



JANUARY 28, 2014

FOUNDATION INVESTIGATION REPORT

**BEKANON ROAD NBL OVERPASS STRUCTURE, SITE NO. 44-459/1
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 5141-08-01**

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REPORT





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PART A

FOUNDATION INVESTIGATION REPORT

BEKANON ROAD NBL OVERPASS STRUCTURE, SITE NO. 44-459/1

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 5141-08-01



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 northbound lane (NBL) structure over Bekanon Road (Site No. 44-459/1), 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 NBL 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 NBL 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 NBL 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 NBL 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 north of the junction between existing Highway 69 and Highway 526. The proposed new four-lane Highway 69 alignment is oriented generally in a south-north direction and parallel to the east side of the existing Highway 69 within the Contract 3 project limits.

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 194.9 m and 193.1 m, referenced to Geodetic datum, and is gently sloping downward from south to north.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the proposed Bekanon Road NBL Overpass structure was carried out on January 18, and between January 24 and 28, 2012 during which time a total of twelve (12) boreholes were advanced at the locations of the structure foundation footprint and approach embankments. A summary of the respective boreholes advanced at each foundation element and approach embankment is presented below.

Foundation Element/Approach Embankment	Borehole No.
South Approach Embankment	B302-11
South Abutment	B302-01 (Bedrock Exposed) B302-02 B302-03 B302-04 B302-05
North Abutment	B302-06 B302-07 B302-08 B302-09 B302-10
North Approach Embankment	B302-12

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 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. The boreholes were advanced through the overburden using 163 mm outer diameter (O.D.) solid-stem augers. 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 operated 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 advanced to auger, casing and/or sampler refusal (i.e. inferred bedrock) and bedrock was confirmed by coring in selected boreholes. The borehole proposed at the west corner of the south abutment was located on a bedrock outcrop. The boreholes were advanced to depths of up to about 7.0 m below existing ground surface, including coring of bedrock for core lengths between about 5.8 m and 7.0 m in Boreholes B302-02 to B302-09. Photographs of the recovered rock samples are provided in Appendix B.



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The groundwater conditions and water levels in the open boreholes were observed during the drilling operations. Within the limits of the south abutment, a piezometer was installed in Borehole B302-03 to monitor the ground water level at this location. The piezometer consists 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 a standpipe piezometer is 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, consisting of 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, ground surface elevations and drilled depths are summarized below.

Borehole No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B302-01 ¹	5079647.3	222870.6	194.6	0.0
B302-02	5079644.5	222877.8	194.9	7.0
B302-03	5079646.6	222884.8	194.5	7.0
B302-04	5079642.8	222891.3	194.3	6.4
B302-05	5079643.9	222898.0	193.8	6.1
B302-06	5079661.0	222874.7	194.2	6.7
B302-07	5079662.2	222881.1	194.5	6.7
B302-08	5079658.5	222887.0	194.4	6.3
B302-09	5079660.5	222894.6	193.9	5.9
B302-10	5079657.6	222904.0	193.1	0.8
B302-11	5079626.0	222881.0	194.3	0.3
B302-12	5079679.2	222890.9	193.6	0.2

Note: 1. Borehole B302-01 refers to a shovel excavation carried out at the east side of the south abutment 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 4². 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 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 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 NBL Overpass structure consist of a layer of topsoil, underlain by a thin, discontinuous non-cohesive deposit of sand and silt to silty sand to sandy silt, underlain by bedrock. The overburden thickness is minimal across the proposed bridge structure, ranging from no cover at the west corner of the south abutment (i.e. bedrock outcrops exposed at ground surface) to up to 0.8 m at the east and west corners of the north abutment.

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

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, between less than about 0.1 m and up to 0.3 m thick, was encountered at the ground surface at all borehole locations except for Borehole B302-01.

4.2.2 Sand to Sandy Silt

A deposit of brown sand to sandy silt was encountered below the topsoil in Boreholes B302-05, B302-06, B302-10 and B302-12. The top of this deposit was encountered between about Elevation 194.1 m and 193.0 m and the thicknesses of the deposit ranges between about 0.1 m and 0.7 m.

The SPT 'N'-values measured within the sand to sandy silt deposit are 2 blows and 4 blows per 0.3 m of penetration indicating a very loose 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 deposit varies in composition from sand, some silt to sandy silt to silty sand to sand and silt, trace clay. The grain size distributions of two (2) samples from the non-cohesive deposit are presented on Figure B1 in Appendix B.

The natural water content measured on five (5) samples of the sand to sandy silt are between about 25 per cent and 46 per cent.

4.2.3 Bedrock/Refusal

Bedrock was encountered and core samples were recovered from Boreholes B302-02 to B302-09. Bedrock outcrops were observed in the area of the proposed structure and the bedrock is exposed at ground surface at the location of Borehole B302-01. The bedrock surface was inferred from split-spoon and auger refusal in Boreholes B302-10 to B302-12. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.

Foundation Element / Approach Embankment	Borehole	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
South Approach Embankment	B302-11	0.3	194.0	Split-Spoon and Auger Refusal
South Abutment	B302-01	0.0	194.6	Bedrock Exposed
	B302-02	<0.1	194.9	Bedrock Cored
	B302-03	0.1	194.4	Bedrock Cored
	B302-04	0.1	194.2	Bedrock Cored
	B302-05	0.2	193.6	Bedrock Cored
North Abutment	B302-06	0.8	193.4	Bedrock Cored
	B302-07	0.2	194.3	Bedrock Cored
	B302-08	<0.1	194.4	Bedrock Cored



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Foundation Element / Approach Embankment	Borehole	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
	B302-09	0.1	193.8	Bedrock Cored
	B302-10	0.8	192.3	Split-Spoon and Auger Refusal
North Approach Embankment	B302-12	0.2	193.4	Split-Spoon and Auger Refusal

In general, the bedrock surface in the area of the Bekanon Road NBL Overpass structure slopes downward from approximately southwest to northeast, with the bedrock surface elevation changing by as much as about 2.6 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 photograph of the recovered core samples on Figures B2 to B5 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 (ISRM³) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 90 per cent to 100 per cent, indicating a rock mass of excellent quality as per Table 3.10 of CFEM (2006). However, portions of core recovered from Borehole B302-08 contain fractured rock with RQD values as low as about 50 per cent, indicating a rock mass of fair quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 68 per cent and 100 per cent and between 57 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 nineteen (19) samples of the granite gneiss bedrock core measured Is_{50} values ranging from about 3.2 MPa to 11.7 MPa and the diametral tests carried out on sixteen (16) samples of the granite gneiss bedrock core measured Is_{50} values ranging from about 2.5 MPa to 7.9 MPa.

Four (4) 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 gneiss bedrock obtained in Boreholes B302-02, B302-03 and B302-08 and measured compressive strengths ranging from about 62 MPa to about 111 MPa, as summarized in Table B2-1 and detailed in Tables B2-2 to B2-5 in Appendix B.

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.



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 strong to very strong (R4, 50 MPa < UCS < 100 MPa to R5, 100 MPa < UCS < 250 MPa).

4.2.4 Groundwater Conditions

The overburden samples taken in the boreholes were moist. The water level observed in the boreholes upon completion of drilling varied between about Elevation 191.5 m and 194.3 m, measured at about 2.9 m below ground surface and at ground surface, respectively. Boreholes B302-10 and B302-12 were dry upon completion of drilling.

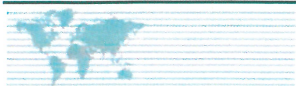
A standpipe piezometer was installed in Borehole B302-03 to allow monitoring of the groundwater level at the site. Details of the piezometer installation are shown on the Record of Borehole sheet in Appendix A. The groundwater level measured in the piezometer installation is summarized below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
South Abutment	B302-03	194.5	193.3	January 25, 2012
			192.8	January 28, 2012
			193.4	March 11, 2012

It should be noted that 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, a senior technician with Golder, directed the drilling program. This report was prepared by Mr. Matt Soderman, E.I.T., and reviewed by Mr. Christopher Ng, P.Eng., a geotechnical engineer and Associate 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.

