



December 15, 2015

## FOUNDATION INVESTIGATION REPORT

**KEY RIVER SBL BRIDGE, SITE NO. 44-462/2**  
**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 5005-10-00; WP 5148-08-01**

**Submitted to:**  
URS Canada Inc.  
30 Leek Crescent, 4th Floor  
Richmond Hill, Ontario L4B 4N4



**GEOCRES NO: 41H-156**

**Report Number:** 09-1111-6014-5525

**Distribution:**

- 1 PDF Copy – Ministry of Transportation, Ontario, Northeastern Region
- 1 PDF Copy - Ministry of Transportation, Ontario, Foundations Section
- 1 Copy – URS Canada Inc., Richmond Hill, Ontario
- 1 PDF Copy - Golder Associates Ltd., Mississauga, Ontario



REPORT





## Table of Contents

### PART A – FOUNDATION INVESTIGATION REPORT

<b>1.0 INTRODUCTION.....</b>	<b>1</b>
<b>2.0 SITE DESCRIPTION.....</b>	<b>1</b>
<b>3.0 INVESTIGATION PROCEDURES .....</b>	<b>2</b>
3.1 Foundation Investigation.....	2
3.2 Optical Borehole Logging .....	4
3.3 Evaluation of Photographic Records and Bedrock Mapping.....	5
<b>4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS .....</b>	<b>5</b>
4.1 Regional Geology .....	5
4.2 Subsurface Conditions.....	6
4.3 South Abutment/Approach.....	6
4.3.1 Bedrock.....	6
4.3.2 Groundwater Conditions .....	8
4.4 South Pier (Pier 1) .....	8
4.4.1 Water .....	8
4.4.2 Organic Silt .....	8
4.4.3 Silt to Sand.....	9
4.4.4 Cobbles and Boulders.....	9
4.4.5 Bedrock.....	9
4.5 North Pier (Pier 2).....	10
4.5.1 Water .....	11
4.5.2 Organic Silt .....	11
4.5.3 Sandy Silt to Silty Sand.....	11
4.5.4 Bedrock.....	12
4.6 North Abutment/Approach .....	13
4.6.1 Bedrock.....	13
4.6.2 Groundwater Conditions .....	14
<b>5.0 CLOSURE .....</b>	<b>14</b>



## **DRAWINGS**

Drawing 1	Index Plan
Drawing 2	Borehole Locations and Soil Strata
Drawing 3	Soil Strata
Drawing 4	Soil Strata

## **FIGURES**

Figure 1	Photograph of South Shore Rock Outcrop
Figure 2	Photograph of North Shore Rock Outcrop

## **APPENDICES**

### **Appendix A Record of Boreholes and Drillholes**

Lists of Symbols and Abbreviations	
Lithological and Geotechnical Rock Description Terminology	
Record of Boreholes	B503-01 to B503-19, B504-10 and B504-14
Record of Borehole	ST-40 (A) (Amec)
Record of Drillholes	B503-01, B503-02, B503-06, B503-09 to B503-13, B503-16, B504-10 and B504-14

### **Appendix B Laboratory Test Results and Bedrock Core Photographs**

Table B1	Point Load Test Results on Rock Samples
Table B2-1	Summary of Uniaxial Compressive Strength Test Results
Table B2-2	Unconfined Compression Test (UC) – Borehole B503-01, Run No. 2
Table B2-3	Unconfined Compression Test (UC) – Borehole B503-06, Run No. 7
Table B2-4	Unconfined Compression Test (UC) – Borehole B503-09, Run No. 3
Table B2-5	Unconfined Compression Test (UC) – Borehole B503-09, Run No. 4
Table B2-6	Unconfined Compression Test (UC) – Borehole B503-12, Run No. 2
Table B2-7	Unconfined Compression Test (UC) – Borehole B503-16, Run No. 6
Figure B1	Plasticity Chart – Organic Silt
Figure B2	Grain Size Distribution – Organic Silt
Figure B3	Plasticity Chart – Silt
Figure B4-1	Grain Size Distribution – Silt to Silt and Sand
Figure B4-2	Grain Size Distribution – Silty Sand to Sand
Figure B5	Bedrock Core Photographs – B503-01 and B503-02
Figure B6	Bedrock Core Photographs – B503-06
Figure B7	Bedrock Core Photographs – B503-09
Figure B8	Bedrock Core Photographs – B503-10
Figure B9	Bedrock Core Photographs – B503-11 and B503-12
Figure B10	Bedrock Core Photographs – B503-13
Figure B11	Bedrock Core Photographs – B503-16
Figure B12	Bedrock Core Photographs – B504-10
Figure B13	Bedrock Core Photographs – B504-14

### **Appendix C Drilling Photographs and Underwater Locates**

Figure C1	Drill Setup Photographs
Figure C2	Drill Setup Photographs
Figure C3	Underwater Cable Locates

### **Appendix D Geophysical Logs, Bedrock Outcrop Photographs and Structural Analysis**

Geophysical Record of Boreholes	B503-06 and B503-16
Figures D1 to D3	Joints and Features – North Abutments
Figures D4 to D8	Joints and Features – South Abutments



# PART A

## FOUNDATION INVESTIGATION REPORT

KEY RIVER SBL BRIDGE, SITE NO. 44-462/2

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 5005-10-00; WP 5148-08-01





## **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 foundation investigation services for the proposed Highway 69 southbound lane (SBL) bridge over Key River (Site No. 44-462/2), which is within the Contract 5 limits of the new Highway 69 alignment. The proposed work in Contract 5 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 and CNR overpass structures; as well as culvert crossings. The Key River SBL bridge is to be located approximately 550 m 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 Index Plan on Drawing 1.

The Terms of Reference 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 5 Key River SBL bridge 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 Key River SBL bridge 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 location, 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. The general arrangement of the proposed structure presented on Drawing 2 was provided to us by URS on November 4, 2013.

Preliminary subsurface information for this project is available and was supplied by the MTO, specifically:

- Preliminary Foundation Investigation and Design Report for Structural Areas (Foundation Investigation 2), Highway 69 Four Laning, From 3.5 km North of Highway 559 to 3.8 km North of Highway 522, GWP 5377-02-00, GEOCRE No. 41H-57, dated July 2006, by Amec Earth and Environmental.

