetan, P. Eng., a geotechnical engineer with Golder and was reviewed by Mr. J. Paul Dittrich, P. Eng., a senior geotechnical engineer and Principal with Golder. Mr. Jorge M. A. Costa, P. Eng., the Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

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ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D5731	Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications
ASTM D7012	Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

Contract Design Estimating and Documentation (CDED):

Special Provision 105S21	Amendment to OPSS 501 – Compacting
Special Provision 110S13	Amendment to OPSS 1010 – Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
Special Provision 206S03	Amendment to OPSS 206 – Rock Excavation, Grading; Rock Excavating, Grading
Special Provision 299F06	Rock Excavation (Controlled Blasting)

Ministry of Transportation Ontario:

MTO Foundations. Embankment Settlement Criteria for Design. March 2010.

MTO Foundations. MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates. September 2010.

Northern Region Engineering Directive NRE 98-200. Northern Region Embankment Design Guidelines. October 1998.

Northeastern Region Engineering Directive. Backfill to Structures Adjacent to Rock Embankment Approaches. November 2002.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ontario Provisional Standard Drawing:

OPSD 3101.200 Walls – Abutment, Backfill – Rock

OPSD 3121.150 Walls – Retaining, Backfill – Minimum Granular Requirement

Ontario Provincial Standard Specification:

OPSS 120 General Specification for Use of Explosives

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

TABLES

Table 1: Evaluation of Foundation Alternatives – Bekanon Road SBL Overpass Structure

Foundation Option	Rank	Advantages	Disadvantages	Relative Costs	Risks / Consequences
Spread Footings on Bedrock	1	■ Relative ease of construction. ■ Reduced bedrock excavation (as compared with pile option); ■ Negligible post-construction settlement; and, ■ Higher axial resistance than pile foundations.	■ Requires removal of up to about 2.6 m of soil and/or bedrock at the abutment locations to reach the proposed founding level; ■ Bedrock will have to be blasted using controlled blasting techniques to minimize shattering and overbreak; and, ■ Fully integral abutment design not achievable.	■ Lower relative cost than piled foundation option; and, ■ Additional costs for vertical dowels, if required to improve lateral resistance.	■ Must take measures to ensure integrity of rock below the footings or repair using mass concrete may be required during construction in areas of overbreak / overshatter.
H-piles in Bedrock Trenches/Sockets	NR	■ Negligible post-construction settlement; and, ■ Fully integral abutment design achievable.	■ Bedrock excavation to form trench or drilling for sockets will be required to achieve minimum required pile lengths; and, ■ Lower axial resistance than shallow foundation as structural strength of piles govern.	■ Higher relative cost than spread footings due to additional costs for excavating trenches or drilling sockets into bedrock.	■ Not recommended due to shallow depth to bedrock and the additional depth of excavation required in medium strong to very strong bedrock.

Note: 1. NR – Not Recommended

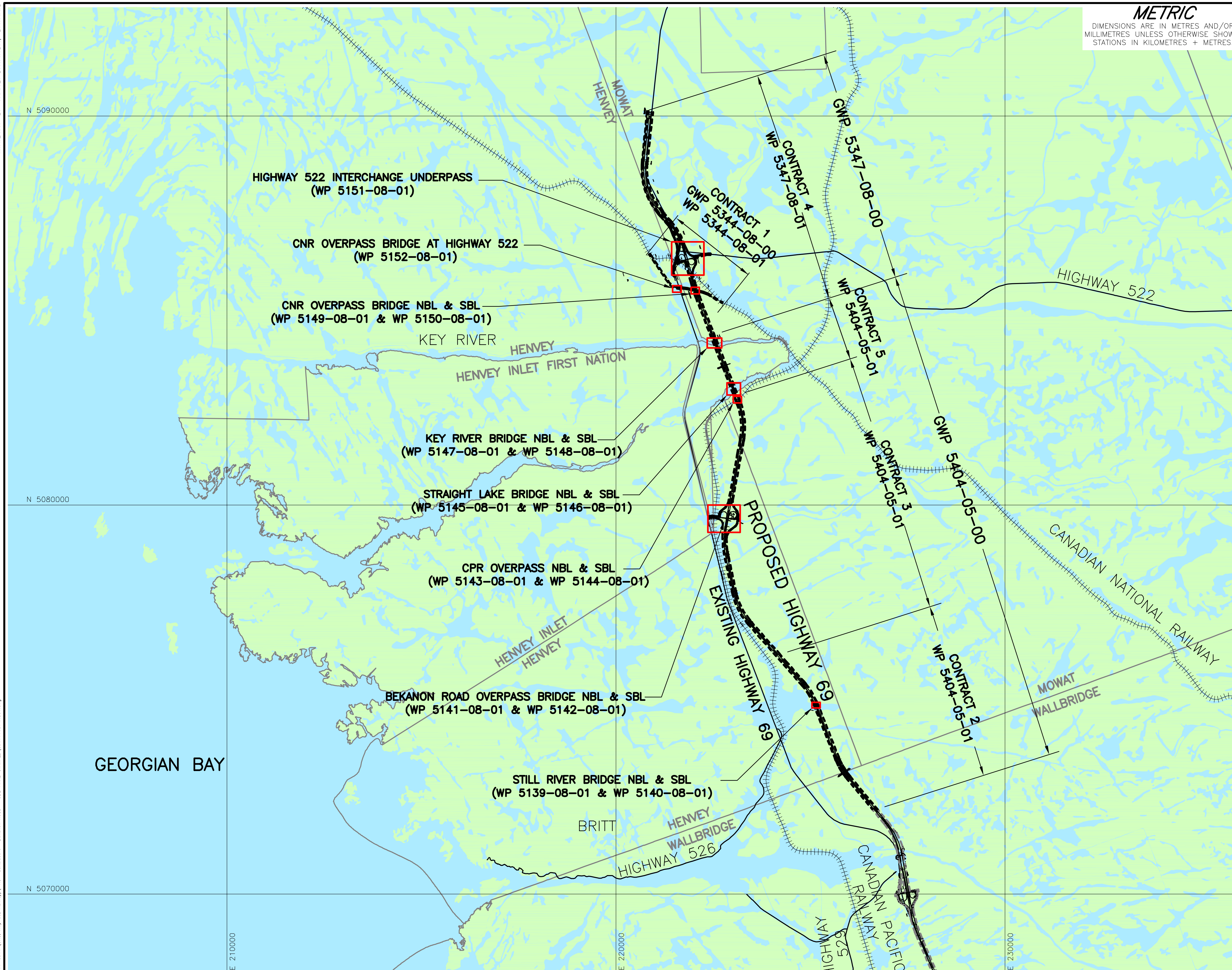
Prepared By: MAS **Checked By:** TVA **Reviewed By:** JPD/JMAC

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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



PLAN

SCALE

1 0 1 2 km

CONT No.
GWP No. 5404-05-00

SHEET

HIGHWAY 69
SITE LOCATION PLAN

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN
NOT TO SCALE

REFERENCE

Base Data – MNR NRVIS, obtained 2004, CANMAP v2008
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Datum : NAD 83 Projection : MTM Zone 10

NO.	DATE	BY	REVISION

Geocres No. 41H-123

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Dec. 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 1

PLOT DATE: January 27, 2014
FILENAME: T:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\-NC- Contract 3- Bekanon Road - SBL-FINAL-STAMPED\09111160140NC01.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

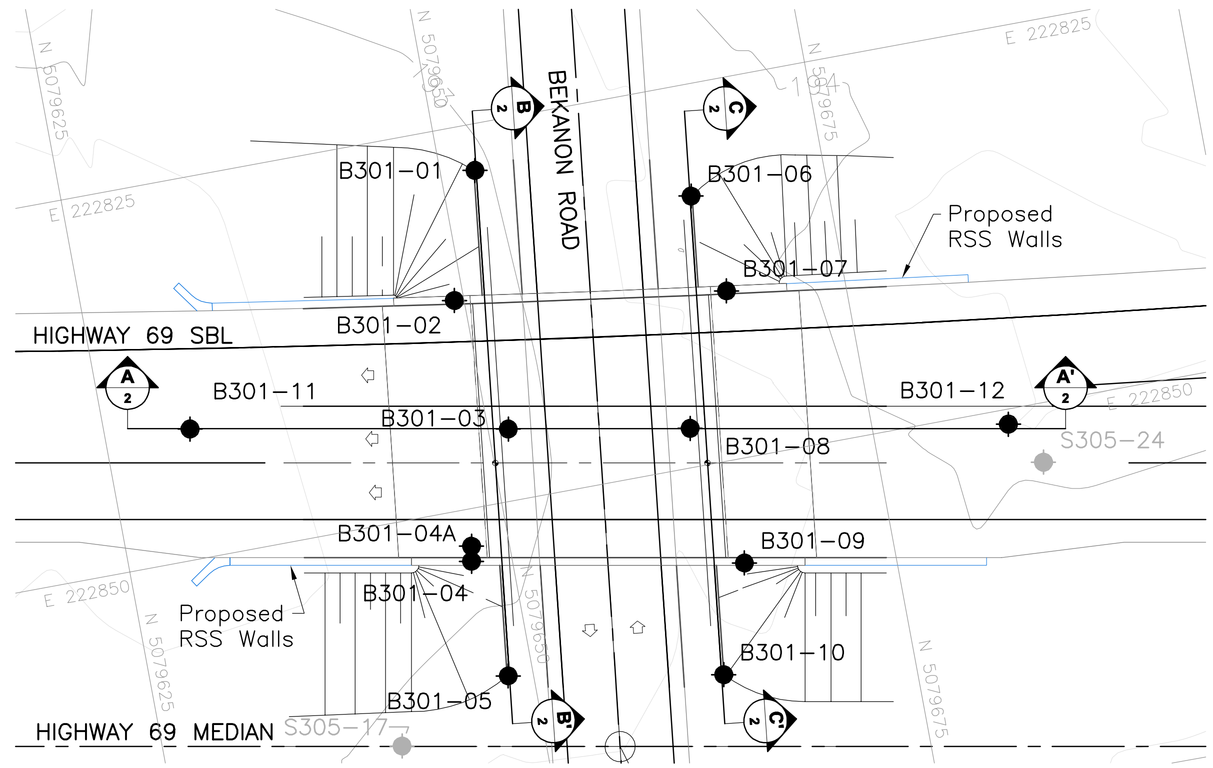
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5142-08-01