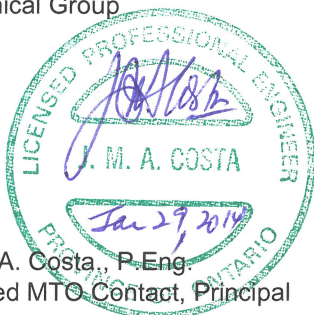


Report Signature Page

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MAS/CN/JPD/JMAC/jl

[https://capws.golder.com/sites/0911116014highway69fourlaning/contract 3/reporting/final/bekanon road overpass nbl/09-1111-6014-3522 rpt 14jan28 bekanon road nbl overpass.docx](https://capws.golder.com/sites/0911116014highway69fourlaning/contract%203/reporting/final/bekanon%20road%20overpass%20nbl/09-1111-6014-3522%20rpt%2014jan28%20bekanon%20road%20nbl%20overpass.docx)



REFERENCES

Bowles, J.E. 1984. Physical and Geotechnical Properties of Soils, Second Edition. McGraw Hill Book Company, New York.

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd., British Columbia.

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

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.

Geology of Ontario. 1991. Ontario Geological Society, Special Volume 4, Part 2. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

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.

Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL-6800, Research Project 1493-6. Prepared for Electric Power Research Institute, Palo Alto, California.

Peck, R.B., Hanson, W.E., and Thornburn, T.H. 1974. Foundation Engineering, Second Edition, John Wiley and Sons, New York.

U.S. Navy. 1986. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.

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

Commercial Software:

Settle3D (Version 2.0) by Rocscience Inc.

Slide (Version 6.0) by Rocscience Inc.

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

Special Provision 206S03 Amendment to OPSS 206 – Earth 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:

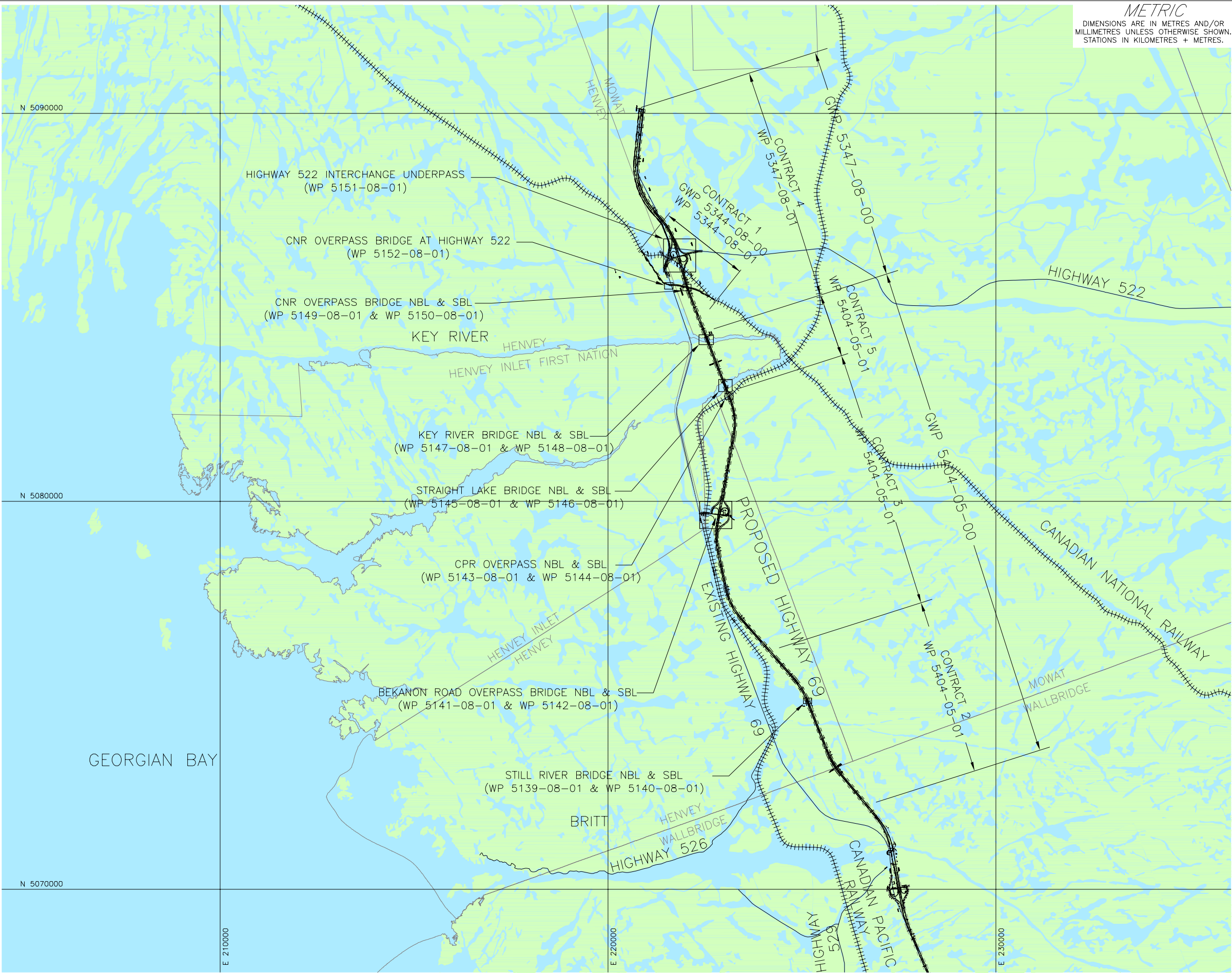
OPSS 120 General Specification for Use of Explosives

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)



DRAWINGS



PLAN



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

CONT No.
GWP No. 5404-05-00

HIGHWAY 69
SITE LOCATION PLAN

SHEET

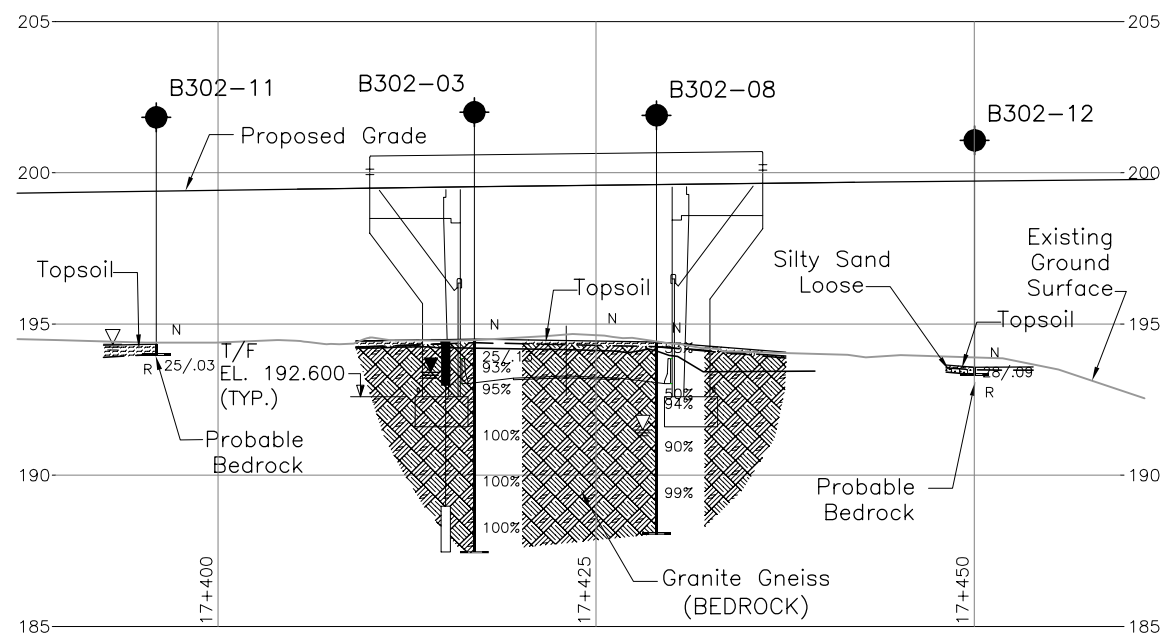
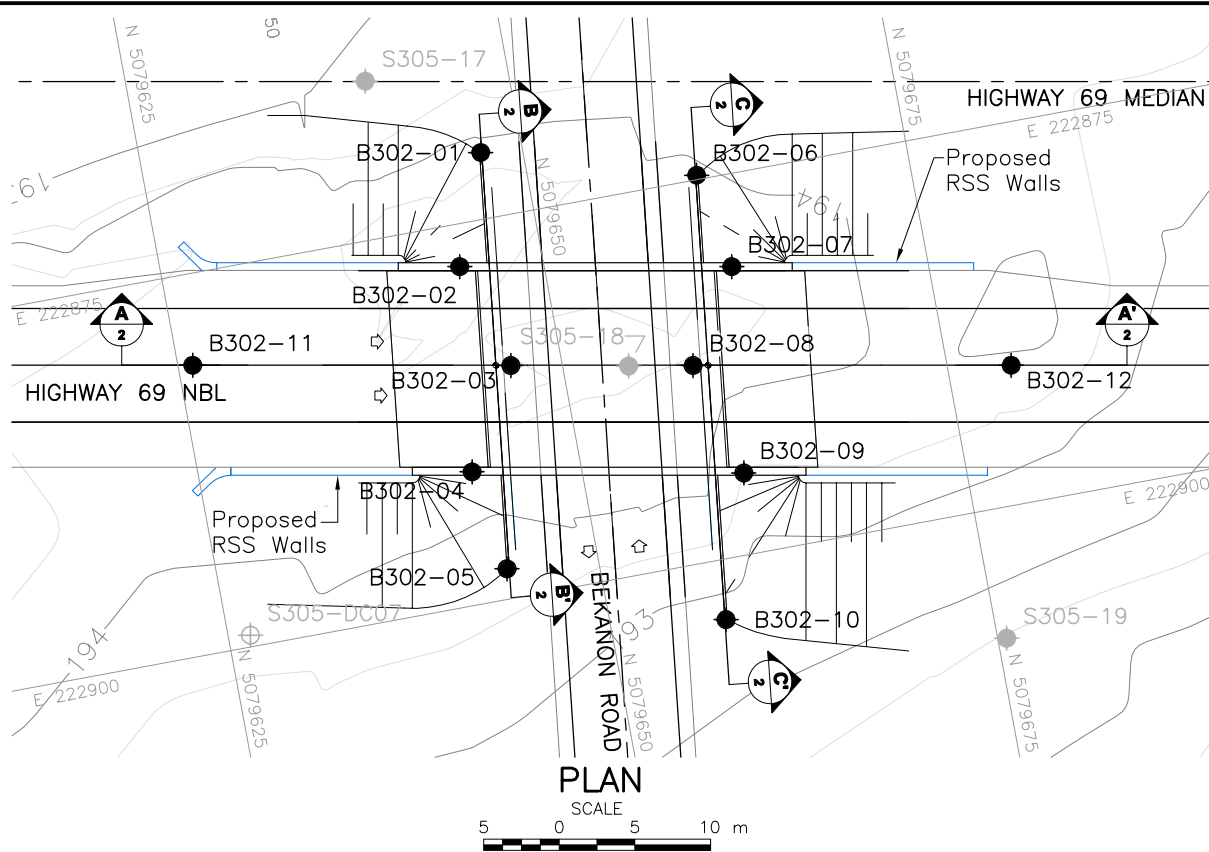
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KEY PLAN
NOT TO SCALE