## **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 Henvey Inlet First Nation Reserve No. 2 and the Township of Mowat to the north. The Contract 5 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 1.6 km in Henvey Inlet First Nation Reserve No. 2. The proposed Key River SBL structure is located approximately 0.5 km east of the existing Highway 69 alignment within the Contract 5 highway alignment and is located approximately 0.2 km from the northern limit of Contract 5, corresponding to approximately 10.3 km north of the junction between the 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. In the immediate area of the SBL bridge, the topography around the bridge site consists of rolling terrain with densely treed areas, and high bedrock outcrops covered in places with low scrub-brush adjacent to the river. The bedrock outcrops generally slope upward steeply from the north and south shores of the river to the proposed north and south abutments. At the south abutment and along the south approach, the bedrock outcrops rise from the river surface (at about Elevation 176 m) and extend as high as about Elevation 198 m, resulting in outcrop up to about 22 m high above the river level. At the north abutments and north approach, the bedrock outcrops rise from the river surface to greater than Elevation 201 m, resulting in outcrop greater than about 25 m high above the river level in this area.

## **3.0 INVESTIGATION PROCEDURES**

### **3.1 Foundation Investigation**

Golder's fieldwork for the proposed Highway 69 SBL structure over Key River was carried out between November 10 and November 23, 2012 as well as between June 19 and August 10, 2014, during which time a total of eighteen boreholes were advanced at or adjacent to the locations of the proposed foundation element footprints and approaches. These boreholes were supplemented with two boreholes advanced along the centreline between the NBL and SBL structures and one borehole drilled near the centre of the river between the two piers of the SBL structure. A summary of the boreholes and their respective locations relative to each foundation element and approach area is presented below.

<b>Foundation Element/Approach Area</b>	<b>Borehole No.</b>
South Approach	B503-03
South Abutment	B503-04
	B503-05
	B503-06
	B503-07
	B503-08
South Pier (Pier 1)	B503-01
	B503-09
	B503-10
	B504-10*
Between South and North Piers	B503-02
	ST-40(A)
North Pier (Pier 2)	B503-11
	B503-12
	B503-13
	B504-14*
North Abutment	B503-14
	B503-15
	B503-16
	B503-17
	B503-18
North Approach	B503-19

Note: \*Boreholes advanced near centreline between NBL and SBL structures.



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 boreholes at the approaches/abutments on the bedrock outcrops were advanced using portable drilling equipment supplied and operated by Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario. The bedrock surface was exposed and confirmed at these boreholes and Boreholes B503-06 and B503-16 were advanced at the centre of the proposed south and north abutments by coring to depths of 9.4 m and 7.5 m, respectively, below ground surface. Photographs of the bedrock outcrops on the south and north shores of the river in the immediate vicinity of the proposed abutments are presented on Figures 1 and 2 respectively.

The boreholes in Key River were advanced from a barge using a D-55 or D-120 drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes in the river were advanced to depths of up to about 50.2 m below the water surface, to between about 19.0 m and 46.2 m below river bottom, through a water column between about 2.3 m and 9.5 m deep.

Photographs of the set-up of the drilling operations on the bedrock outcrops at the abutments and on the barge in the river are shown on Figures C1 and C2 in Appendix C. In addition, it is noted that an underwater hydro cable (owned by Hydro One Inc.) exists within Key River in the vicinity of the proposed south pier footprints of the SBL and NBL bridge structures. This cable had to be located prior to start of the in-water field investigations using an underwater diving supplied by ASI Group Ltd. Photographs showing the set-up of the dive crew are shown on Figure C3 in Appendix C. The approximate location of the underwater cable in the vicinity of the south piers is shown on Drawing 2.

The boreholes were advanced through the overburden using HW casing with wash boring techniques. In general, soil samples were obtained at intervals of depth between about 0.75 m and 3.0 m, using a 50 mm outside diameter split-spoon sampler operated by automatic hammers on the drill rigs on the barges, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Bedrock coring was carried out using an 'HQ' and/or 'NQ' core barrel. Photographs of the recovered rock core samples are provided in Appendix B. It is noted that no split-spoon sampling was carried out in boreholes B503-10, B503-12, B503-13, B504-10 and B504-14, however bedrock was confirmed by coring in each of these boreholes. The overburden in these boreholes was inferred from observations during the drilling and from information in the adjacent boreholes.

The groundwater conditions were observed during the drilling operations and all boreholes were backfilled 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, organic content, grain size distribution and Atterberg limits) 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.

At the abutments, approaches and piers, the boreholes were located in the field and the ground/water surface elevations were surveyed by Callon Dietz prior to drilling. The locations given on 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)		Water/Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B503-01	5084113.5	222545.0	175.5*	26.5
B503-02	5084155.6	222527.3	175.5*	50.2
B503-03	5084058.8	222567.6	197.7	Bedrock Outcrop
B503-04	5084075.2	222552.4	193.2	Bedrock Outcrop
B503-05	5084081.1	222550.0	191.1	Bedrock Outcrop
B503-06	5084078.4	222559.4	193.9	9.4 (Bedrock Outcrop)
B503-07	5084075.9	222568.4	192.7	Bedrock Outcrop
B503-08	5084081.8	222565.9	190.0	Bedrock Outcrop
B503-09	5084126.4	222541.4	176.3*	50.3
B503-10	5084124.1	222530.8	176.3*	47.3
B503-11	5084185.8	222514.4	176.3*	30.5
B503-12	5084192.2	222511.4	176.1*	27.1
B503-13	5084188.3	222501.8	175.9*	28.8
B503-14	5084227.5	222489.3	193.2	Bedrock Outcrop
B503-15	5084233.4	222486.8	195.8	Bedrock Outcrop
B503-16	5084230.8	222496.0	194.8	7.5 (Bedrock Outcrop)
B503-17	5084228.2	222505.2	194.9	Bedrock Outcrop
B503-18	5084234.1	222502.8	197.4	Bedrock Outcrop
B503-19	5084250.5	222487.9	200.9	Bedrock Outcrop
B504-10	5084119.3	222562.6	176.3*	24.8
B504-14	5084190.2	222532.4	176.3*	29.1

\*Water surface; Borehole Depth includes water column.