HIGHWAY 69
BEKANON ROAD SBL OVERPASS STRUCTURE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

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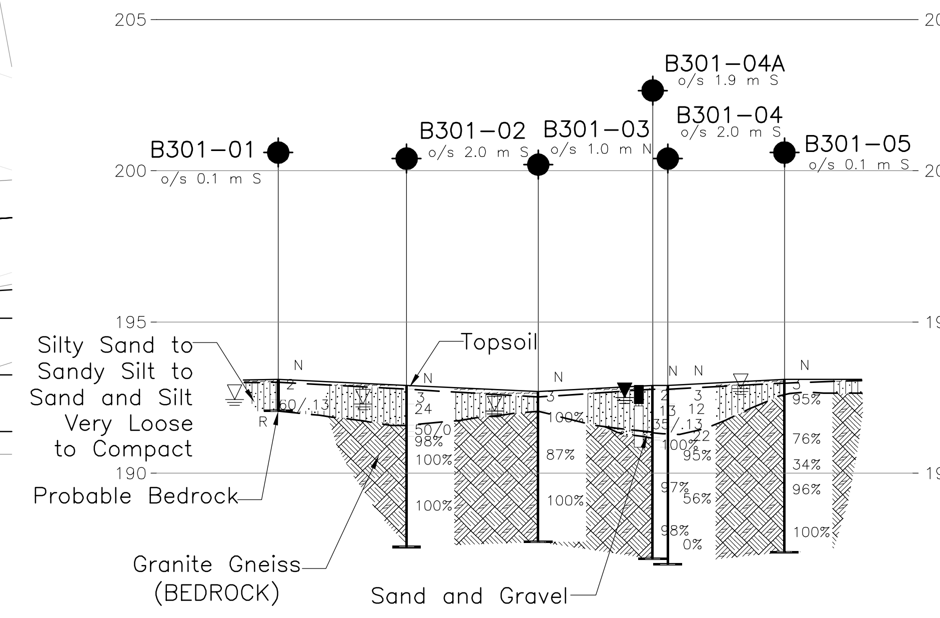
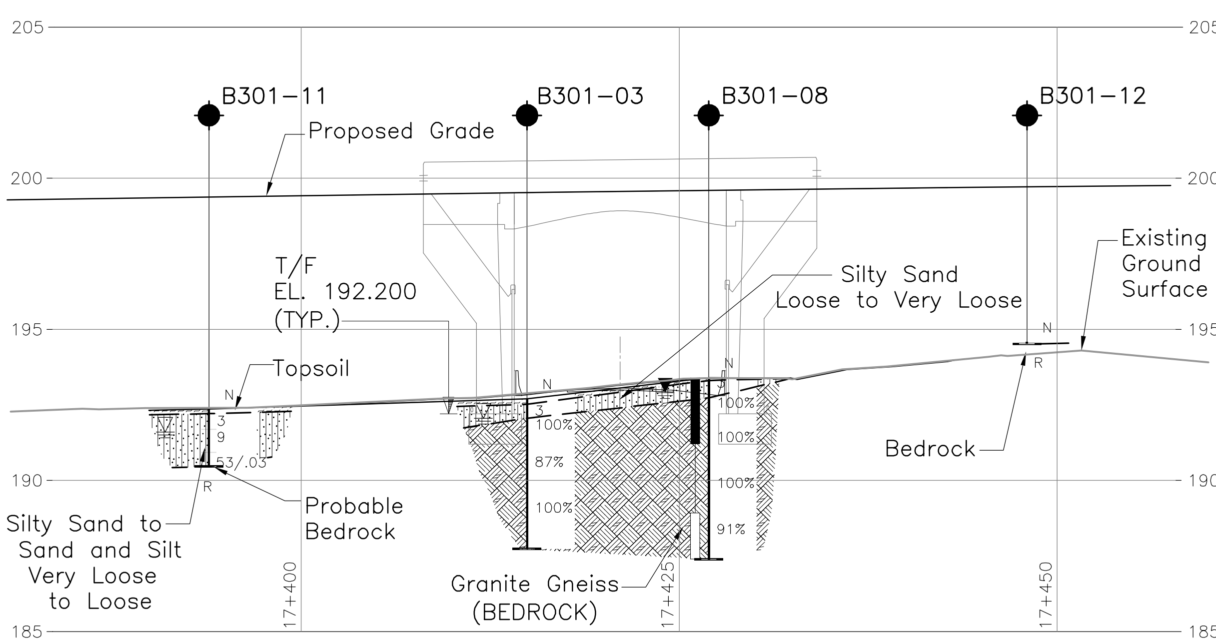


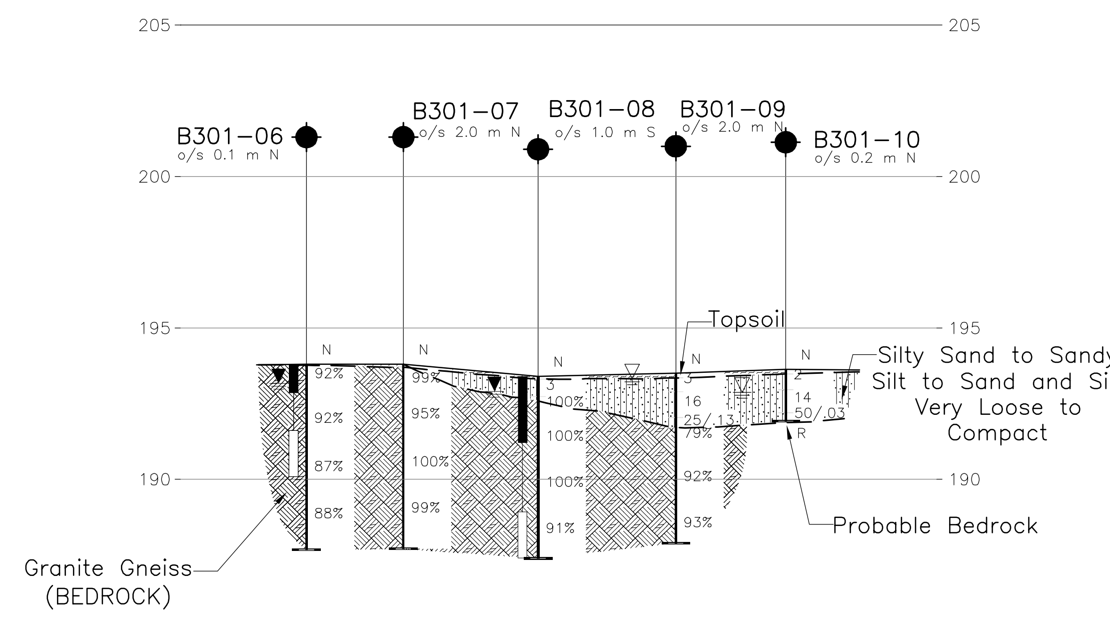
B-B' 2 SOUTH ABUTMENT HIGHWAY 69 (SBL)

HORIZONTAL SCALE 5 0 5 10 m
2.5 0 2.5 5 m VERTICAL SCALE



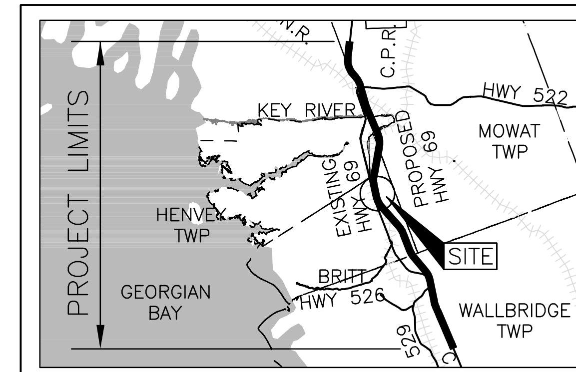
A-A' 2 CENTRELINE PROFILE HIGHWAY 69 (SBL)