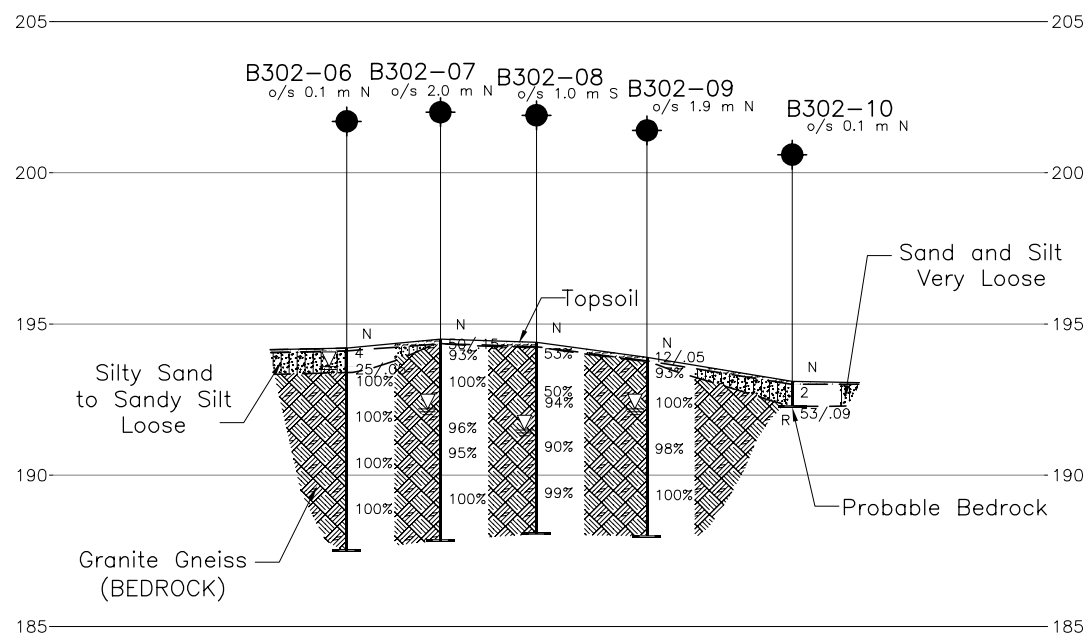
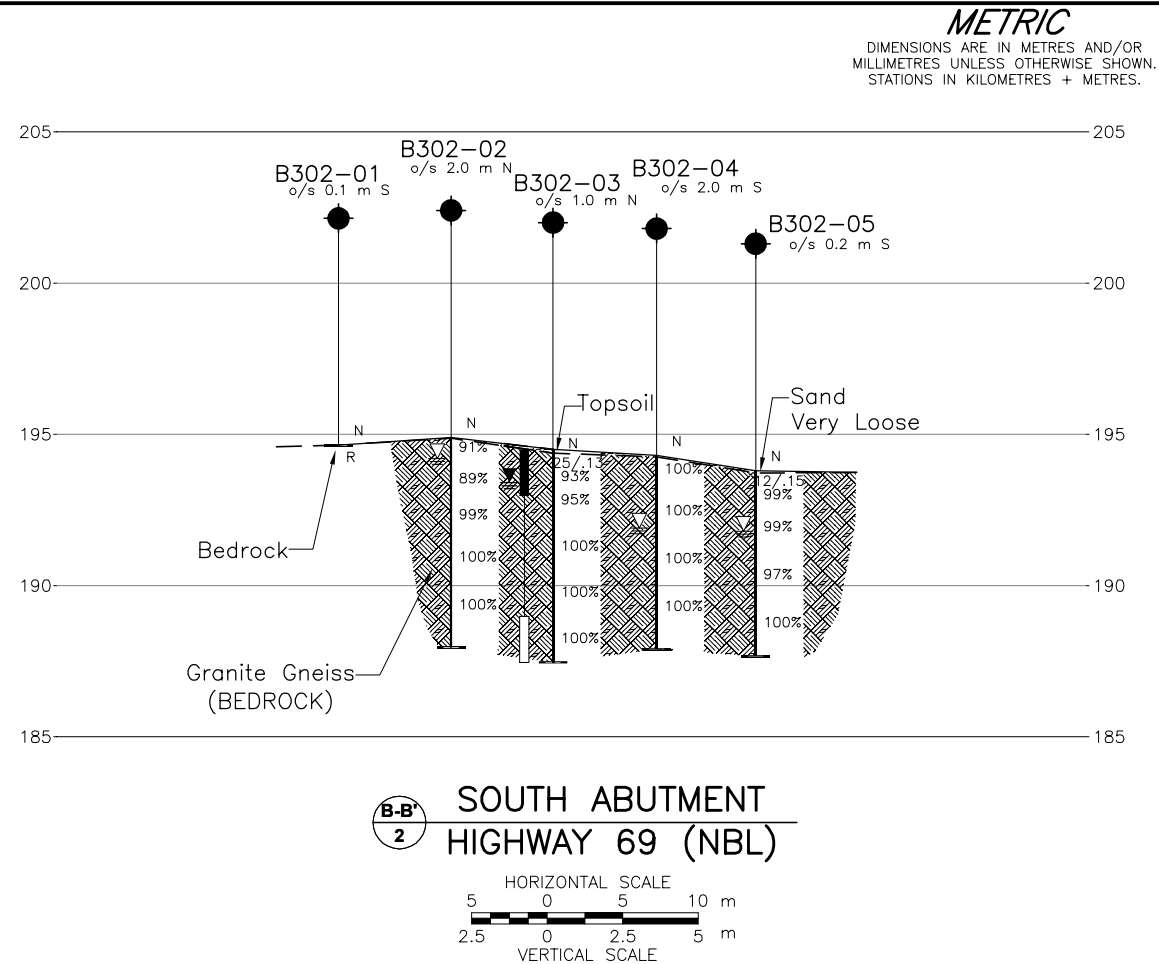
REFERENCE
Base Data - MNR NRVIS, obtained 2004, CANMAP v2008
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Datum : NAD 83 Projection : MTM Zone 10

NO.	DATE	BY	REVISION
Geocres No.41H-122			
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



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 NBL GA.dwg, received December
12, 2011 and Proposed and Existing Grades obtained from drawing file
Hwy69_profile March 2012.dwg, received March 14, 2012.