## 3.2 Optical Borehole Logging

Geophysical borehole surveys (optical borehole logging) were carried out by Golder personnel on August 7 and August 8, 2014. The surveys were conducted in the boreholes located at the mid-point at each abutment location (Boreholes B503-06 and B503-16) to collect detailed, oriented optical images of the borehole walls, and the images were interpreted for the type and orientation of the discontinuities intersected by the boreholes. The survey depths are summarized below.

Borehole No.	Borehole Location	Optical Televiewer Depth Range (m)	Caliper Depth Range (m)
B503-06	SBL, South Abutment	1.6 – 9.25	1.35 – 9.0
B503-16	SBL, North Abutment	1.6 – 7.2	1.35 – 7.25



The optical televiewer and caliper surveys were carried out using an ALT Optical Borehole Imager (ALT-OBI40) and a Caliper Probe (2PCA-1000), respectively. The optical televiewer generates a high resolution digital image of the borehole wall and is capable of resolving fractures as narrow as 0.1 mm at a radial resolution of 1 degree. The data is recorded together with data from an internal magnetometer and a tiltmeter allowing the determination of the orientation (dip and dip direction) of the structural features recorded. The caliper probe measures the borehole diameter with three linked arms that operate a single resistive sensor in the probe. The data is used to determine the average borehole diameter and indicate borehole anomalies such as rough borehole walls or washouts.

The survey data was processed using WellCAD software (Advanced Logic Technology Ltd.) and oriented to magnetic north prior to image interpretation. The downhole logs from the optical borehole survey are shown on the Geophysical Record of Borehole sheets presented in Appendix D.

The data were oriented to geographic (true) north prior to interpretation using a magnetic declination of 10.32 degrees.

### **3.3 Evaluation of Photographic Records and Bedrock Mapping**

The bedrock conditions in the area of the abutment locations were assessed using the data from the optical borehole logging as well as photographic records of the rock faces (see Figures D1 to D8 in Appendix D) and the results were used to identify potential failure modes which might require pre-support, stabilization or remedial measures during or following excavation.

## **4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

As delineated in *The Physiography of Southern Ontario*<sup>1</sup>, 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<sup>2</sup>. Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

<sup>1</sup> 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.

<sup>2</sup> *Geology of Ontario*, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



## **4.2 Subsurface Conditions**

The detailed subsurface soil, bedrock 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 on 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. The bedrock surface has been inferred from observations made during drilling and coring and generally represents a transition from overburden to the bedrock surface and should not be inferred to represent the exact surface elevation of the bedrock. Furthermore, subsurface conditions will vary between and beyond the borehole locations. It should be noted that the interpreted stratigraphy shown on Drawings 2 to 4 is a simplification of the subsurface conditions.

The subsurface conditions at the site of the SBL structure are characterized essentially by: granitic gneiss bedrock outcrops at the south and north abutments/approaches; and by a sequence of organic silt or silty clay, and silt to sand deposits, underlain by granitic gneiss bedrock at the south and north piers below the river water level.

The results of the strength tests on the rock core samples are presented in Tables B1 and B2 and the results of the laboratory testing on the soil samples are presented on Figures B1 to B4, in Appendix B. Photographs of the bedrock core samples are presented on Figures B5 to B13, inclusive, in Appendix B.

A detailed description of the subsurface conditions encountered in the boreholes at the approaches/abutments and at the piers is provided in the following sections. Borehole BH503-02 was advanced in between the two piers near the centre of the river. As this borehole was not advanced in proximity of the piers, the soil stratigraphy and laboratory test results are presented in this report but are not discussed in the following sections.

Because the boreholes were advanced on bedrock outcrops or in the water, and water was introduced into the boreholes during the drilling process, the water level noted in the boreholes is not considered representative of groundwater conditions. Further, the groundwater and river water levels are subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

## **4.3 South Abutment/Approach**

A total of six boreholes (B503-03 to B503-8) were advanced in the vicinity of the proposed south abutment/approach. Bedrock coring was carried out in Borehole B504-06. The interpreted stratigraphy at the south abutment/approach is shown in profile on Drawing 2 and in cross-section on Drawing 3.

### **4.3.1 Bedrock**

Exposed bedrock outcrops were observed at ground surface at each of the borehole locations and bedrock core samples were recovered from Borehole B503-06. The corresponding bedrock surface elevations are summarized below.





**FOUNDATION REPORT – KEY RIVER SBL BRIDGE – HIGHWAY 69**  
**GWP 5005-10-00; WP 5148-08-01**

Foundation Element	Borehole	Bedrock Surface Elevation (m)	Comments
South Abutment/Approach	B503-03	197.7	Bedrock Exposed
	B503-04	193.2	Bedrock Exposed
	B503-05	191.1	Bedrock Exposed
	B503-06	193.9	Bedrock Exposed-Cored
	B503-07	192.7	Bedrock Exposed
	B503-08	190.0	Bedrock Exposed

In general, the bedrock surface along the south approach and in the area of the proposed south abutment of the SBL structure slopes downward from south to north with the bedrock surface elevation changing by as much as about 3.9 m at the abutment borehole locations and up to 7.7 m relative to the approach borehole about 21 m south of the abutment.

Discontinuities in the rock mass noted in the walls of Borehole B503-06 recorded by the optical televiewer were predominantly minor open joints (opening width less than 10 mm) or healed joints. In general, no major anomalies were determined along the borehole walls.

Based on a review of the bedrock core samples recovered from Borehole B503-06, the bedrock consists of granitic gneiss. In general the bedrock samples are described as slightly weathered, foliated, coarse grained, faintly porous, medium strong to strong, grey and pink, as presented in the Record of Drillhole sheet in Appendix A, and shown on the photograph of the recovered core samples on Figure B6 in Appendix B. The degree of weathering of the bedrock samples (e.g. slightly weathered – W2) is based on field identification, and the strength classification of the intact rock mass is based on laboratory testing (e.g. strong - R4) and is described in accordance with the International Society for Rock Mechanics (ISRM<sup>3</sup>) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples ranges from about 84 per cent to 100 per cent, indicating a rock mass of good to excellent quality as per Table 3.10 of CFEM (2006)<sup>4</sup>. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are 100 per cent and between 13 per cent and 98 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 test carried out on one sample of the granitic gneiss bedrock core measured an  $Is_{50}$  value of about 6.5 MPa and the diametral tests carried out on two samples of the granitic gneiss bedrock core measured  $Is_{50}$  values of about 7.9 MPa.