HORIZONTAL SCALE 5 0 5 10 m
2.5 0 2.5 5 m VERTICAL SCALE



C-C' 2 NORTH ABUTMENT HIGHWAY 69 (SBL)

HORIZONTAL SCALE 5 0 5 10 m
2.5 0 2.5 5 m VERTICAL SCALE



KEY PLAN
SCALE 5 0 5 10 km

LEGEND

●	Borehole – Current Investigation
	Seal
	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
	WL in piezometer
	WL upon completion of drilling
R	Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
B301-01	193.1	5079652.3	222828.1
B301-02	192.9	5079649.4	222836.3
B301-03	192.7	5079651.3	222845.3
B301-04	192.9	5079647.3	222853.4
B301-04A	192.9	5079647.5	222852.4
B301-05	193.1	5079648.4	222861.3
B301-06	193.8	5079666.0	222832.3
B301-07	193.8	5079667.2	222838.9
B301-08	193.4	5079663.2	222847.4
B301-09	193.5	5079665.1	222856.8
B301-10	193.6	5079662.4	222863.8
B301-11	192.4	5079630.6	222841.4
B301-12	194.6	5079683.9	222851.0

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 URS, drawing file nos. Hwy69_plan.dwg, received February 2, 2012, Hwy69_Contour-Plan_C3.dwg, received April 23, 2012 and BEKANON RD SBL GA.dwg, received December 12, 2011 and Proposed and Existing Grades obtained from drawing file Hwy69_profile March 2012.dwg, received March 14, 2012.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Jan. 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.P. DITTRICH Jan. 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-123

HWY. 69		PROJECT NO. 09-1111-6014	DIST.
SUBM'D. MAS	CHKD. MAS	DATE: Dec. 2012	SITE: 44-459/2
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 2

PLOT DATE: January 27, 2014
FILENAME: T:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\...

APPENDIX A

Record of Boreholes and Drillholes

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 = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan 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	Sand and Gravel
	With (cohesive)	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		

Golder Associates

RECORD OF BOREHOLE No B301-01

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014
W.P. 5404-05-00
LOCATION N 5079652.3 ;E 222828.1
ORIGINATED BY MR
DIST
HWY 69
BOREHOLE TYPE 163 mm O.D. Continuous Flight Solid Stem Augers
COMPILED BY MAS
DATUM Geodetic
DATE January 19, 2012
CHECKED BY TVA/CN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
193.1	GROUND SURFACE					193						
0.0	TOPSOIL	1A	SS	2								
0.1 / 192.4	Silty SAND, containing rootlets and organics, Very loose, Brown, Moist	1B			∇							
192.1 / 1.0	Sandy SILT, trace gravel, trace clay, containing silt seams, Compact, Brown and grey, Wet	2	SS	60/0.13			o		1	23	74	2

END OF BOREHOLE
SPOON AND AUGER REFUSAL

NOTE:

1. Water level in open borehole at a depth of 0.7 m below ground surface (Elev. 192.4 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O 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
REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No B301-02

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014

W.P. 5404-05-00 LOCATION N 5079649.4 ;E 222836.3 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY CS

DATUM Geodetic DATE January 30, 2012 CHECKED BY TVA/CN

ELEV / DEPTH (m)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.9	GROUND SURFACE						
0.0 / 0.1	TOPSOIL	1A					
	Silty SAND, trace gravel, containing topsoil	1B	SS	3	∇		
192.3 / 0.6	Very loose, Brown, Moist	2	SS	24		192	0 33 66 1
191.6	SAND and SILT, trace clay, containing sand seams, Compact, Brown to grey, Wet	3	SS	50/0			
1.7	Cobble	1	RC	REC 98%		191	RQD = 98%
	SAND, Brown, Wet						
	Granitic Gneiss (BEDROCK)	2	RC	REC 100%		190	RQD = 100%
	Bedrock cored from depths of 1.7 m to 5.3 m					189	
	For bedrock coring details refer to Record of Drillhole B301-02	3	RC	REC 100%		188	RQD = 100%
187.6 / 5.3	END OF BOREHOLE						

NOTE:

1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev 192.3 m) upon completion of drilling.

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: 09-1111-6014

RECORD OF DRILLHOLE: B301-02

SHEET 1 OF 1

LOCATION: N 5079649.4 ;E 222836.3

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE:

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DATUM: Geodetic

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough; MB - Mechanical Break, BR - Broken Rock. NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	NOTES
		Continued from Record of Borehole B301-02	191.22						
2	NW Casing	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, very strong, grey, pink and black	1.68	1	FR,PL,RO	1.5	1	1	
									(Axial)
3	NQRC January 30, 2012			2				0.5	
4				3	FR,IR,RO	3	1	1	
5			187.57 5.33						UC=128.9 MPa (Axial)
		END OF DRILLHOLE							

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 1/28/14

RECORD OF BOREHOLE No B301-03

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5404-05-00 LOCATION N 5079651.3 ;E 222845.3 ORIGINATED BY MR
DIST HWY 69 BOREHOLE TYPE NQ Coring COMPILED BY CS
DATUM Geodetic DATE January 30, 2012 CHECKED BY TVA/CN

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
192.7	GROUND SURFACE							
0.0	TOPSOIL	1A	SS	3				
0.2	Silty SAND, trace clay, containing organics Very loose Brown Moist	1B			∇	192	o	
192.0 / 0.7	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 0.7 m to 5.0 m For bedrock coring details refer to Record of Drillhole B301-03	1	RC	REC 100%		191		RQD = 100%
		2	RC	REC 100%		190		RQD = 87%
		3	RC	REC 100%		189, 188		RQD = 100%
187.7 / 5.0	END OF BOREHOLE							

NOTE:

1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev 192.1 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O 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; GR SA SI CL

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B301-03

SHEET 1 OF 1

LOCATION: N 5079651.3 ;E 222845.3

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE:

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	MB - Mechanical Break
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	BR - Broken Rock
SH - Shear	CO - Contact	UN - Undulating	SM - Smooth	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
VN - Vein	OR - Orthogonal	ST - Stepped	RO - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	VR - Very Rough	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH / COLOUR % RETURN	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 m (5 10 15 20)	B Angle (0 90 180 270)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B301-03		192.01																
	NQRC, January 30, 2012	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, very strong, grey, pink and black		0.69	1								JN,PL,SM	1	1					
1																1				
													JN,PL,SM	1	2					
2					2								FR,PL,SM	1	1	2				(Axial)
													JN,PL,SM	1	2					
													JN,PL,SM	1	2					
3													FR,IR,SM	2	5					
4					3											0.5				
				187.73																
5		END OF DRILLHOLE		4.97																
6																				
7																				
8																				
9																				
10																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

Golder Associates

RECORD OF BOREHOLE No B301-04

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-00 LOCATION N 5079647.3 ;E 222853.4 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE NW Casing, Wash Boring COMPILED BY CS

DATUM Geodetic DATE January 31, 2012 CHECKED BY TVA/CN

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.9	GROUND SURFACE							
0.0	TOPSOIL	1A	SS	3	∇			
192.3 0.6 (0.2)	SILT, trace sand, containing rootlets and organics. Very loose, Brown, Wet	1B					○	
191.5 1.4	SAND and SILT, trace to some clay, containing sand seams. Compact, Brown to grey, Wet	2	SS	12		192	○	0 46 48 6
191.1	Silty SAND, trace clay. Compact, Brown, Wet	3A / 3B	SS	22		191	○	
2.0	SAND and GRAVEL. Compact, Grey, Wet							
	Granitic Gneiss (BEDROCK). Bedrock cored from depths of 2.0 m to 5.9 m. For bedrock coring details refer to Record of Drillhole B301-04	1	RC	REC 98%		190		RQD = 95%
		2	RC	REC 97%		189, 188		RQD = 56%
		3	RC	REC 99%		187		RQD = 0%
187.0 5.9	END OF BOREHOLE							

NOTE:

1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 192.4 m) upon completion of drilling.