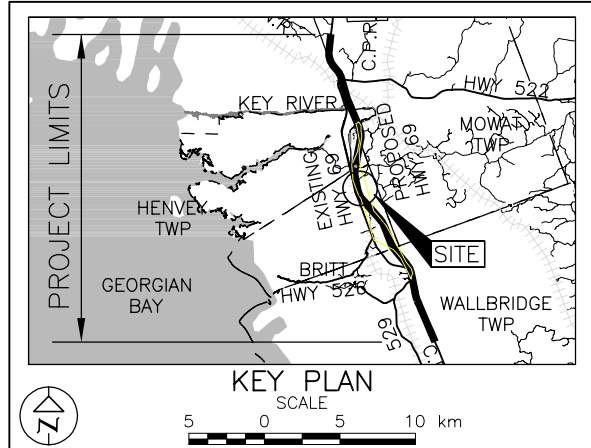


CONT No.
WP No.5141-08-01

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



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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
B302-01	194.6	5079647.3	222870.6
B302-02	194.9	5079644.5	222877.8
B302-03	194.5	5079646.6	222884.8
B302-04	194.3	5079642.8	222891.3
B302-05	193.8	5079643.9	222898.0
B302-06	194.2	5079661.0	222874.7
B302-07	194.5	5079662.2	222881.1
B302-08	194.4	5079658.5	222887.0
B302-09	193.9	5079660.5	222894.6
B302-10	193.1	5079657.6	222904.0
B302-11	194.3	5079626.0	222881.0
B302-12	193.6	5079679.2	222890.9

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.

NO.	DATE	BY	REVISION
Geocres No. 41H-122			
HWY. 69	PROJECT NO.		DIST.
SUBM'D. MAS	CHKD. MAS	DATE: Dec. 2012	SITE: 44-459/1
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 2





APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B302-01				SHEET 1 OF 1		METRIC								
W.P. 5404-05-00		LOCATION N 5079647.3 ; E 222870.6				ORIGINATED BY MR										
DIST HWY 69		BOREHOLE TYPE Hand Excavation				COMPILED BY MAS										
DATUM Geodetic		DATE January 18, 2012				CHECKED BY CN/JMAC										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
194.6 0.0	GROUND SURFACE BEDROCK															
	NOTES: 1. Pick refusal on outcropping bedrock 2. Hand excavation dry upon completion.															

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B302-02		SHEET 1 OF 1		METRIC	
W.P. <u>5404-05-00</u>		LOCATION <u>N 5079644.5 ;E 222877.8</u>		ORIGINATED BY <u>MR</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>NQ Coring</u>		COMPILED BY <u>CS</u>			
DATUM <u>Geodetic</u>		DATE <u>January 28, 2012</u>		CHECKED BY <u>CN/JMAC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	W _p	W	W _L			
194.9	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL																
	Granitic Gneiss (BEDROCK)																
	Bedrock cored from depths of 0.1 m to 7.0 m		1	RC	REC 96%											RQD = 91%	
	For bedrock coring details refer to Record of Drillhole B302-02		2	RC	REC 97%											RQD = 89%	
			3	RC	REC 99%											RQD = 99%	
			4	RC	REC 100%											RQD = 100%	
			5	RC	REC 100%											RQD = 100%	
187.9	END OF BOREHOLE																
7.0	NOTE: 1. Water level in open borehole at a depth of 0.7 m below ground surface (Elev. 194.2 m) upon completion of drilling.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-02

SHEET 1 OF 1

LOCATION: N 5079644.5 ; E 222877.8

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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		Continued from Record of Borehole B302-02		194.87 0.03																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
1	NQRC January 28, 2012	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong, grey, pink and black		1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

PROJECT		RECORD OF BOREHOLE		No B302-03		SHEET 1 OF 1		METRIC									
W.P. 5404-05-00		LOCATION		N 5079646.6 ; E 222884.8		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		NQ Coring		COMPILED BY		CS							
DATUM		Geodetic		DATE		January 24, 2012		CHECKED BY		CN/JMAC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
194.5	GROUND SURFACE																
0.0	TOPSOIL		1	SS	25/0.13												
0.1	Granitic Gneiss (BEDROCK)		1	RC	REC 99%												RQD = 93%
	Bedrock cored from depths of 0.1 m to 7.0 m																
	For bedrock coring details refer to Record of Drillhole B302-03																
			2	RC	REC 100%												RQD = 95%
			3	RC	REC 100%												RQD = 100%
			4	RC	REC 100%												RQD = 100%
			5	RC	REC 100%												RQD = 100%
187.5	END OF BOREHOLE																
7.0	NOTES:																
	1. Water level in open borehole at ground surface upon completion of drilling.																
	2. Water level measurement in Piezometer:																
	Date Depth (m) Elev. (m)																
	25/01/12 1.2 193.3																
	28/01/12 1.7 192.8																
	11/03/12 1.1 193.4																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-03

SHEET 1 OF 1

LOCATION: N 5079646.6 ; E 222884.8

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	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.	NOTES
		Continued from Record of Borehole B302-03		194.38									
1		GRANITE GNEISS Fresh, medium crystalline, slightly porous, strong to very strong, dark grey to grey, pink to white		0.12	1								6.3
2					2								9.9 MPa (Axial)
3					3								6.9 MPa
4					4								4.4 MPa
5					5								UC=111 MPa 3.9 MPa
6													
7		END OF DRILLHOLE		187.46									7.3 MPa (Axial)
8				7.04									
9													
10													

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

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

PROJECT		RECORD OF BOREHOLE		No B302-04		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5079642.8 ; E 222891.3		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		NQ Coring		COMPILED BY									
CS		DATE		January 27, 2012		CHECKED BY		CN/JMAC									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
194.3	GROUND SURFACE																
0.9	TOPSOIL																
	Granitic Gneiss (BEDROCK)																
	Bedrock cored from depths of 0.1 m to 6.4 m																
	For bedrock coring details refer to Record of Drillhole B302-04																
			1	RC	REC 100%												RQD = 100%
			2	RC	REC 100%												RQD = 100%
			3	RC	REC 100%												RQD = 100%
			4	RC	REC 100%												RQD = 100%
187.9	END OF BOREHOLE																
6.4	NOTE:																
	1. Water level in open borehole at a depth of 2.4 m below ground surface (Elev. 191.9 m) upon completion of drilling.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-04

SHEET 1 OF 1

LOCATION: N 5079642.8 ; E 222891.3

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	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.	NOTES
1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Continued from Record of Borehole B302-04		194.24 0.06									
		GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong, grey, pink and black											
1					1								7.6 MPa (Axial)
2					2					JN, PL, RO			4.0 MPa
3					3								4.3 MPa
4					4								8.8 MPa (Axial)
5													
6													
7		END OF DRILLHOLE		187.90 6.40									
8													
9													
10													

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

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

PROJECT		RECORD OF BOREHOLE		No B302-05		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5079643.9 ; E 222898.0		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		NQ Coring		COMPILED BY									
DATUM		Geodetic		DATE		January 27, 2012		CHECKED BY									
								CN/JMAC									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
193.8	GROUND SURFACE																
0.0	TOPSOIL		1A	SS	12/0.15												
0.2	SAND, some silt, containing topsoil and rootlets Very loose Brown Moist Granitic Gneiss (BEDROCK)		1B														
	Bedrock cored from depths of 0.2 m to 6.1 m																
	For bedrock coring details refer to Record of Drillhole B302-05																
			1	RC	REC 99%												RQD = 99%
			2	RC	REC 99%												RQD = 99%
			3	RC	REC 97%												RQD = 97%
			4	RC	REC 100%												RQD = 100%
187.7	END OF BOREHOLE																
6.1	NOTE: 1. Water level in open borehole at a depth of 2.0 m below ground surface (Elev. 191.8 m) upon completion of drilling.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-05