<sup>3</sup> 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.

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





One Unconfined Compression (UC) test (ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens) was carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B503-06. The test result indicates a compressive strength of about 88 MPa as summarized in Table B2-1 and detailed in Table B2-3 in Appendix B.

Table B1 also presents estimated Uniaxial Compressive Strengths (UCS) correlated to the Point Load Test (PLT) strength based on the relationship between  $Is_{50}$  and UCS. The relationship between  $Is_{50}$  and UCS values, given by correlation factor (K), varies depending on the size of the core sample and the strength of the rock. For the NBL (as well as for the SBL) bridge using the consolidated rock strength data from both sites, an average correlation factor (K) was calculated by matching UCS test values and PLT values at similar depths from the same boreholes. The average correlation factor (K) of 14 was estimated.

Based on the UCS and PLT results at the south abutment, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa).

#### **4.3.2 Groundwater Conditions**

The water level in Borehole B503-06 was measured at a depth of 9.3 m below ground surface upon completion of drilling, corresponding to Elevation 184.6 m.

### **4.4 South Pier (Pier 1)**

A total of four boreholes (B503-01, B503-09, B503-10 and B504-10) were advanced in the vicinity of the proposed south pier: soil sampling and bedrock coring was carried out in Boreholes B503-01 and B503-09 while Boreholes B503-10 and B504-10 were advanced to the bedrock surface without soil sampling but were cored to obtain additional bedrock information. The soil strata shown on the Record of Boreholes B503-10 and B504-10 are inferred based on the soil information from the adjacent Boreholes B503-01 and B503-09; the inferred soil strata from Boreholes B503-10 and B504-10 are not included in Sections 4.4.2 to 4.4.4. The interpreted stratigraphy at the south pier is shown in profile on Drawing 2 and in cross-section on Drawing 3.

#### **4.4.1 Water**

The water surface in Key River at the time of drilling Boreholes B503-01, B503-09, B503-10 and B504-10 in November 2012 and July and August 2014 was at Elevations 175.5 m and 176.3 m, respectively, and the depth of water at the boreholes was between 2.3 m and 4.1 m.

#### **4.4.2 Organic Silt**

A 5.9 m and 2.3 m thick deposit of brown to black to grey organic silt was encountered from the riverbed in Boreholes B503-01 and B503-09 at Elevations 173.2 m and 172.2 m, respectively.

The SPT 'N'-values measured within the organic silt are 0 blows (i.e., weight of hammer) per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging between 8 kPa and 26 kPa, and the sensitivity is calculated to range between 1 and 4. The field vane test results indicate that the organic silt to silty clay deposit has a very soft to firm consistency.



The natural water content measured on four samples of the organic silt deposit range from 70 per cent to 138 per cent. The organic content measured on two samples of the deposit are 5.2 per cent and 10.0 per cent.

Atterberg limits were carried out on three samples of the deposit and measured liquid limits ranging from about 47 per cent to 82 per cent, plastic limits ranging from about 27 per cent to 59 per cent and plasticity indices ranging from about 20 per cent to 23 per cent. The results of the Atterberg limits tests are shown on the plasticity chart Figure B1 in Appendix B and together with the organic content indicate the material is classified as an organic silt of high plasticity with the upper portion of the stratum in Borehole B503-09 being classified as an organic silty clay of intermediate plasticity.

The results of the grain size distribution test completed on one sample of the organic silt is shown on Figure B2 in Appendix B.

#### **4.4.3 Silt to Sand**

In Boreholes B503-01 and B503-09, a 14.2 m and 33.2 m thick deposit of grey silt, sandy silt, silty sand and/or sand was encountered below the organic silt at Elevations 167.3 m and 169.9 m, respectively.

The SPT 'N'-values measured within the silt to sand deposit range from 3 blows to 32 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The natural water content measured on samples of the silt to sand deposit range from 16 per cent to 30 per cent.

An Atterberg limits test carried out on one sample of the silt portion of the overall deposit measured a liquid limit of about 21 per cent, a plastic limit of about 19 per cent, with a corresponding plasticity index of about 2 per cent. The result of this test, which is shown on Figure B3 in Appendix B, indicates that the material is classified as a silt of slight plasticity.

The results of the grain size distribution tests completed on eight samples of this deposit are shown on Figure B4-1 and B4-2 in Appendix B.

#### **4.4.4 Cobbles and Boulders**

In Borehole B503-09, a 3.3 m thick layer of cobbles and boulders was encountered at Elevation 136.7 m overlying the bedrock.

#### **4.4.5 Bedrock**

Bedrock was encountered and core samples were recovered from Boreholes B503-01, B503-09, B503-10 and B504-10. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.



Foundation Element	Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
Pier 1 (South Pier)	B503-01	22.4	153.1	Bedrock Cored
	B503-09	42.9	133.4	Bedrock Cored
	B503-10	41.3	135.0	Bedrock Cored
	B504-10	21.3	155.0	Bedrock Cored

In general, the bedrock surface in the area of the proposed Pier 1 (South) SBL structure slopes downward from south to north and east to west, with the bedrock surface elevation varying by as much as about 21.6 m at the borehole locations.

Based on a review of the bedrock core samples recovered from the boreholes, the bedrock consists of granitic gneiss. In general the bedrock samples are described as fresh to slightly weathered, foliated or massive and brecciated, medium to coarse grained, slightly porous, medium strong to strong, grey and black to dark grey and red, as presented in the Record of Drillhole sheets in Appendix A, and shown on the photograph of the recovered core samples on Figures B4, B6, B7 and B11 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples ranges from about 21 per cent to 100 per cent, indicating a rock mass of very poor to excellent quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 97 per cent and 100 per cent and between 0 per cent and 86 per cent, respectively.

Point load strength index tests (ASTM D5731) 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 two samples of the granitic gneiss bedrock core measured  $Is_{50}$  values of about 1.4 MPa and 15.3 MPa and the diametral tests carried out on three samples of the granitic gneiss bedrock core measured  $Is_{50}$  values ranging from about 1.1 MPa to 12.6 MPa.

Three UC tests (ASTM D7012) carried out on selected samples of the granitic gneiss bedrock obtained in Boreholes B503-01 and B503-09 measured compressive strengths of 140 MPa, 21 MPa and 28 MPa as summarized in Table B2-1 and detailed in Tables B2-2, B2-4 and B2-5, respectively, in Appendix B. The two relatively low UC test results in Borehole B503-09 (21 MPa and 28 MPa) are due to the tests being carried out on specimens containing a joint in the bedrock.