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: 09-1111-6014

RECORD OF DRILLHOLE: B301-04

LOCATION: N 5079647.3 ;E 222853.4

DRILLING DATE:

DATUM: Geodetic

DRILL RIG: D25 Bombardier

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: WALKER DRILLING

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough, MB - Mechanical Break, BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	NOTES
		Continued from Record of Borehole B301-04	190.86						
	NW Casing	GRANITE GNEISS Slightly weathered to fresh, foliated, medium crystalline, slightly porous, very strong, grey, pink and black	2.04						
					JN,PL,SM	1	1		
					JN,PL,RO	1.5	2		
				1				3	(Axial)
3					JN,PL,SM	1	6		
					JN,PL,SM	1	6		
	NQRC, January 31, 2012				JN,PL,SM	1	6		
4				2				3	
					JN,PL,SM	1	2		
					JN,PL,SM	0.75	6		
5				3					
			186.99 5.91						
6		END OF DRILLHOLE							
7									
8									
9									
10									
11									
12									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 1/28/14

RECORD OF BOREHOLE No B301-04A

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-00

LOCATION N 5079647.5 ;E 222852.4

ORIGINATED BY MR

DIST ____ HWY 69

BOREHOLE TYPE NW Casing, Wash Boring

COMPILED BY CS

DATUM Geodetic

DATE January 31, 2012

CHECKED BY TVA/CN

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.9	GROUND SURFACE					
0.0	TOPSOIL					
0.1	SILT, trace to some sand, trace to some clay, containing rootlets and organics to a depth of 0.6 m, containing sand seams; Very loose to compact; Brown to grey; Moist	1A / 1B	SS	2		0 10 84 6
		2	SS	13	192	
191.5	Sandy SILT, trace clay; Compact; Brown; Wet	3A	SS	35/0.13		0 29 68 3
191.2	SAND and GRAVEL; Grey; Wet	3B			191	
1.8	Granitic Gneiss (BEDROCK). Bedrock cored from depths of 1.8 m to 5.7 m. For bedrock coring details refer to Record of Drillhole B301-04A	1	RC	REC 100%	190	RQD = 100%
		2	RC	REC 97%	189	RQD = 97%
		3	RC	REC 100%	188	RQD = 98%
187.2 / 5.7	END OF BOREHOLE					

Plot column headings: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (20 40 60 80 100) — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

NOTES:

1. Water level in open borehole at ground surface (Elev. 192.9 m) upon completion of drilling.

2. Standpipe piezometer was installed 1.0 m east of Borehole B301-04A.

3. Water level measurement in Piezometer :

Date	Depth (m)	Elev. (m)
31/01/12	0.0	192.9
11/03/12	0.4	192.5

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

RECORD OF DRILLHOLE: B301-04A

PROJECT: 09-1111-6014

SHEET 1 OF 1

LOCATION: N 5079647.5 ;E 222852.4

DRILLING DATE:

DATUM: Geodetic

DRILL RIG: D25 Bombardier

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: WALKER DRILLING

JN - Joint, FLT - Fault, SH - 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, VR- Very Rough, MB - Mechanical Break, BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	NOTES
		Continued from Record of Borehole B301-04A	191.10						
2	NW Casing	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong to very strong, grey, pink and black	1.80						Screen
					JN,PL,RO	1.5	1		
				1				1	
									9.6 MPa (Axial)
3									
	NQRC, January 31, 2012			2	JN,PL,SM	1	1		
					JN,PL,SM	1	10		
					JN,PL,SM	1	10		
					FR,PL,RO	1.5			
4								2	
					FR,PL,SM	1	6		
5				3	FR,PL,SM	1	6		
					FR,PL,SM	1	6		
								1	
									(Axial)
			187.17						
6		END OF DRILLHOLE	5.73						

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 2/3/14

Golder Associates

RECORD OF BOREHOLE No B301-05

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-00

LOCATION N 5079648.4 ;E 222861.3

ORIGINATED BY MR

DIST ____ HWY 69

BOREHOLE TYPE NQ Coring

COMPILED BY CS

DATUM Geodetic

DATE February 1, 2012

CHECKED BY TVA/CN

ELEV DEPTH	SOIL PROFILE 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 + 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.1	GROUND SURFACE										
0.0	TOPSOIL		1A	SS	3	∇	193		○		
192.6 0.5	SAND, some silt, containing organics and rootlets Very loose Brown Wet		1B								
	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 0.5 m to 5.7 m For bedrock coring details refer to Record of Drillhole B301-05		1	RC	REC 98%		192				RQD = 95%
			2	RC	REC 100%		191				RQD = 76%
			3	RC	REC 94%		190				RQD = 34%
			4	RC	REC 100%		189				RQD = 96%
187.4			5	RC	REC 100%		188				RQD = 100%
5.7	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 192.8 m) upon completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B301-05

SHEET 1 OF 1

LOCATION: N 5079648.4 ;E 222861.3

DRILLING DATE:

DATUM: Geodetic

DRILL RIG: D25 Bombardier

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: WALKER DRILLING

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough, MB - Mechanical Break, BR - Broken Rock

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

Columns: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH | COLOUR % RETURN | RECOVERY (TOTAL CORE %, SOLID CORE %) | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn) | HYDRAULIC CONDUCTIVITY K, cm/sec | Diametral Point Load Index (MPa) | RMC -Q' AVG. | NOTES

Depth	Drilling record	Description	Elev. / Depth (m)	Run No.	Type and surface description	Jr	Ja	Jn	Notes
		Continued from Record of Borehole B301-05	192.61						
0.49	NQRC, February 1, 2012	GRANITE GNEISS Slightly weathered to fresh, medium crystalline, slightly porous, very strong, grey, pink and black	0.49	1				2	(Axial)
				1	JN,PL,SM JN,PL,SM JN,PL,SM JN,PL,SM	1 1 1 1	2 1 1 2		
				2	JN,PL,RO	1.5	1		
				2	JN,PL,SM	1	1		
				2	JN,IR,SM	2	2	3	
				2	JN,PL,RO	1.5	6		
				3	FLT,IR,SM	4	2		
				3	JN,PL,SM	1	4	3	
				3	FLT,PL,SM FLT,PL,SM	2 2	6 6		
				4	JN,IR,SM	2	2	2	8.7 MPa (Axial)
				4	JN,PL,SM JN,PL,SM	1 1	2 1		
				5				0.5	
5.70		END OF DRILLHOLE	187.40 5.70						

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

Golder Associates

RECORD OF BOREHOLE No B301-06

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-00

LOCATION N 5079666.0 ;E 222832.3

ORIGINATED BY MR

DIST

HWY 69

BOREHOLE TYPE NQ Coring

COMPILED BY CS

DATUM Geodetic

DATE January 29, 2012

CHECKED BY TVA/CN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.8	GROUND SURFACE					
0.0	TOPSOIL					
	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 0.03 m to 6.1 m For bedrock coring details refer to Record of Drillhole B301-06	1	RC	REC 100%	193	RQD = 92%
		2	RC	REC 100%	192 / 191	RQD = 92%
		3	RC	REC 91%	190	RQD = 87%
187.7		4	RC	REC 100%	189 / 188	RQD = 88%
6.1	END OF BOREHOLE					

Chart headings: 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; STRAT PLOT; GROUND WATER CONDITIONS

NOTE:

1. Water level measurement in Piezometer :

Date	Depth (m)	Elev. (m)
29/01/12	0.2	193.6
11/03/12	0.6	193.2

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B301-06

SHEET 1 OF 1

LOCATION: N 5079666.0 ;E 222832.3

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE:

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DATUM: Geodetic

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough
MB - Mechanical Break, BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	DISCONTINUITY TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	NOTES
		Continued from Record of Borehole B301-06	193.77						
	NQRC, January 29, 2012	GRANITE GNEISS Fresh, medium crystalline, slightly porous, strong to very strong, grey, pink and black	0.03	1				2	
					FLT,IR,SM JN,PL,SM	2 1	5 1		
					JN,PL,SM	1	4		
				2	JN,PL,SM				
					JN,PL,SM	1	1		
					FR,IR,SM	1	2	2	
									(Axial)
					JN,PL,RO JN,PL,SM	1 1	2 2		
				3	FR,PL,SM FR,PL,SM FR,PL,SM FR,PL,SM FR,PL,SM	1 1 1 1 1	1 1 1 1 1		
								1	
				4					8.4 MPa (Axial)
					JN,PL,SM JN,PL,SM JN,PL,SM	1 1 1	1 1 1	1	
			187.67 6.13						
		END OF DRILLHOLE							

Depth scale: 1 2 3 4 5 6 7 8 9 10

Column headings: DEPTH SCALE METRES; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. DEPTH (m); RUN No.; FLUSH; COLOUR % RETURN; RECOVERY TOTAL CORE % 80 60 40 20; SOLID CORE % 80 60 40 20; R.Q.D. % 80 60 40 20; FRACT. INDEX PER 0.3 m 5 10 15 20; DISCONTINUITY DATA: B Angle 0 90 180 270; DIP w.r.t. CORE AXIS 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jr; Ja; Jn; HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}; Diametral Point Load Index (MPa) 2 4 6; RMC -Q' AVG.; NOTES

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

RECORD OF BOREHOLE No B301-07

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-00 LOCATION N 5079667.2 ;E 222838.9 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE NQ Coring COMPILED BY CS

DATUM Geodetic DATE January 28, 2012 CHECKED BY TVA/CN

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
193.8	GROUND SURFACE						
0.0	TOPSOIL						
0.1	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 0.1 m to 6.1 m For bedrock coring details refer to Record of Drillhole B301-07	1	RC	REC 99%	▽	193	RQD = 99%
		2	RC	REC 95%		192 191	RQD = 95%
		3	RC	REC 100%		190	RQD = 100%
		4	RC	REC 100%		189 188	RQD = 99%
187.7 6.1	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.9 m below ground surface (Elev. 192.9 m) upon completion of drilling.						