SHEET 1 OF 1

LOCATION: N 5079643.9 ; E 222898.0

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	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.	NOTES
1		Continued from Record of Borehole B302-05		193.65									
1		GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong, grey, pink and black		0.15	1								
2					2								
3					3								
4					4								
5													
6													
7													
8													
9													
10													
		END OF DRILLHOLE		187.67									
				6.13									

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

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

PROJECT		RECORD OF BOREHOLE		No B302-06		SHEET 1 OF 1		METRIC												
W.P.		LOCATION		ORIGINATED BY		MR														
DIST		BOREHOLE TYPE		COMPILED BY		CS														
DATUM		DATE		CHECKED BY		CN/JMAC														
09-1111-6014		N 5079661.0 ; E 222874.7																		
5404-05-00		NQ Coring																		
Geodetic		January 26, 2012																		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR	SA	SI	CL
							20	40	60	80	100	20	40	60						
194.2		GROUND SURFACE																		
0.0		TOPSOIL		1A	SS	4	194													
193.6		Silty SAND, containing topsoil and rootlets		1B	SS	25/0.05														
0.8		Loose Brown Moist		2	SS															
		Sandy SILT, trace clay		1	RC	REC 100%	193													
		Loose Brown Moist																		
		Granitic Gneiss (BEDROCK)																		
		Bedrock cored from depths of 0.8 m to 6.7 m		2	RC	REC 100%	192													
		For bedrock coring details refer to Record of Drillhole B302-06																		
				3	RC	REC 100%	191													
				4	RC	REC 100%	190													
							189													
							188													
187.5	6.7	END OF BOREHOLE																		
NOTE: 1. Water level in open borehole at a depth of 0.6 m below ground surface (Elev. 193.6 m) upon completion of drilling.																				

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-06

SHEET 1 OF 1

LOCATION: N 5079661.0 ; E 222874.7

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY				R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY K, cm/sec				Diameter Point Load Index (MPa)	RMC -Q AVG.	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
								TOTAL CORE %	SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 10 10 10	10 10 10 10	10 10 10 10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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1	NORC January 26, 2012	Continued from Record of Borehole B302-06		193.37																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

PROJECT		RECORD OF BOREHOLE		No B302-07		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5079662.2 ; E 222881.1		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		NQ Coring		COMPILED BY		CS							
DATUM		Geodetic		DATE		January 25, 2012		CHECKED BY		CN/JMAC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
194.5	GROUND SURFACE		1	SS	50/0.15												
0.0	TOPSOIL																
0.2	Granitic Gneiss (BEDROCK)		1	RC	REC 97%												RQD = 93%
	Bedrock cored from depths of 0.2 m to 6.7 m		2	RC	REC 100%												RQD = 100%
	For bedrock coring details refer to Record of Drillhole B302-07		3	RC	REC 98%												RQD = 96%
			4	RC	REC 100%												RQD = 95%
			5	RC	REC 100%												RQD = 100%
187.8	END OF BOREHOLE																
6.7	NOTE: 1. Water level in open borehole at a depth of 2.3 m below ground surface (Elev. 192.2 m) upon completion of drilling.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-07

SHEET 1 OF 1

LOCATION: N 5079662.2 ; E 222881.1

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint		BD - Bedding		PL - Planar		PO - Polished		MB - Mechanical Break		NOTES
							FLT - Fault	SH - Shear	FO - Foliation	CO - Contact	CU - Curved	K - Slickensided	BR - Broken Rock				
							VN - Vein	CJ - Conjugate	OR - Orthogonal	ST - Stepped	UN - Undulating	SM - Smooth	NOTE: For additional abbreviations refer to list of abbreviations & symbols.				
							CL - Cleavage	IR - Irregular	VR - Very Rough								
RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.3 m		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		Diameter Point Load Index (MPa)		RMC -Q' AVG.					
TOTAL CORE %	SOLID CORE %					B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 cm	10 cm	10 cm	2.5 cm		
<div>Continued from Record of Borehole B302-07</div> <div>GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong to very strong, grey, pink and black</div>																	
1		1		1		1		JN,PL,SM		1 1				7.2 MPa (Axial)			
2		2		2		2		JN,PL,RO		1.5 1				5.5 MPa			
3		3		3		3		JN,PL,SM		1 2				10.4 MPa (Axial)			
4		4		4		4		JN,PL,RO JN,PL,SM		1.5 2 2 6				5.6 MPa			
5		5		5		5		JN,IR,RO JN,IR,RO		3 6 1.5 1				8.3 MPa (Axial)			
6		6		6		6				0.5							
7		7		7		7											
8		8		8		8											
9		9		9		9											
10		10		10		10											
END OF DRILLHOLE		END OF DRILLHOLE		END OF DRILLHOLE		END OF DRILLHOLE		END OF DRILLHOLE		END OF DRILLHOLE		END OF DRILLHOLE		END OF DRILLHOLE			

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

PROJECT		RECORD OF BOREHOLE		No B302-08		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5079658.5 ; E 222887.0		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		NQ Coring		COMPILED BY		CS							
DATUM		Geodetic		DATE		January 25, 2012		CHECKED BY		CN/JMAC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
194.4	GROUND SURFACE																
0.0	TOPSOIL																
	Granitic Gneiss (BEDROCK)																
	Bedrock cored from depths of 0.003 m to 6.3 m																
	For bedrock coring details refer to Record of Drillhole B302-08																
			1	RC	REC 100%		194										RQD = 53%
			2	RC	REC 68%		193										RQD = 50%
			3	RC	REC 100%		192										RQD = 94%
			4	RC	REC 100%		191										RQD = 90%
			5	RC	REC 99%		189										RQD = 99%
188.1	END OF BOREHOLE																
6.3	NOTE: 1. Water level in open borehole at a depth of 2.9 m below ground surface (Elev. 191.5 m) upon completion of drilling.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-08

SHEET 1 OF 1

LOCATION: N 5079658.5 ; E 222887.0

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)		NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
							RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K, cm/sec	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	10 ⁻²																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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							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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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Continued from Record of Borehole B302-08																			194.37																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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Slightly weathered to fresh, medium crystalline, slightly porous, strong to very strong, dark grey, grey, pink and black																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: CN/JMAC

PROJECT		RECORD OF BOREHOLE		No B302-09		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5079660.5 ; E 222894.6		ORIGINATED BY		MR									
DIST		HWY 69		BOREHOLE TYPE		NQ Coring		COMPILED BY									
CS		DATE		January 26, 2012		CHECKED BY		CN/JMAC									
DATUM		Geodetic															
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
193.9	GROUND SURFACE																
0.0	TOPSOIL		1	SS	12/0.05												
0.1	Granitic Gneiss (BEDROCK)																
	Bedrock cored from depths of 0.1 m to 5.9 m		1	RC	REC 94%												RQD = 93%
	For bedrock coring details refer to Record of Drillhole B302-09																
			2	RC	REC 100%												RQD = 100%
			3	RC	REC 100%												RQD = 98%
			4	RC	REC 100%												RQD = 100%
188.0	END OF BOREHOLE																
5.9	NOTE: 1. Water level in open borehole at a depth of 1.7 m below ground surface (Elev. 192.2 m) upon completion of drilling.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B302-09

SHEET 1 OF 1

LOCATION: N 5079660.5 ; E 222894.6

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY				R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES						
									TOTAL CORE %	SOLID CORE %	CORROSION %	FRACTURE INDEX			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K ₁₀	K ₅₀	K ₉₀	K _{max}											
																							B Angle	DIP w.r.t. CORE AXIS				DIP w.r.t. CORE AXIS	DIP w.r.t. CORE AXIS	DIP w.r.t. CORE AXIS	DIP w.r.t. CORE AXIS	DIP w.r.t. CORE AXIS	DIP w.r.t. CORE AXIS
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.																													
		Continued from Record of Borehole B302-09		193.78																													
1		GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong to very strong, grey, pink, white and dark grey		0.12	1																				5.8 MPa								
2	2																									5.8 MPa (Axial)							
3	3																									5.1 MPa							
4	4																									7.5 MPa (Axial)							
5																																	
6		END OF DRILLHOLE		187.99	5.91																												
7																																	
8																																	
9																																	
10																																	

DEPTH SCALE

1 : 50





LOGGED: MR

CHECKED: CN/JMAC

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B302-10		SHEET 1 OF 1		METRIC											
W.P. 5404-05-00		LOCATION N 5079657.6 ; E 222904.0		ORIGINATED BY MR													
DIST _____ HWY 69		BOREHOLE TYPE 163 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY MAS													
DATUM Geodetic		DATE January 18, 2012		CHECKED BY CN/JMAC													
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
193.1	GROUND SURFACE																
0.0	TOPSOIL		1A	SS	2		193										
192.3	SAND and SILT, trace gravel, trace clay, containing organics and rootlets		1B	SS	2												1 55 39 5
0.8	Very loose Brown Moist		2	SS	53/0.08												
END OF BOREHOLE SPOON AND AUGER REFUSAL																	
NOTE: 1. Open borehole dry upon completion of drilling.																	