Table B1 also presents estimated UCS correlated to the PLT strengths based on the relationship between  $Is_{50}$  and UCS and applying an average correlation factor (K) of 14 as discussed in Section 4.3.1.

Based on the UCS and PLT results at the south pier, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as weak to very strong (R2 to R5, 5 MPa < UCS < 250 MPa).

## 4.5 North Pier (Pier 2)

A total of four boreholes (B503-11 to B503-13 and B504-14) were advanced in the vicinity of the proposed north pier: soil sampling and bedrock coring was carried out in Borehole B503-11 while Boreholes B503-12, B503-13 and B504-14 were advanced to the bedrock surface without soil sampling but cored to obtain additional bedrock



information. The soil strata shown on the Record of Boreholes B503-12, B503-13 and B504-14 are inferred based on the soil information from the adjacent Borehole B503-11; the inferred soil strata from Boreholes B503-12, B503-13 and B504-14 are not included in Sections 4.5.2 and 4.5.3. The interpreted stratigraphy at the north pier is shown in profile on Drawing 2 and in cross-section on Drawing 4.

#### **4.5.1 Water**

The water surface in Key River measured at the time of drilling Boreholes B503-11 to B503-13 and B504-14 in July 2014 was between Elevations 175.9 m and 176.3 m, respectively, and the depth of water at the boreholes was between 7.4 m and 8.8 m.

#### **4.5.2 Organic Silt**

A 5.8 m thick deposit of grey organic silt was encountered from the riverbed in Borehole B503-11 at Elevation 167.6 m.

The SPT 'N'-values measured within the organic silt are 0 blows (i.e., weight of hammer) per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging between 11 kPa and 24 kPa, and the sensitivity is calculated to be 2 and 3. The field vane test results indicate that the organic silt deposit has a very soft to soft consistency.

The natural water content measured on two samples of the organic silt deposit are about 110 per cent and 145 per cent.

Atterberg limits tests were carried out on two samples of the deposit and measured liquid limits of about 55 per cent and 69 per cent, plastic limits of about 33 per cent and 53 per cent and plasticity indices of about 22 per cent and 16 per cent, respectively. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B1 in Appendix B and indicate that the material is classified as an organic silt of high plasticity.

#### **4.5.3 Sandy Silt to Silty Sand**

An 11.3 m thick deposit of grey sandy silt to silt and sand to silty sand was encountered below the organic silt in Borehole B503-11 at Elevation 161.8 m.

The SPT 'N'-values measured within this deposit range from 2 blows to 26 blows per 0.3 m of penetration indicating a very loose to compact relative density.

The natural water content measured on four samples of the sandy silt to silty sand deposit range from about 14 per cent to 22 per cent.

The results of the grain size distribution tests completed on four samples of this deposit are shown on Figure B4-1 and B4-2.



#### 4.5.4 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes B503-11 to B503-13 and B504-14. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.

Foundation Element	Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
Pier 2 (North Pier)	B503-11	25.8	150.5	Bedrock Cored
	B503-12	23.4	152.7	Bedrock Cored
	B503-13	25.2	150.7	Bedrock Cored
	B504-14	25.5	150.8	Bedrock Cored

In general, the bedrock surface in the area of the proposed Pier 2 (North) SBL structure slopes downward from north to south and is relatively flat from east to west, with the bedrock surface elevation varying by up to about 2.2 m at the borehole locations.

Based on a review of the bedrock core samples recovered from the boreholes, the bedrock consists of granitic gneiss. In general the bedrock samples are described as fresh to slightly weathered, slightly foliated to foliated, medium to coarse grained, slightly porous, medium strong to very strong, grey to grey and pink to dark grey, as presented in the Record of Drillhole sheets in Appendix A, and shown on the photograph of the recovered core samples on Figures B9, B10 and B13 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 76 per cent to 100 per cent, indicating a rock mass of good to excellent quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 89 per cent and 100 per cent and between 54 per cent and 100 per cent, respectively.

Point load strength index tests (ASTM D5731) 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 two samples of the granitic gneiss bedrock core measured  $Is_{50}$  values of about 7.6 MPa to 8.3 MPa and the diametral tests carried out on seven samples of the granitic gneiss bedrock core measured  $Is_{50}$  values ranging from about 5.9 MPa to 8.8 MPa with one test indicating an  $Is_{50}$  value of 0.9 MPa likely an indication of a localized horizontal fracture.

One UC test (ASTM D7012) was carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B503-12 and measured a compressive strength of about 101 MPa as summarized in Table B2-1 and detailed in Table B2-6 in Appendix B.

Table B1 also presents estimated UCS correlated to the PLT strengths based on the relationship between  $Is_{50}$  and UCS and applying an average correlation factor (K) of 14 as discussed in Section 4.3.1.

Based on the UCS and PLT results at the north pier, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is generally classified as strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa), considering that the above noted  $Is_{50}$  value of 0.9 MPa (estimated UCS of 13 MPa) is considered a localized anomaly.



## 4.6 North Abutment/Approach

A total of six boreholes (B503-14 to B503-19) were advanced in the vicinity of the proposed north abutment/approach. Bedrock coring was carried out in Borehole B503-16. The interpreted stratigraphy at the north abutment is shown in profile on Drawing 2 and in cross-section on Drawing 4.

### 4.6.1 Bedrock

The north abutment and approach are located on a bedrock outcrop as observed at the borehole locations and core samples were recovered from Borehole B503-16. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.

Foundation Element	Borehole	Bedrock Surface Elevation (m)	Comments
North Abutment/Approach	B503-14	193.2	Bedrock Exposed
	B503-15	195.8	Bedrock Exposed
	B503-16	194.8	Bedrock Exposed-Cored
	B503-17	194.9	Bedrock Exposed
	B503-18	197.4	Bedrock Exposed
	B503-19	200.9	Bedrock Exposed

In general, the bedrock surface in the area of the proposed north abutment and along the north approach of the SBL structure slopes downward from north to south and east to west, with the bedrock surface elevation varying by up to about 4.2 m at the abutment borehole locations and up to 7.7 m relative to the approach borehole.