SOIL PROFILE — STRAT PLOT; SAMPLES

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

GR SA SI CL

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B301-07

LOCATION: N 5079667.2 ;E 222838.9

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough, MB - Mechanical Break, BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	NOTES
		Continued from Record of Borehole B301-07	193.71						
0	NQRC, January 28, 2012	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, very strong, grey, pink and black	0.09	1	JN,PL,SM	1	1	1	(Axial)
1				1	JN,PL,SM	1	1		
2				2	JN,CU,SM	2	2	1	UC= 146.5 MPa
3–4				3				0.5	(Axial)
5				4	JN,PL,SM	1	8	1	
				4	JN,PL,SM	1	1		
6				4	JN,PL,SM	1	3		
		END OF DRILLHOLE	187.70 6.10						

Column headings also printed: SYMBOLIC LOG; COLOUR % RETURN; FLUSH; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER 0.3 m; DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS); HYDRAULIC CONDUCTIVITY K, cm/sec; Diametral Point Load Index (MPa); RMC -Q' AVG.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

RECORD OF BOREHOLE No B301-08

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5404-05-00 LOCATION N 5079663.2 ;E 222847.4 ORIGINATED BY MR
DIST HWY 69 BOREHOLE TYPE NQ Coring COMPILED BY CS
DATUM Geodetic DATE January 29, 2012 CHECKED BY TVA/CN

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
193.4	GROUND SURFACE					
0.0 / 0.1	TOPSOIL					
192.7	Silty SAND, trace gravel, Very loose, Brown, Moist	1A / 1B	SS	3	193	
0.7	Granitic Gneiss (BEDROCK)	1	RC	REC 100%	192	RQD = 100%
	Bedrock cored from depths of 0.7 m to 6.0 m	2	RC	REC 100%	191	RQD = 100%
	For bedrock coring details refer to Record of Drillhole B301-08	3	RC	REC 100%	190, 189	RQD = 100%
		4	RC	REC 100%	188	RQD = 91%
187.4 / 6.0	END OF BOREHOLE					

NOTE:

1. Water level measurement in Piezometer :

Date	Depth (m)	Elev. (m)
29/01/12	0.0	193.4
11/03/12	0.5	192.9

Plot headers: 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; GR SA SI CL

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B301-08

SHEET 1 OF 1

LOCATION: N 5079663.2 ;E 222847.4

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE:

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DATUM: Geodetic

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough
MB - Mechanical Break, BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	NOTES
		Continued from Record of Borehole B301-08	192.73						
	NQRC, January 29, 2012	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, very strong, grey, pink and black	0.67		FR,PL,RO FR,PL,RO	1.5 1.5	1		
1				1				1	(Axial)
					JN,PL,RO	1.5	1		
2					JN,IR,RO	3	1		
				2				1	
3					JN,PL,RO	1.5			
					FR,CU,PO	1.5	2		
4				3				1	10.0 MPa (Axial)
					FR,IR,SM	2	10		
5				4				2	
					FR,PL,RO FR,PL,RO FR,IR,RO FR,IR,RO FR,IR,RO	1.5 1.5 3 3 3	2		
6		END OF DRILLHOLE	187.39 6.01						
7									
8									
9									
10									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: TVA/CN

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 1/28/14

Golder Associates

RECORD OF BOREHOLE No B301-09

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014
W.P. 5404-05-00
LOCATION N 5079665.1 ;E 222856.8
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE NW Casing, Wash Boring
COMPILED BY CS
DATUM Geodetic
DATE February 1, 2012
CHECKED BY TVA/CN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.5	GROUND SURFACE							
0.0	TOPSOIL	1A	SS	3	▽	193		
0.2 / 192.9 / 0.6	SILT, trace sand, containing organics and rootlets. Very loose, Brown, Wet	1B						
192.0	SAND and SILT, trace to some clay, containing sand seams. Compact, Brown to grey, Wet	2	SS	16		192		0 36 58 6
191.7 / 1.8	Silty SAND. Compact, Grey, Wet	3	SS	25/0.13				
	Granitic Gneiss (BEDROCK). Bedrock cored from depths of 1.8 m to 5.6 m. For bedrock coring details refer to Record of Drillhole B301-09	1	RC	REC 96%		191		RQD = 79%
		2	RC	REC 96%		190, 189		RQD = 92%
187.9		3	RC	REC 100%		188		RQD = 93%
5.6	END OF BOREHOLE							

NOTE:

1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 193.3 m) upon completion of drilling.

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: 09-1111-6014

RECORD OF DRILLHOLE: B301-09

SHEET 1 OF 1

LOCATION: N 5079665.1 ;E 222856.8

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE:

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DATUM: Geodetic

JN - Joint, FLT - Fault, SH - 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, VR - Very Rough
MB - Mechanical Break, BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

Column headings: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | COLOUR % RETURN | FLUSH | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.3 m (5 10 15 20) | DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3}) | Diametral Point Load Index (MPa) (2 4 6) | RMC -Q' AVG. | NOTES

Continued from Record of Borehole B301-09 — 191.70

Drilling record: NW Casing; NQRC, February 1, 2012

ELEV. / DEPTH (m)	DESCRIPTION	RUN No.
191.70 / 1.80	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, very strong, grey, pink and black	1, 2, 3
187.89 / 5.61	END OF DRILLHOLE	

TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn
FR,PL,SM	1	1	
FR,PL,SM	1	1	
FR,PL,SM	1	1	
FR,PL,SM	1	1	
FR,PL,SM	1	1	
FR,PL,RO	1	1	
FR,PL,RO	1.5		2
FR,IR,SM	1	2	
JN,PL,SM	1	1	
JN,PL,SM	1	3	
JN,PL,SM	1	3	
FR,PL,RO	1.5		2
FR,PL,SM	1	2	
FR,PL,SM	1	1	
FR,IR,RO	3	1	
FR,PL,SM	1	1	
FR,IR,RO	3	1	1
FR,PL,RO	1	1	

NOTES: (Axial) [at ~2.1 m]; 9.3 MPa [at ~4.3 m]; 10.0 MPa (Axial) [at ~5.6 m]

Depth scale: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Golder Associates

RECORD OF BOREHOLE No B301-10

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5404-05-00
LOCATION N 5079662.4 ;E 222863.8
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 163 mm O.D. Continuous Flight Solid Stem Augers
COMPILED BY BM
DATUM Geodetic
DATE January 19, 2012
CHECKED BY TVA/CN

ELEV DEPTH	DESCRIPTION
193.6	GROUND SURFACE
0.0	TOPSOIL
0.2	Sandy SILT, trace to some clay, containing organics, Very loose, Brown, Wet
192.9 / 0.7	SAND and SILT, trace to some clay, containing sand seams, Compact, Brown and grey, Wet
192.2	
191.9 / 1.7	Silty SAND, Compact, Brown, Wet
	END OF BOREHOLE, SPOON AND AUGER REFUSAL

SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
1A / 1B	SS	2						
			∇	193				
2	SS	14			0	32	61	7
3	SS	50/0.03		192				

Column headings: 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; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE:

1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 192.8 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No B301-11

SHEET 1 OF 1 **METRIC**

PROJECT	09-1111-6014				
W.P.	5404-05-00	LOCATION	N 5079630.6 ;E 222841.4	ORIGINATED BY	MR
DIST		HWY 69	BOREHOLE TYPE 163 mm O.D. Continuous Flight Solid Stem Augers	COMPILED BY	BM
DATUM	Geodetic	DATE	January 18, 2012	CHECKED BY	TVA/CN

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
192.4	GROUND SURFACE											
0.0	TOPSOIL	1A	SS	3		192						
191.7 / 0.2–0.7	Silty SAND, trace clay, containing rootlets. Very loose. Brown and grey. Wet	1B			∇							
191.0 / 1.4	SAND and SILT, trace to some clay, containing sand seams. Loose. Brown and grey. Wet	2	SS	9		191	o (~20)		0	35	59	6
190.5 / 1.9	Silty SAND. Compact. Brown and grey. Wet	3	SS	53/0.03								
	END OF BOREHOLE. SPOON AND AUGER REFUSAL											

NOTE:

1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 191.6 m) upon completion of drilling.

Chart legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O 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; REMARKS & GRAIN SIZE DISTRIBUTION (%).

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No B301-12

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5404-05-00

LOCATION N 5079683.9 ;E 222851.0

ORIGINATED BY MR

DIST

HWY 69

BOREHOLE TYPE Hand Excavation

COMPILED BY MAS

DATUM Geodetic

DATE January 18, 2012

CHECKED BY TVA/CN

SOIL PROFILE 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: O 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.6	GROUND SURFACE										
0.0	TOPSOIL										
0.1	BEDROCK										
	NOTE:										
	1. Hand excavation dry upon completion.										