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B302-11				SHEET 1 OF 1		METRIC								
W.P. 5404-05-00		LOCATION N 5079626.0 ; E 222881.0				ORIGINATED BY MR										
DIST _____ HWY 69		BOREHOLE TYPE 163 mm O.D. Continuous Flight Solid Stem Augers				COMPILED BY MAS										
DATUM Geodetic		DATE January 18, 2012				CHECKED BY CN/JMAC										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
194.3	GROUND SURFACE															
0.0 194.0	TOPSOIL		1	SS	25/0.03		194									
0.3	END OF BOREHOLE SPOON AND AUGER REFUSAL															
	NOTE: 1. Water level in open borehole at ground surface (Elev. 194.3 m) upon completion of drilling.															

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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B302-12				SHEET 1 OF 1		METRIC								
W.P. 5404-05-00		LOCATION N 5079679.2 ; E 222890.9				ORIGINATED BY MR										
DIST _____ HWY 69		BOREHOLE TYPE 163 mm O.D. Continuous Flight Solid Stem Augers				COMPILED BY MAS										
DATUM Geodetic		DATE January 18, 2012				CHECKED BY CN/JMAC										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
193.6	GROUND SURFACE															
0.0	TOPSOIL		1A	SS	28/0.09											
0.2	Silty SAND, containing organics and rootlets Loose Brown Moist END OF BOREHOLE SPOON AND AUGER REFUSAL NOTE: 1. Open borehole dry upon completion of drilling.		1B													



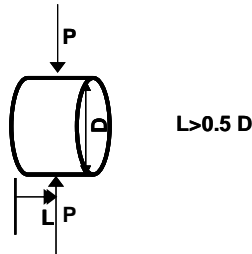
APPENDIX B

Laboratory Test Results and Bedrock Core Photographs

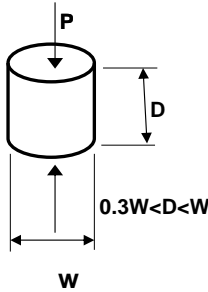
TABLE B1
POINT LOAD TEST RESULTS ON ROCK SAMPLES

Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core Diameter ⁽²⁾ (mm)	Is (50mm) (MPa)	Approx. UCS Value ⁽¹⁾ (MPa)
B302-02	1	1.1	193.8	Granite Gneiss	Axial	16.72	47.32	11.459	172
B302-02	2	1.8	193.1	Granite Gneiss	Diametral	38.61	41.14	7.901	119
B302-02	3	3.5	191.4	Granite Gneiss	Axial	18.60	47.42	11.676	175
B302-02	4	4.4	190.5	Granite Gneiss	Diametral	43.66	44.16	5.599	84
B302-02	5	6.7	188.2	Granite Gneiss	Axial	16.34	47.39	9.219	138
B302-03	1	0.7	193.8	Granite Gneiss	Diametral	49.51	44.29	6.288	94
B302-03	2	2.1	192.4	Granite Gneiss	Axial	18.09	47.35	9.910	149
B302-03	3	3.1	191.4	Granite Gneiss	Diametral	42.84	44.20	6.923	104
B302-03	3	3.7	190.8	Granite Gneiss	Diametral	50.91	43.06	4.417	66
B302-03	4	5.6	188.9	Granite Gneiss	Diametral	45.6	43.86	3.949	59
B302-03	5	6.6	187.9	Granite Gneiss	Axial	15.33	47.31	7.254	109
B302-04	1	0.7	193.6	Granite Gneiss	Axial	20.44	47.11	7.602	114
B302-04	2	2.2	192.1	Granite Gneiss	Diametral	39.33	44.39	4.040	61
B302-04	3	4.2	190.1	Granite Gneiss	Diametral	46.13	45.01	4.320	65
B302-04	4	5.3	189.0	Granite Gneiss	Axial	19.45	47.35	8.755	131
B302-05	1	1.3	192.5	Granite Gneiss	Axial	19.26	47.17	6.657	100
B302-05	2	2.8	191.0	Granite Gneiss	Diametral	46.25	46.01	2.838	43
B302-05	3	3.9	189.9	Granite Gneiss	Axial	18.12	47.38	6.595	99
B302-05	4	5.9	187.9	Granite Gneiss	Diametral	39.18	44.93	4.207	63
B302-06	1	1.4	192.8	Granite Gneiss	Axial	20.63	47.37	7.867	118
B302-06	3	4.6	189.6	Granite Gneiss	Axial	17.62	47.36	9.892	148
B302-06	4	6.1	188.1	Granite Gneiss	Diametral	44.8	42.21	3.609	54
B302-07	1	0.6	193.9	Granite Gneiss	Axial	18.61	46.65	7.166	107
B302-07	2	1.7	192.8	Granite Gneiss	Diametral	40.2	43.88	5.506	83
B302-07	3	3.3	191.2	Granite Gneiss	Axial	18.37	47.15	10.383	156
B302-07	4	4.6	189.9	Granite Gneiss	Diametral	40.6	43.86	5.603	84
B302-07	5	6.3	188.2	Granite Gneiss	Axial	19.37	47.32	8.308	125
B302-08	1	0.7	193.7	Granite Gneiss	Axial	15.50	47.08	11.482	172
B302-08	3	2.4	192.0	Granite Gneiss	Axial	15.22	47.23	10.790	162
B302-08	4	3.8	190.6	Granite Gneiss	Diametral	59.4	42.36	2.520	38
B302-08	5	6.0	188.4	Granite Gneiss	Axial	17.19	47.35	3.167	47
B302-09	1	0.6	193.3	Granite Gneiss	Diametral	49.0	42.93	5.802	87
B302-09	2	2.2	191.7	Granite Gneiss	Axial	19.84	47.31	5.765	86
B302-09	3	3.7	190.2	Granite Gneiss	Diametral	40.6	43.05	5.069	76
B302-09	4	5.6	188.3	Granite Gneiss	Axial	17.770	47.320	7.522	113
⁽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 nineteen (19) 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
Checked By: CN
Reviewed By: JPD/JMAC

TABLE B2-1
SUMMARY OF UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
BEKANON ROAD NBL OVERPASS STRUCTURE
HIGHWAY 69 GWP 5404-05-00; WP 5141-08-01

Borehole Number (Core Run)	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
B302-02 (1)	1.5	193.4	Granite Gneiss	47.4	103.3
B302-03 (4)	5.3	189.2	Granite Gneiss	47.3	111.3
B302-08 (1)	0.7	193.7	Granite Gneiss	46.9	61.8
B302-08 (2)	2.6	191.8	Granite Gneiss	47.2	104.2

Compiled By: MASChecked By: CNReviewed By: JPD/JMAC

TABLE B2-2
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-10

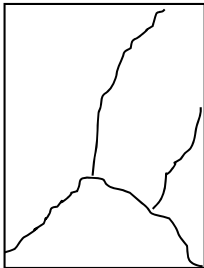
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	1
BOREHOLE NUMBER	B302-02	SAMPLE DEPTH, m	1.43-1.55
TEST CONDITIONS			
MACHINE SPEED, mm/min	0.00	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.33
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	11.03	WATER CONTENT, (specimen) %	0.04
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m ³	26.77
SAMPLE AREA, cm ²	17.66	DRY UNIT WT., kN/m ³	26.76
SAMPLE VOLUME, cm ³	194.80	SPECIFIC GRAVITY	-
WET WEIGHT, g	531.95	VOID RATIO	-
DRY WEIGHT, g	531.74		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	103.3
REMARKS:	N/A	DATE:	2012-11-21
CHECKED BY:	MAS	REVIEWED BY:	JPD/JMAC

TABLE B2-3
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-10

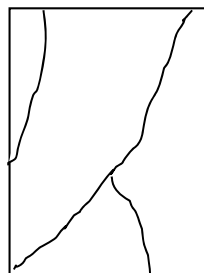
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	4
BOREHOLE NUMBER	B302-03	SAMPLE DEPTH, m	5.20-5.33

TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.34

SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	11.05	WATER CONTENT, (specimen) %	0.10
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m ³	27.01
SAMPLE AREA, cm ²	17.59	DRY UNIT WT., kN/m ³	26.98
SAMPLE VOLUME, cm ³	194.37	SPECIFIC GRAVITY	-
WET WEIGHT, g	535.50	VOID RATIO	-
DRY WEIGHT, g	534.97		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	111.3
REMARKS:	N/A	DATE:	2012-03-16
CHECKED BY:	MAS	REVIEWED BY:	JPD/JMAC

TABLE B2-4
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-10

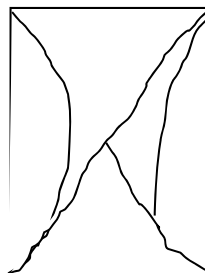
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	1
BOREHOLE NUMBER	B302-08	SAMPLE DEPTH, m	0.68-0.81

TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.31

SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	10.84	WATER CONTENT, (specimen) %	0.18
SAMPLE DIAMETER, cm	4.69	UNIT WEIGHT, kN/m ³	26.11
SAMPLE AREA, cm ²	17.28	DRY UNIT WT., kN/m ³	26.06
SAMPLE VOLUME, cm ³	187.30	SPECIFIC GRAVITY	-
WET WEIGHT, g	498.90	VOID RATIO	-
DRY WEIGHT, g	498.00		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	61.8
REMARKS:	N/A	DATE:	2012-03-16
CHECKED BY:	CN	REVIEWED BY:	JPD/JMAC

TABLE B2-5
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-10

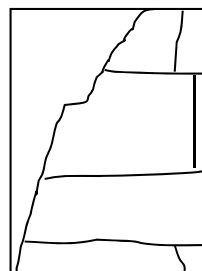
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B302-08	SAMPLE DEPTH, m	2.54-2.64

TEST CONDITIONS			
MACHINE SPEED, mm/min	0.00	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.32

SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	10.97	WATER CONTENT, (specimen) %	0.07
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m ³	26.00
SAMPLE AREA, cm ²	17.50	DRY UNIT WT., kN/m ³	25.98
SAMPLE VOLUME, cm ³	191.95	SPECIFIC GRAVITY	-
WET WEIGHT, g	509.05	VOID RATIO	-
DRY WEIGHT, g	508.69		

VISUAL INSPECTION

FAILURE SKETCH

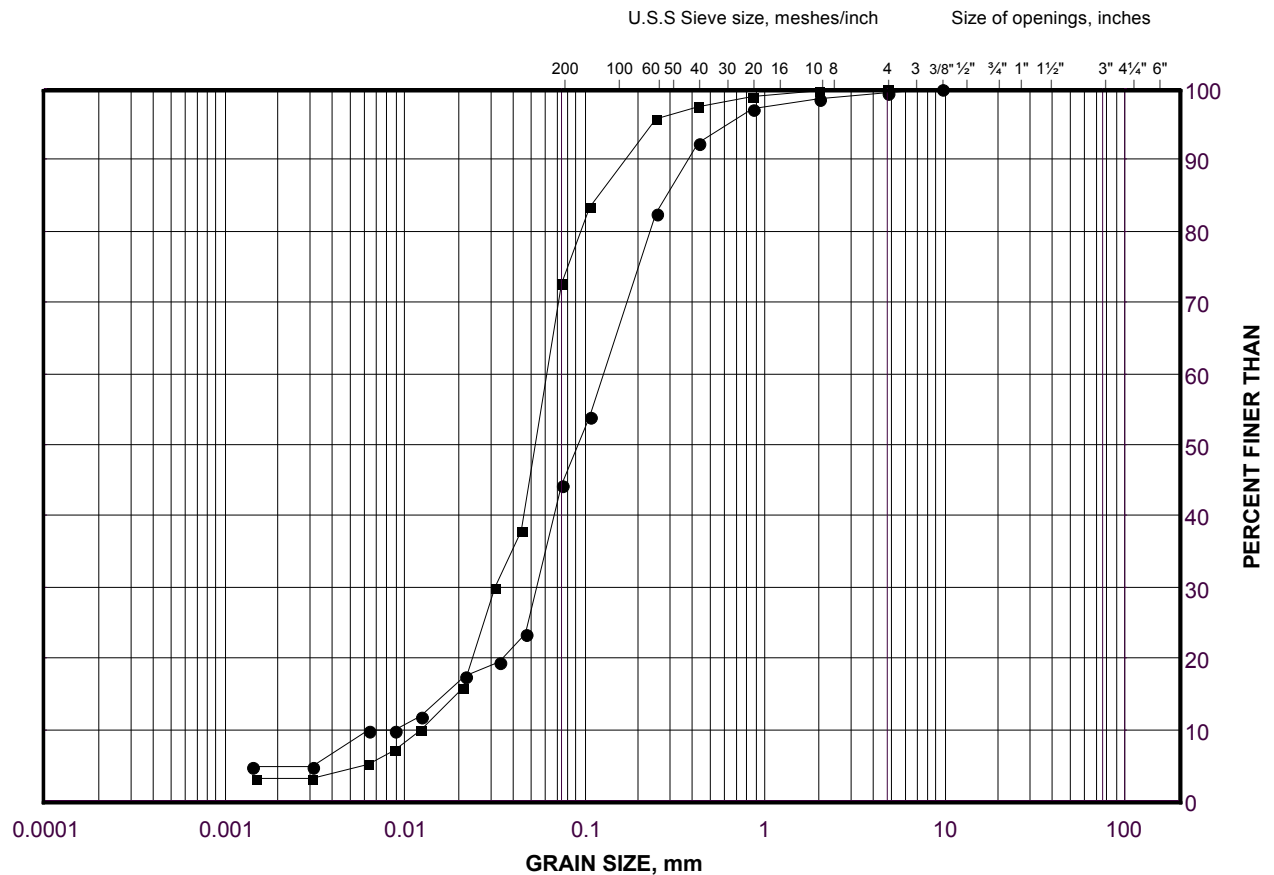


TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	104.2
REMARKS:	N/A	DATE:	2012-11-21
CHECKED BY:	CN	REVIEWED BY:	JPD/JMAC

GRAIN SIZE DISTRIBUTION

Sandy Silt to Sand and Silt
Bekanon Road NBL Overpass Structure

FIGURE B1



Borehole B302-02



Box 1: 0.03 m – 3.78 m



Box 2: 3.78 m – 6.95 m

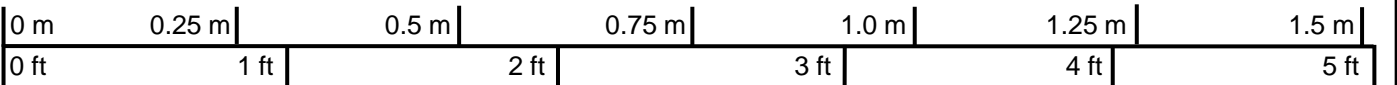
Borehole B302-03




Box 1: 0.12 m – 4.05 m



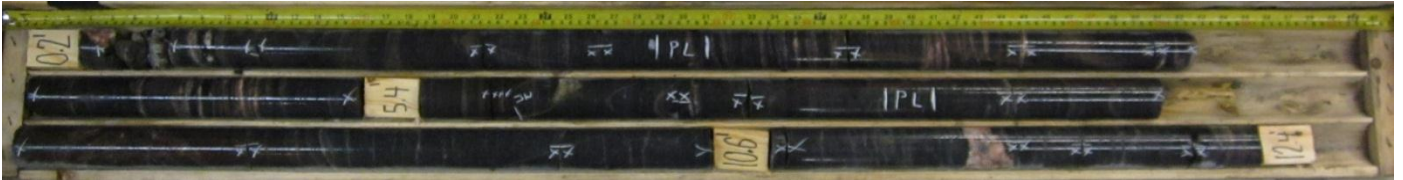
Box 2: 4.05 m – 7.04 m



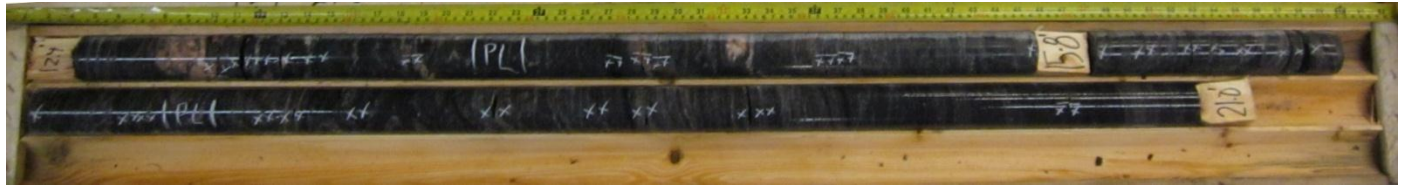
Scale

PROJECT					
Bekanon Road NBL Overpass Structure Highway 69 Four-Laning GWP 5404-05-00; WP 5141-08-01					
TITLE					
Bedrock Core Photographs – B302-02 and B302-03					
			PROJECT No. 09-1111-6014		FILE No. ----
			DESIGN	MAS	NOV12
			CADD	--	
			CHECK	CN	NOV12
			REVIEW	JMAC	NOV12
			SCALE	NTS	REV.
FIGURE B2					