Discontinuities in the rock mass noted in Borehole B503-16 walls recorded by the optical televiewer, as presented in Appendix D, were predominantly minor open joints (opening width less than 10 mm) or healed joints. In general, no major anomalies were determined along the borehole walls.

Based on a review of the bedrock core samples recovered from Borehole B503-16, the bedrock consists of granitic gneiss. In general the bedrock samples are described as slightly weathered, foliated, coarse grained, slightly porous, medium strong, grey and pink, as presented in the Record of Drillhole sheet in Appendix A, and shown on the photograph of the recovered core samples on Figure B11 in Appendix B. Although not discerned in the optical televiewer images shown in Appendix D, visual examination of the rock core samples indicates the presence of a 50 mm infilling of rootlets/organic matter within the fracture zone at about 2.0 m depth.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 92 per cent to 100 per cent, indicating a rock mass of excellent quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are 100 per cent and between 27 per cent and 100 per cent, respectively.

Point load strength index tests (ASTM D5731) were carried out on four 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 two samples of the granitic gneiss bedrock



core measured  $Is_{50}$  values of about 7.9 MPa and 9.3 MPa and the diametral tests carried out on two samples of the granitic gneiss bedrock core measured  $Is_{50}$  values of about 4.8 MPa and 7.3 MPa.

One UC test (ASTM D7012) was carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B503-16 and measured a compressive strength of about 103 MPa as summarized in Table B2-1 and detailed in Table B2-7 in Appendix B.

Table B1 also presents estimated UCS correlated to the PLT strengths based on the relationship between  $Is_{50}$  and UCS and applying an average correlation factor (K) of 14 as discussed in Section 4.3.1.

Based on the UCS and PLT results at the north abutment, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa).

#### **4.6.2 Groundwater Conditions**

The water level in Borehole B503-16 was measured at 4.4 m below ground surface on the morning after completion of drilling, corresponding to Elevation 190.4 m.

## **5.0 CLOSURE**

The drilling program was directed by Lubomir Kosci and Trevor Moxam. This report was prepared by Mr. Matt Thibeault, EIT., and reviewed by Mr. André Bom, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal of Golder, conducted an independent quality control review of the report.





## Report Signature Page

GOLDER ASSOCIATES LTD.

*Matt Thibeault*

Matt Thibeault, EIT  
Geotechnical Engineering Intern

*André Bom*

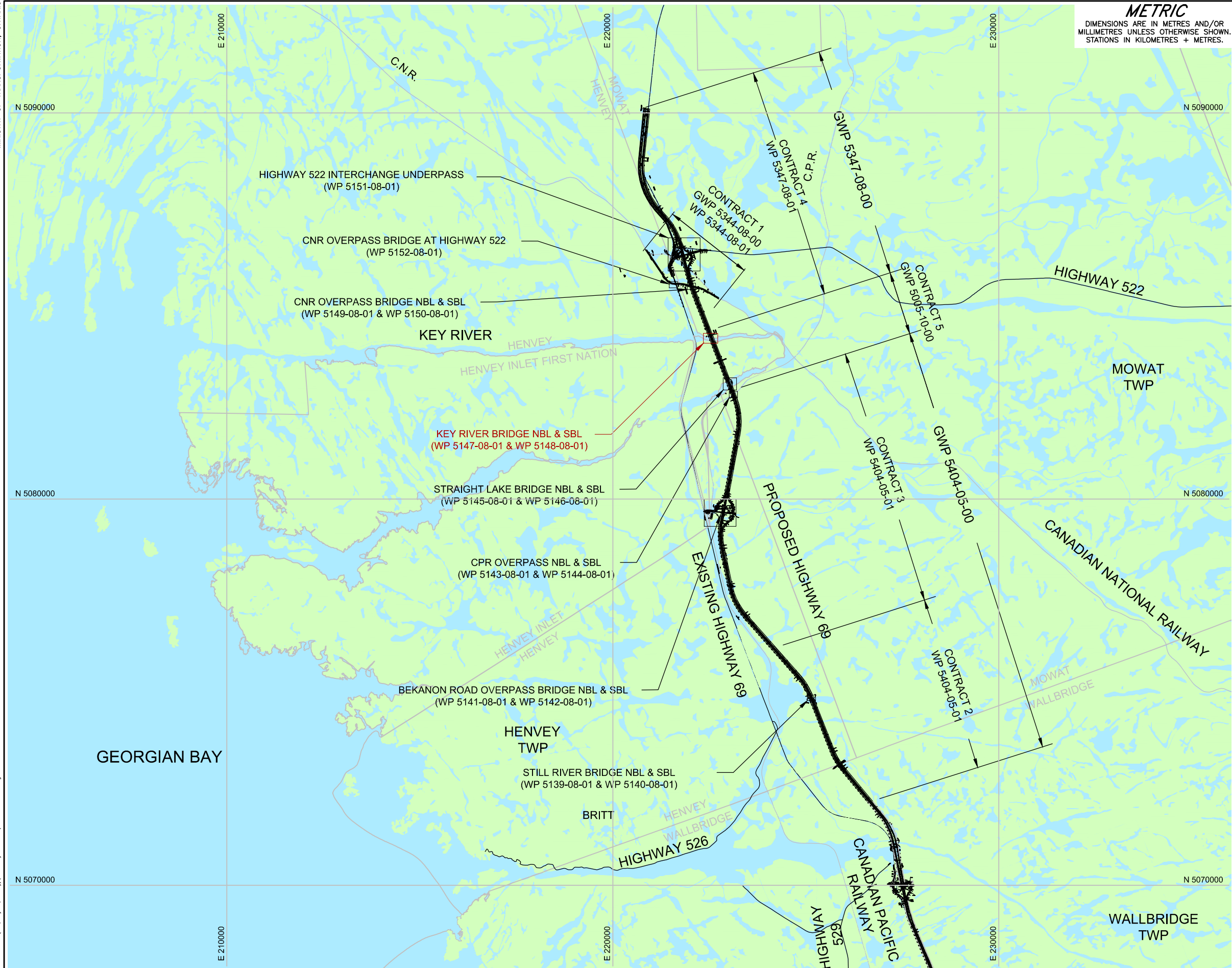
André Bom, P.Eng.  
Senior Geotechnical Engineer, Associate