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 1/28/14

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

APPENDIX B

Laboratory Test Results and Bedrock Core Photographs

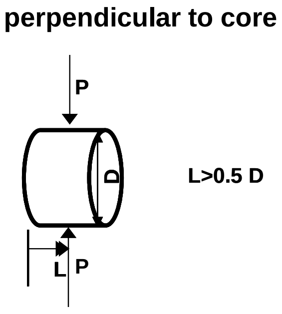
TABLE B1

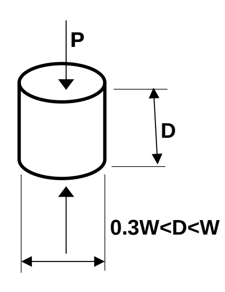
POINT LOAD TEST RESULTS ON ROCK SAMPLES

Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core [2] Diameter (mm)	**Is (50mm)** (MPa)	**Approx. UCS Value [1]** (MPa)
B301-02	1	2.4	190.5	Granite Gneiss	Axial	17.94	47.35	7.666	115
B301-02	2	3.6	189.3	Granite Gneiss	Diametral	43.13	41.04	5.006	75
B301-02	3	5.2	187.7	Granite Gneiss	Axial	19.23	47.32	7.626	114
B301-03	1	1.5	191.2	Granite Gneiss	Diametral	40.28	41.60	6.505	98
B301-03	2	2.5	190.2	Granite Gneiss	Axial	16.62	47.33	6.826	102
B301-03	3	4.0	188.7	Granite Gneiss	Diametral	46.77	41.62	4.334	65
B301-04	1	2.7	190.2	Granite Gneiss	Axial	19.18	47.38	7.771	117
B301-04	2	4.5	188.4	Granite Gneiss	Diametral	39.76	44.02	5.571	84
B301-04A	1	2.6	190.3	Granite Gneiss	Axial	19.95	47.40	9.633	144
B301-04A	2	3.8	189.1	Granite Gneiss	Diametral	42.50	45.09	2.840	43
B301-04A	3	5.4	187.5	Granite Gneiss	Axial	21.50	47.36	7.343	110
B301-05	1	1.0	192.1	Granite Gneiss	Axial	19.22	47.38	6.259	94
B301-05	2	1.8	191.3	Granite Gneiss	Diametral	42.7	41.52	7.273	109
B301-05	3	4.0	189.1	Granite Gneiss	Axial	16.74	47.36	8.715	131
B301-05	4	5.5	187.6	Granite Gneiss	Diametral	40.01	43.25	6.429	96
B301-06	1	0.3	193.5	Granite Gneiss	Diametral	42.7	41.31	5.903	89
B301-06	2	2.7	191.1	Granite Gneiss	Axial	18.18	47.36	6.336	95
B301-06	3	4.3	189.5	Granite Gneiss	Diametral	43.72	44.43	3.078	46
B301-06	4	5.1	188.7	Granite Gneiss	Axial	20.1	47.39	8.377	126
B301-07	1	0.6	193.2	Granite Gneiss	Axial	18.63	47.37	7.879	118
B301-07	2	2.6	191.2	Granite Gneiss	Diametral	41.6	43.97	6.664	100
B301-07	3	3.6	190.2	Granite Gneiss	Axial	17.11	47.35	7.501	113
B301-07	4	5.8	188.0	Granite Gneiss	Diametral	47.32	41.92	5.442	82
B301-08	1	1.2	192.2	Granite Gneiss	Axial	19.21	47.37	7.805	117
B301-08	2	2.5	190.9	Granite Gneiss	Diametral	41.02	43.92	5.563	83
B301-08	3	4.3	189.1	Granite Gneiss	Axial	17.59	47.38	9.975	150
B301-08	4	5.6	187.8	Granite Gneiss	Diametral	43.62	41.77	6.154	92
B301-09	1	2.1	191.4	Granite Gneiss	Axial	19.98	47.37	6.195	93
B301-09	2	4.3	189.2	Granite Gneiss	Diametral	45.1	44.38	9.260	139
B301-09	3	5.5	188.0	Granite Gneiss	Axial	19.63	47.46	9.961	149

[1] Is_{50} x K, from ASTM Designation: D 5731 "Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications". A value of K = 15 has been used based on the average of sixteen (16) Is_{50} axial tests and UCS tests for similar bedrock core zones at the bridge location.

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS
note: Diametral tests are perpendicular to core axis
(planes of weakness)





AXIAL SPECIMEN SHAPE REQUIREMENTS
note: Axial tests are parallel to core axis
(planes of weakness)

Compiled By: MAS/CC
Checked By: TVA/CN
Reviewed By: JPD/JMAC

TABLE B2-1
SUMMARY OF UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
BEKANON ROAD SBL OVERPASS STRUCTURE
HIGHWAY 69 GWP 5404-05-00; WP 5142-08-01

Borehole Number (Core Run)	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
B301-02 (3)	5.2	187.7	Granite Gneiss	47.3	128.9
B301-07 (2)	2.7	191.1	Granite Gneiss	47.4	146.5

Compiled By: MAS
Checked By: TVA
Reviewed By: JPD/JMAC

TABLE B2-2

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	3
BOREHOLE NUMBER	B301-02	SAMPLE DEPTH, m	5.10-5.22

TEST CONDITIONS

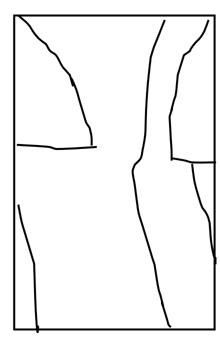
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.44

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.53	WATER CONTENT, (specimen) %	0.12
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m^3	26.24
SAMPLE AREA, cm^2	17.60	DRY UNIT WT., kN/m^3	26.21
SAMPLE VOLUME, cm^3	202.94	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	543.20	VOID RATIO	0.01
DRY WEIGHT, g	542.55		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	128.9
REMARKS:	N/A	DATE:	2012-03-16
CHECKED BY:	MAS/TVA	REVIEWED BY:	JPD/JMAC

TABLE B2-3

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B301-07	SAMPLE DEPTH, m	2.60-2.73

TEST CONDITIONS

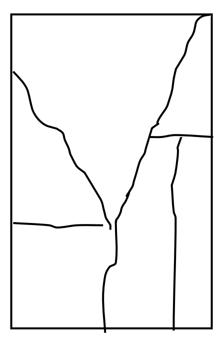
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.43

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.53	WATER CONTENT, (specimen) %	0.12
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m^3	26.27
SAMPLE AREA, cm^2	17.62	DRY UNIT WT., kN/m^3	26.24
SAMPLE VOLUME, cm^3	203.12	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	544.40	VOID RATIO	0.01
DRY WEIGHT, g	543.75		

VISUAL INSPECTION

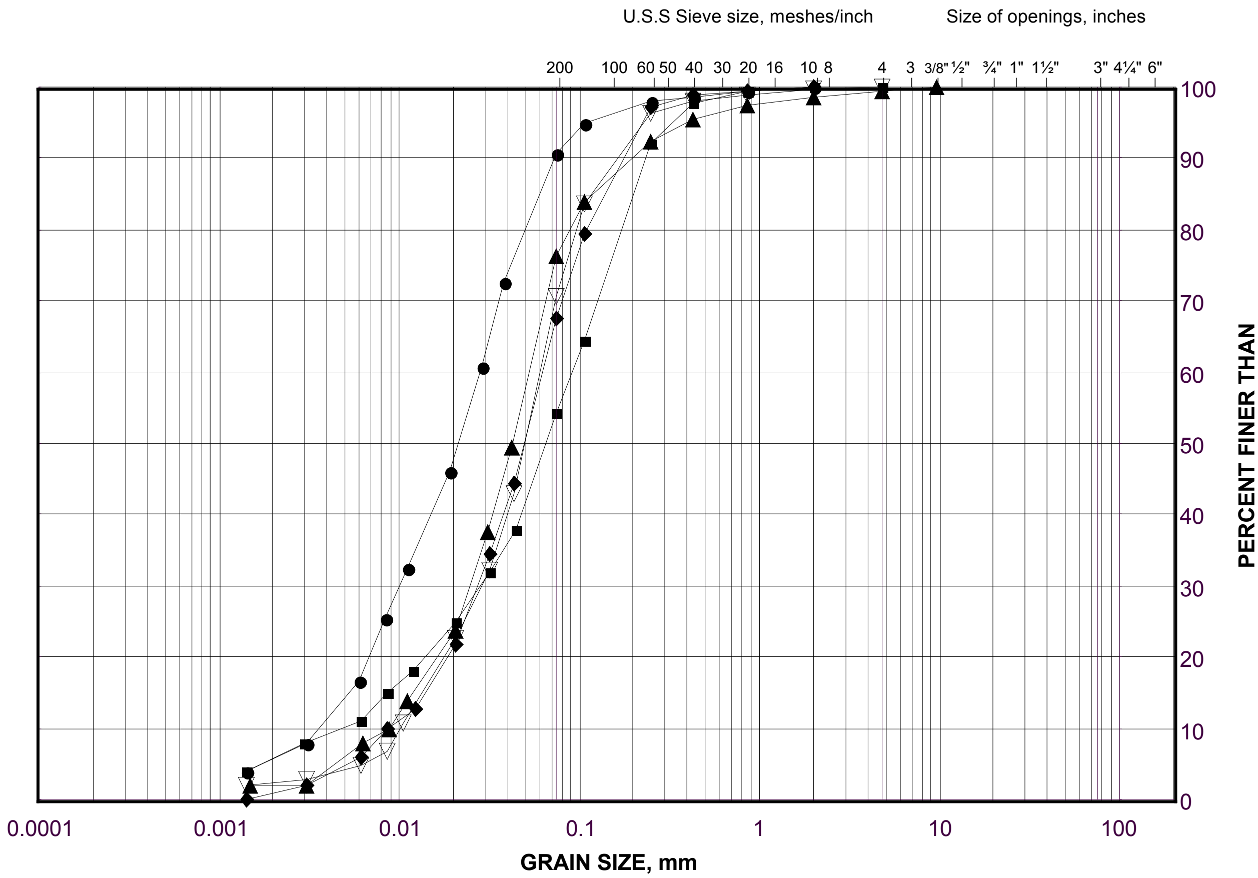
FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	146.5
REMARKS: N/A		DATE:	2012-03-16
CHECKED BY: MAS/TVA		REVIEWED BY:	JPD/JMAC