Borehole B302-04

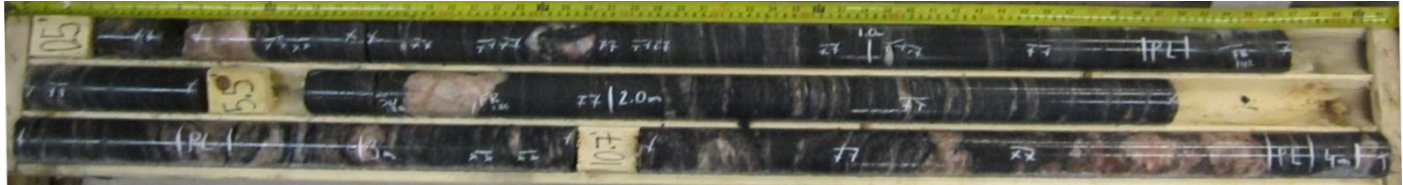


Box 1: 0.06 m – 3.78m

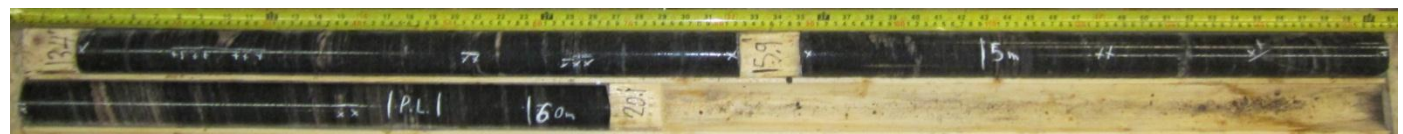


Box 2: 3.78 m – 6.40 m

Borehole B302-05

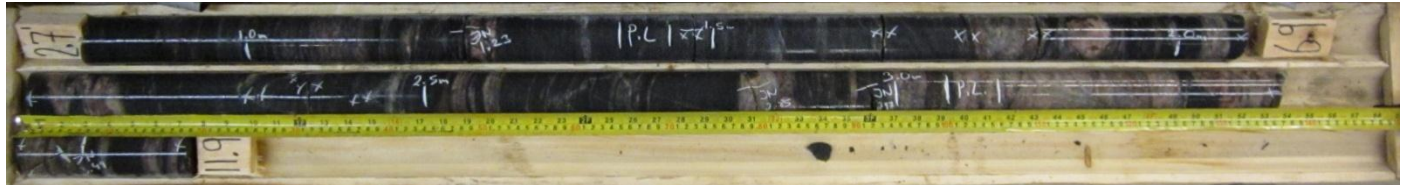


Box 1: 0.15 m – 4.08 m



Box 2: 4.08 m – 6.13 m

Borehole B302-06




Box 1: 0.83 m – 3.63 m



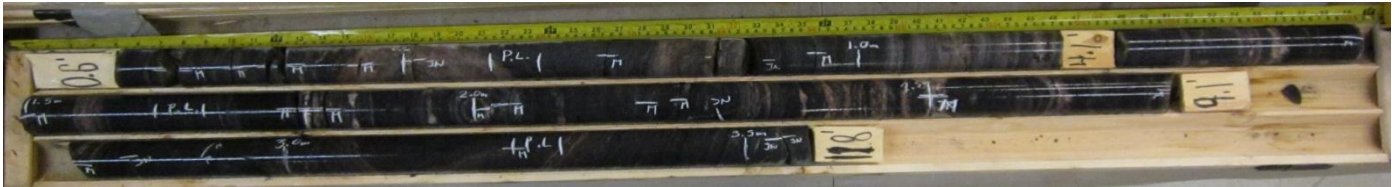
Box 2: 3.63 m – 6.68 m

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	

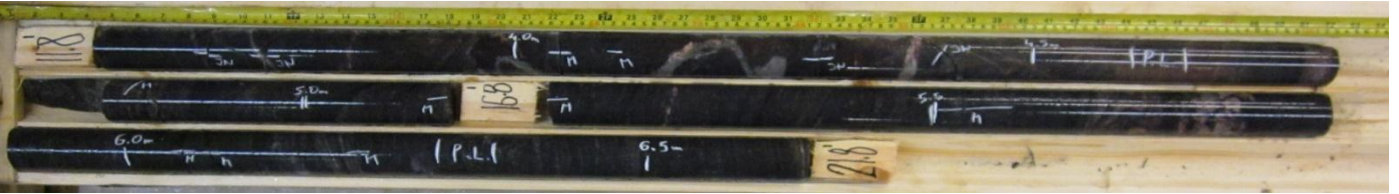
Scale

PROJECT		Bekanon Road NBL Overpass Structure Highway 69 Four-Laning GWP 5404-05-00; WP 5141-08-01					
TITLE		Bedrock Core Photographs – B302-04 to B302-06					
		PROJECT No. 09-1111-6014			FILE No. ----		
		DESIGN	MAS	NOV12	SCALE	NTS	REV.
		CADD	--		FIGURE B3		
		CHECK	CN	NOV12			
		REVIEW	JMAC	NOV12			

Borehole B302-07



Box 1: 0.18 m – 3.60 m

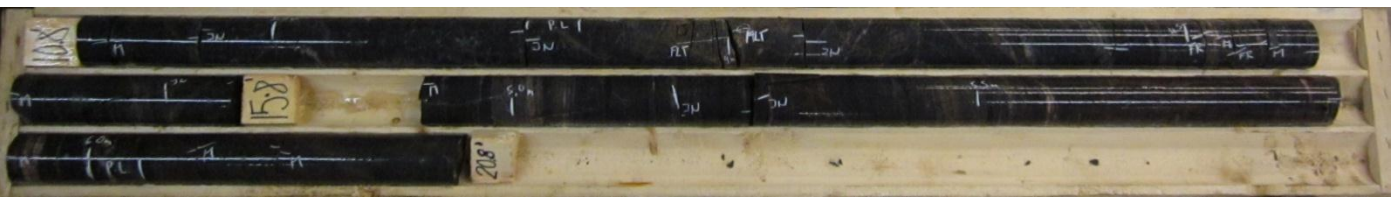


Box 2: 3.60 m – 6.65 m

Borehole B302-08



Box 1: 0.03 m – 3.29 m



Box 2: 3.29 m – 6.34 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 NBL Overpass Structure Highway 69 Four-Laning GWP 5404-05-00; WP 5141-08-01					
TITLE					
Bedrock Core Photographs – B302-07 and B302-08					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	MAS	NOV12	SCALE	NTS	REV.
CADD	--		FIGURE B4		
CHECK	CN	NOV12			
REVIEW	JMAc	NOV12			



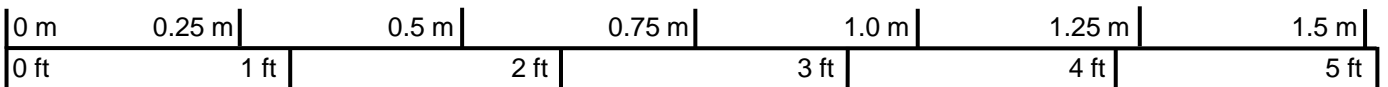
Borehole B302-09




Box 1: 0.12 m – 4.05 m



Box 2: 4.05 m – 5.91 m



Scale

PROJECT		Bekanon Road NBL Overpass Structure Highway 69 Four-Laning GWP 5404-05-00; WP 5141-08-01			
TITLE		Bedrock Core Photographs – B302-09			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	MAS	NOV12	SCALE NTS
		CADD	--		REV.
		CHECK	CN	NOV12	FIGURE B5
		REVIEW	JMAC	NOV12	

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