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

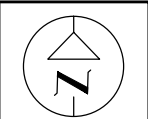
MT/AB/JPD/JMAC/kp

n:\active\2009\1190 sudbury\09-1111-6014 temporary folder\key river\sbl\final\09-1111-6014-5524 rpt 15dec15 key river bridge sbl fdr.docx



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

CONT No.	WP No.
	5148-08-01
HIGHWAY 69 KEY RIVER SBL BRIDGE	
INDEX PLAN	



SHEET



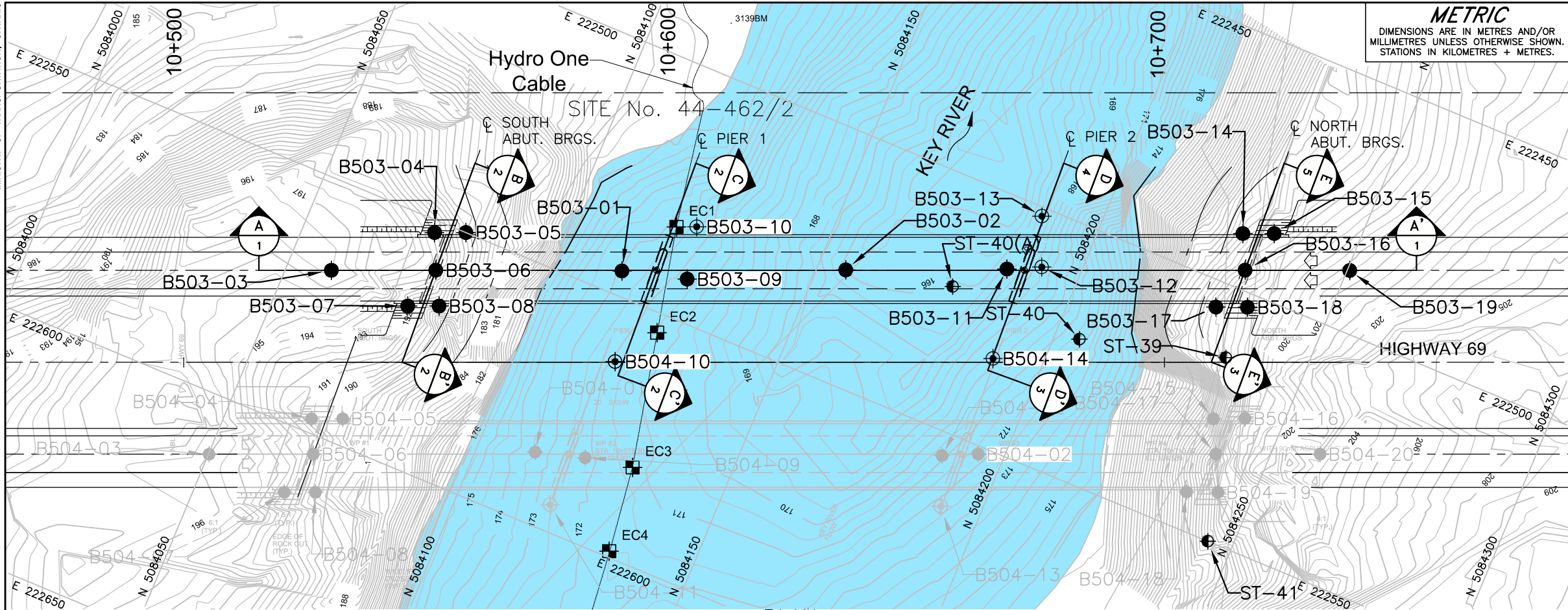
PLAN



**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-156			
HWY. 69		PROJECT NO. 09-1111-6014	DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015	SITE: 44-462/2
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC	DWG. 1

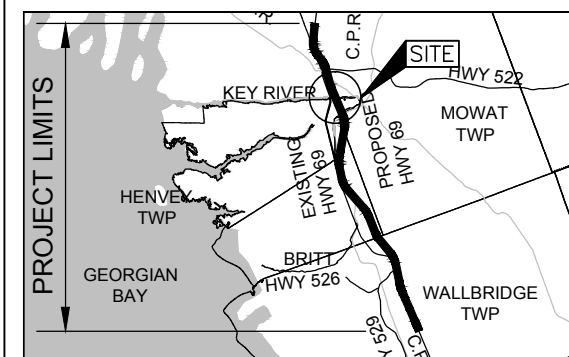




CONT No.  
WP No.5148-08-01

HIGHWAY 69  
KEY RIVER SBL BRIDGE  
BOREHOLE LOCATIONS AND  
SOIL STRATA

SHEET



LEGEND

- Borehole - Current Investigation
- Probehole - Current Investigation
- Borehole - Previous Investigation (AMEC)
- Hydro One Cable
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