GRAIN SIZE DISTRIBUTION Silt to Sandy Silt to Sand and Silt Bekanon Road SBL Overpass Structure	FIGURE B1-1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B301-04A	1B	192.5
■	B301-04	2	192.0
◆	B301-02	2	192.0
▲	B301-01	2	192.2
▽	B301-04A	3A	191.3

Project Number: 09-1111-6014

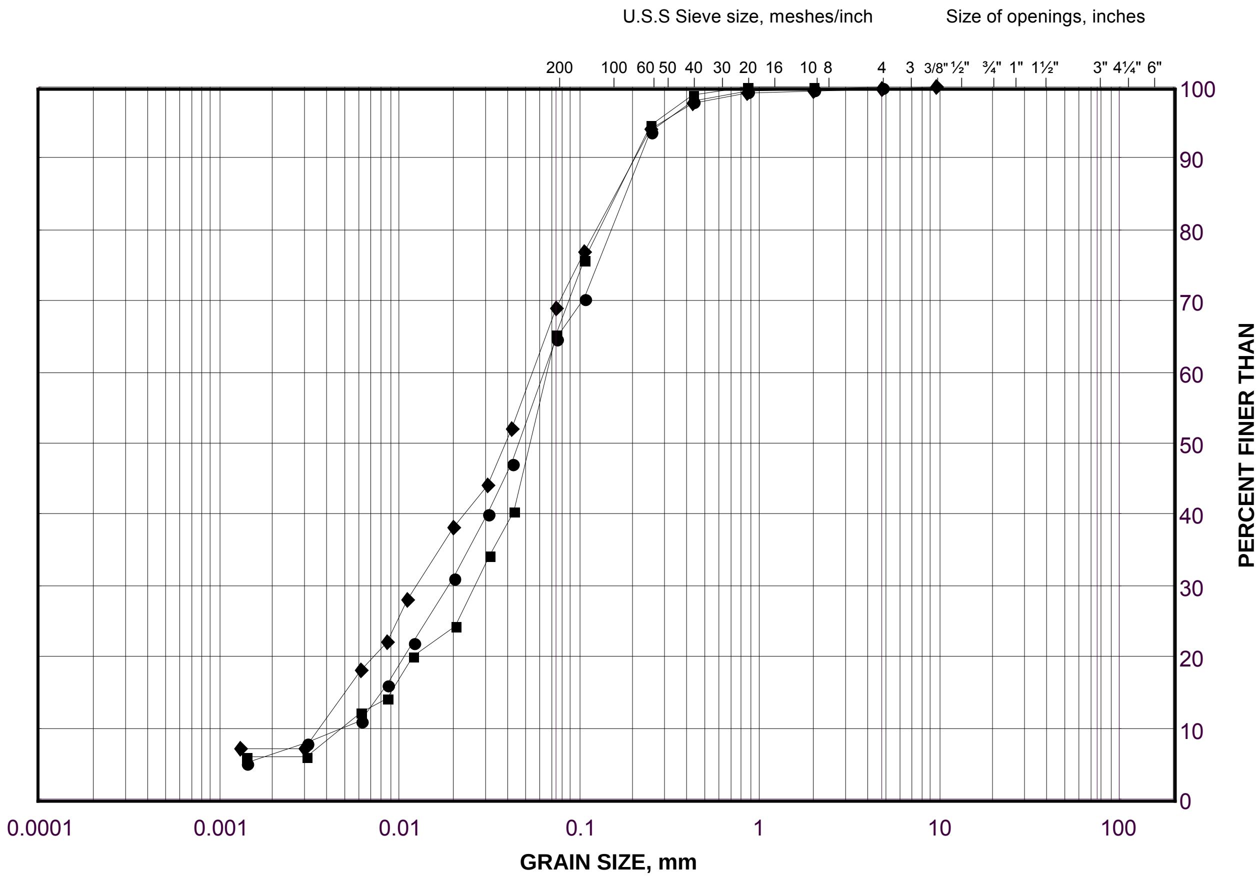
Checked By: CN

Golder Associates

Date: 17-Jul-12

GRAIN SIZE DISTRIBUTION
Sand and Silt
Bekanon Road SBL Overpass Structure

FIGURE B1-2



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B301-09	2	192.4
■	B301-11	2	191.4
◆	B301-10	2	192.6

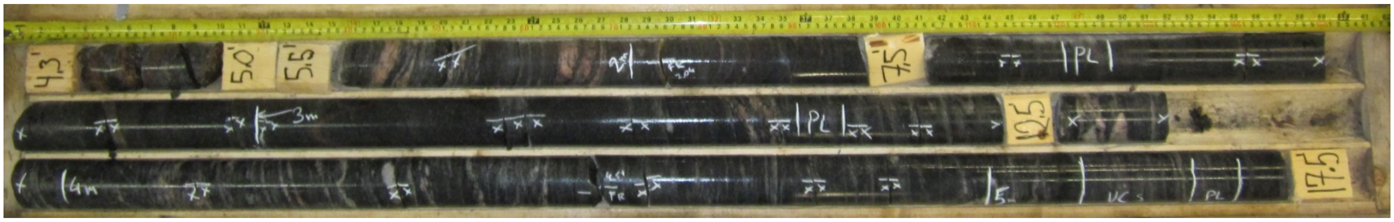
Project Number: 09-1111-6014

Checked By: CN

Golder Associates

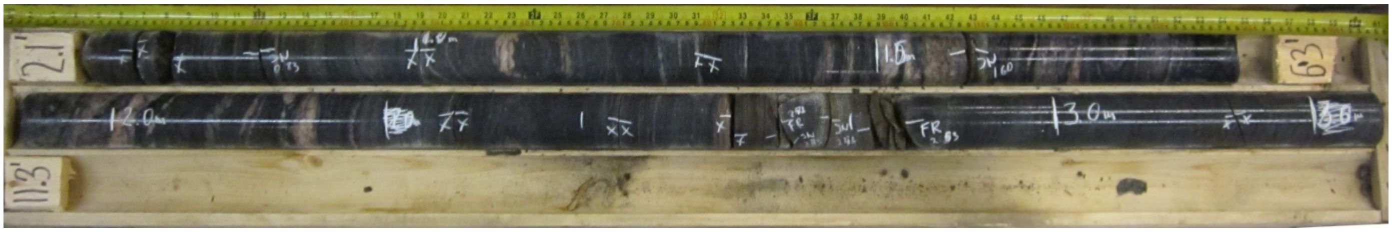
Date: 07-Aug-12

Borehole B301-02

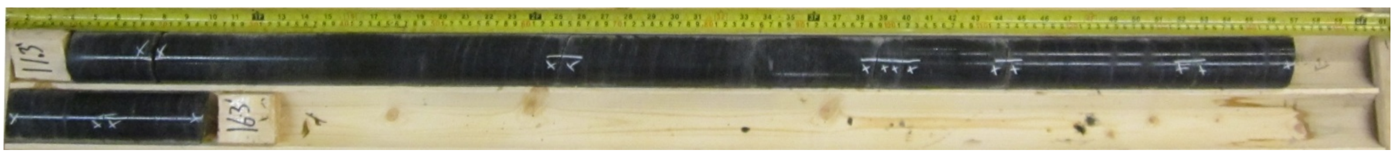


Box 1: 1.68 m – 5.33 m

Borehole B301-03



Box 1: 0.69 m – 3.44 m



Box 2: 3.44 m – 4.97 m

Borehole B301-04

Box 1: 2.04 m – 5.09 m

Box 2: 5.09 m – 5.91 m

0 m | 0.25 m | 0.5 m | 0.75 m | 1.0 m | 1.25 m | 1.5 m

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

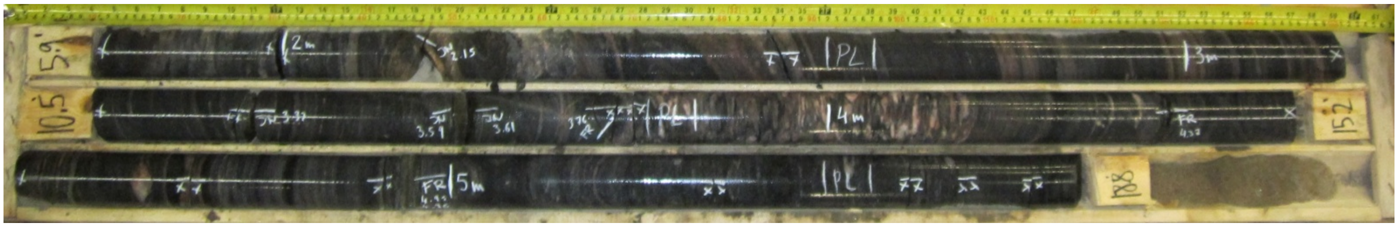
Scale

PROJECT	**Bekanon Road SBL Overpass Structure Highway 69 Four-Laning GWP 5404-05-00; WP 5142-08-01**
TITLE	**Bedrock Core Photographs – B301-02 to B301-04**

PROJECT No.	09-1111-6014	FILE No.	----
DESIGN	MAS	SCALE	NTS REV.
CADD	--		
CHECK	TVA	**FIGURE B2**	
REVIEW	JMAC		

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

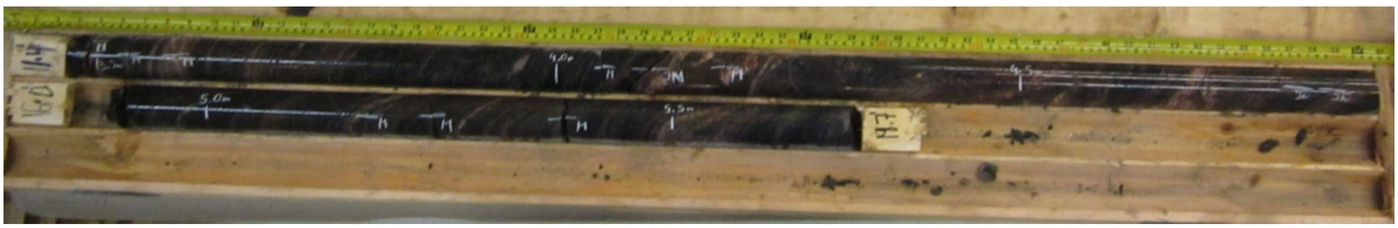
Borehole B301-04A



Box 1: 1.80 m – 5.73 m

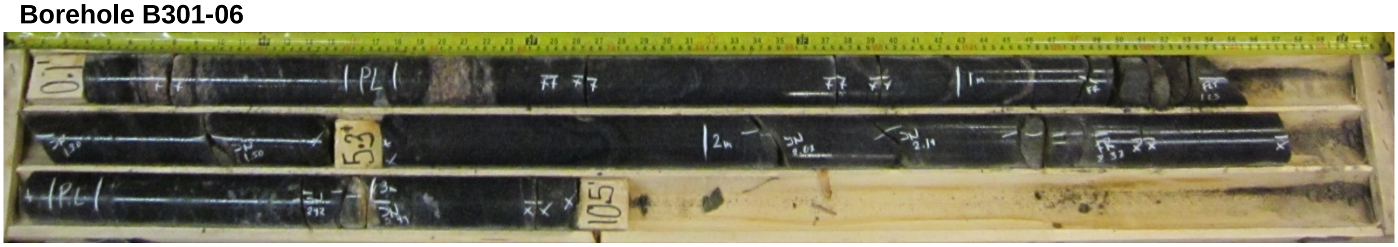
Borehole B301-05

Box 1: 0.49 m – 3.47 m



Box 2: 3.47 m – 5.70 m

Borehole B301-06



Box 1: 0.03 m – 3.20 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT **Bekanon Road SBL Overpass Structure**
Highway 69 Four-Laning
GWP 5404-05-00; WP 5142-08-01

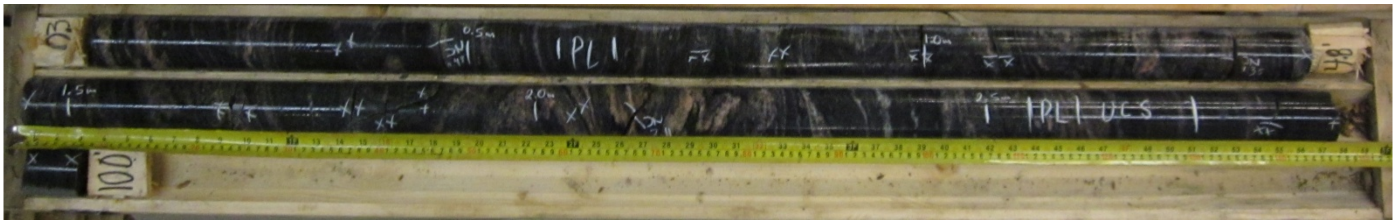
TITLE **Bedrock Core Photographs – B301-04A to B301-06**

Golder Associates

PROJECT No. 09-1111-6014		FILE No. ----	
DESIGN	MAS	SCALE NTS	REV.
CADD	--	**FIGURE B3**	
CHECK	TVA		
REVIEW	JMAC		

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

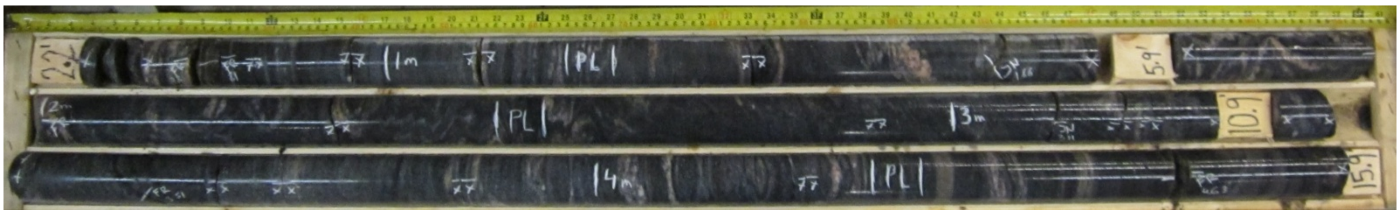
Borehole B301-07



Box 1: 0.09 m – 3.05 m

Box 2: 3.05 m – 6.10 m

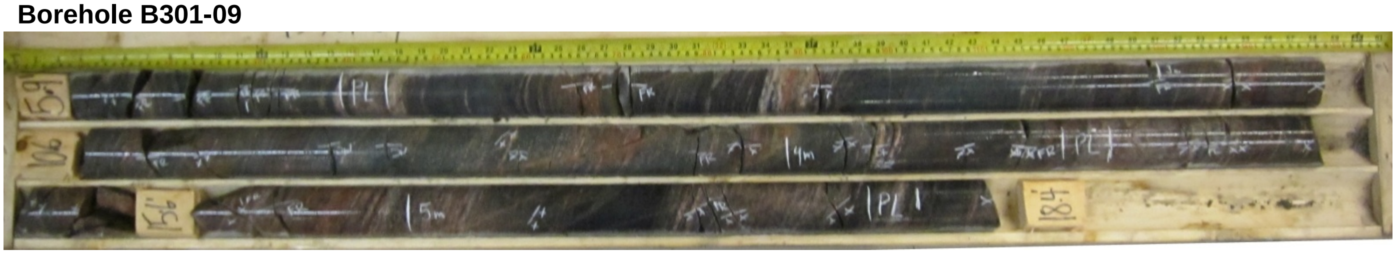
Borehole B301-08



Box 1: 0.67 m – 4.85 m

Box 2: 4.85 m – 6.01 m

Borehole B301-09



Box 1: 1.80 m – 5.61 m

0 m | 0.25 m | 0.5 m | 0.75 m | 1.0 m | 1.25 m | 1.5 m

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Scale

PROJECT **Bekanon Road SBL Overpass Structure**
Highway 69 Four-Laning
GWP 5404-05-00; WP 5142-08-01

TITLE
Bedrock Core Photographs – B301-07 to B301-09

Golder Associates

PROJECT No. 09-1111-6014		FILE No. ----		
DESIGN	MAS	SCALE	NTS	REV.
CADD	--	**FIGURE B4**		
CHECK	TVA			
REVIEW	JMAC			

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

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 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 25 MPa at 28 days.

If 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.

Bridge	Foundation	Number of Dowels for Performance Testing
Highway 69 / Bekanon Road Bridge (SBL)	North and South Abutment	2

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 abutment and pier 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

---

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

MASS CONCRETE - Item No.

Non-Standard Special Provision

Scope of Work

The scope of work for the above noted tender item includes mass concrete under the south abutment footings.

Construction

Concrete shall be of the same strength as the footing concrete and placed in accordance with OPSS.PROV 904 Concrete Structures[i].

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

[i] OPSS.PROV 904 Construction Specification for Concrete Structures

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