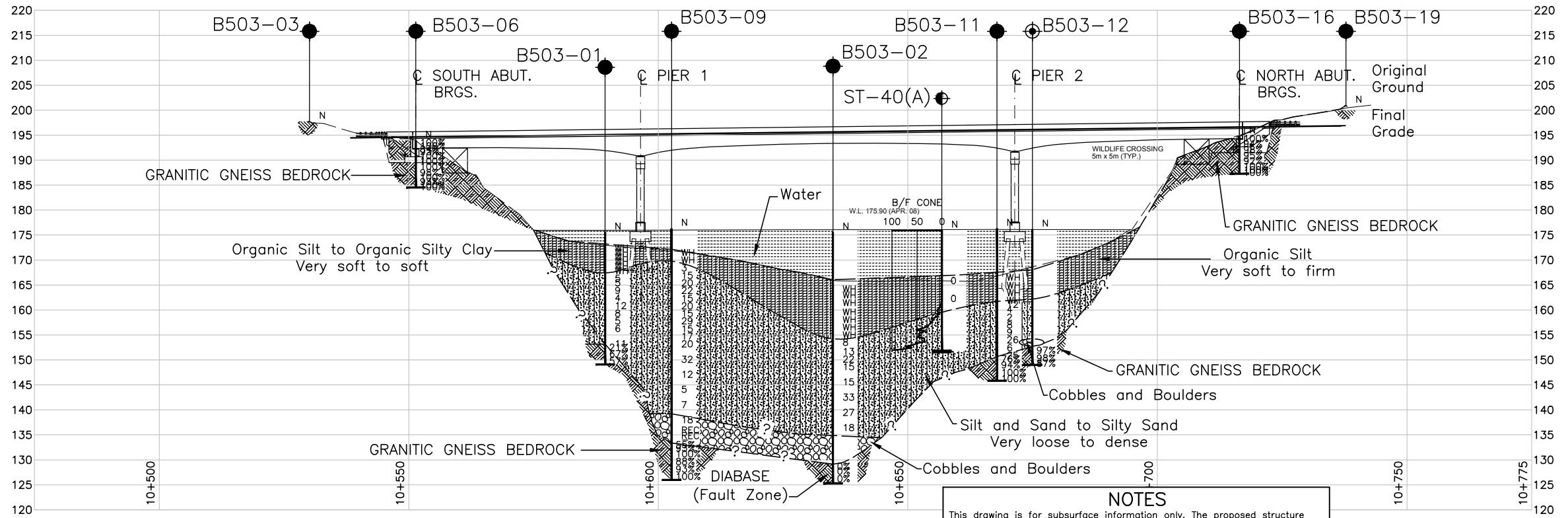
No.	ELEVATION	NORTHING	EASTING
B503-01	175.5	5084113.5	222545.0
B503-02	175.5	5084155.6	222527.3
B503-03	197.7	5084058.8	222567.6
B503-04	193.2	5084075.2	222552.4
B503-05	191.1	5084081.1	222550.0
B503-06	193.9	5084078.4	222559.4
B503-07	192.7	5084075.9	222568.4
B503-08	190.0	5084081.8	222565.9
B503-09	176.3	5084126.4	222541.4
B503-10	176.3	5084124.1	222530.8
B503-11	176.3	5084185.8	222514.4
B503-12	176.1	5084192.2	222511.4
B503-13	175.9	5084188.3	222501.8
B503-14	193.2	5084227.5	222489.3
B503-15	195.8	5084233.4	222486.8
B503-16	194.8	5084230.8	222496.0
B503-17	194.9	5084228.2	222505.2
B503-18	197.4	5084234.1	222502.8
B503-19	200.9	5084250.5	222487.9
B504-10	176.3	5084119.3	222562.6
B504-14	176.3	5084190.2	222532.4

REFERENCE

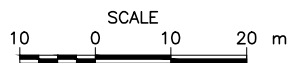
Base plans provided in digital format by URS, drawing file nos. Contours from Hwy69\_Contour-Plan\_C5.dwg, received August 31, 2012, KEY RIVER CROSSING OPTION B\_Northbound\_GA.dwg and KEY RIVER CROSSING OPTION B\_Southbound\_GA.dwg, received November 4, 2013.

Geocres No. 41H-156

HWY. 69	PROJECT NO. 09-1111-6014	DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC
		SITE: 44-462/2
		DWG. 2



SBL CENTRELINE PROFILE



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.



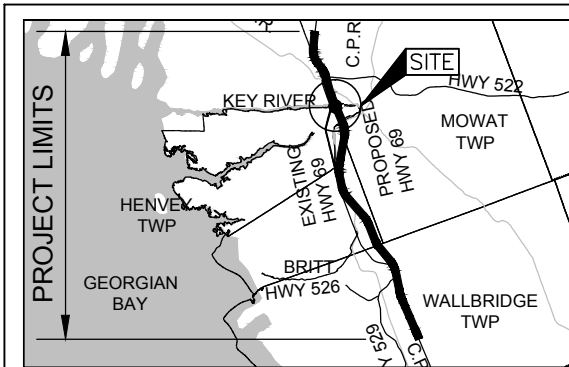
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No. .  
WP No. 5148-08-01

HIGHWAY 69  
KEY RIVER SBL BRIDGE

SOIL STRATA

SHEET



KEY PLAN  
SCALE  
0 6 12 km

LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
B503-04	193.2	5084075.2	222552.4
B503-06	193.9	5084078.4	222559.4
B503-07	192.7	5084075.9	222568.4
B503-09	176.3	5084126.4	222541.4
B503-10	176.3	5084124.1	222530.8
B504-10	176.3	5084119.3	222562.6

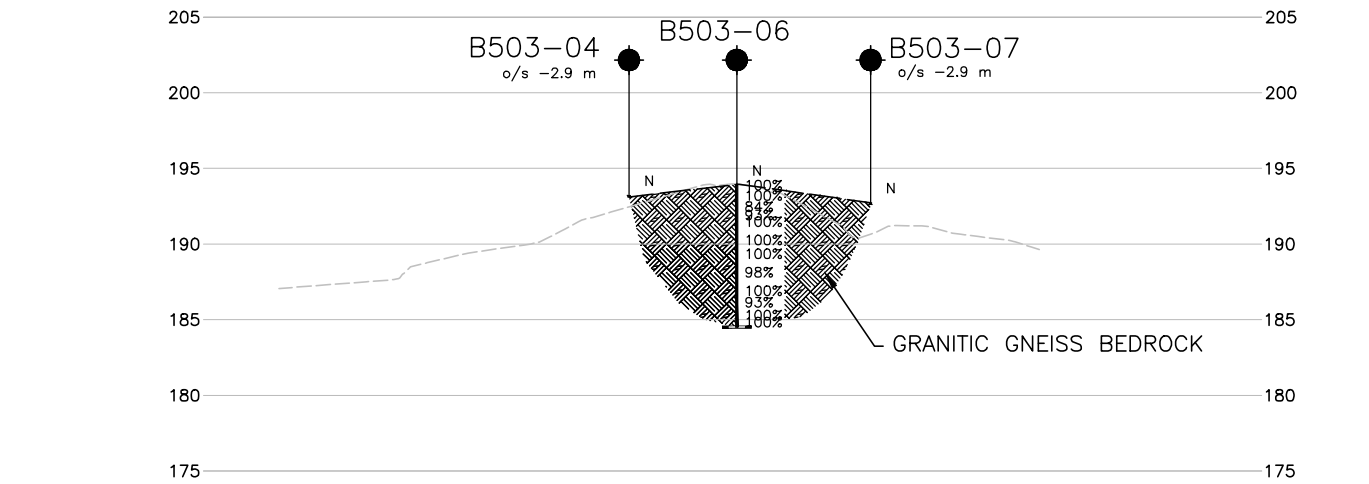
NOTES

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.

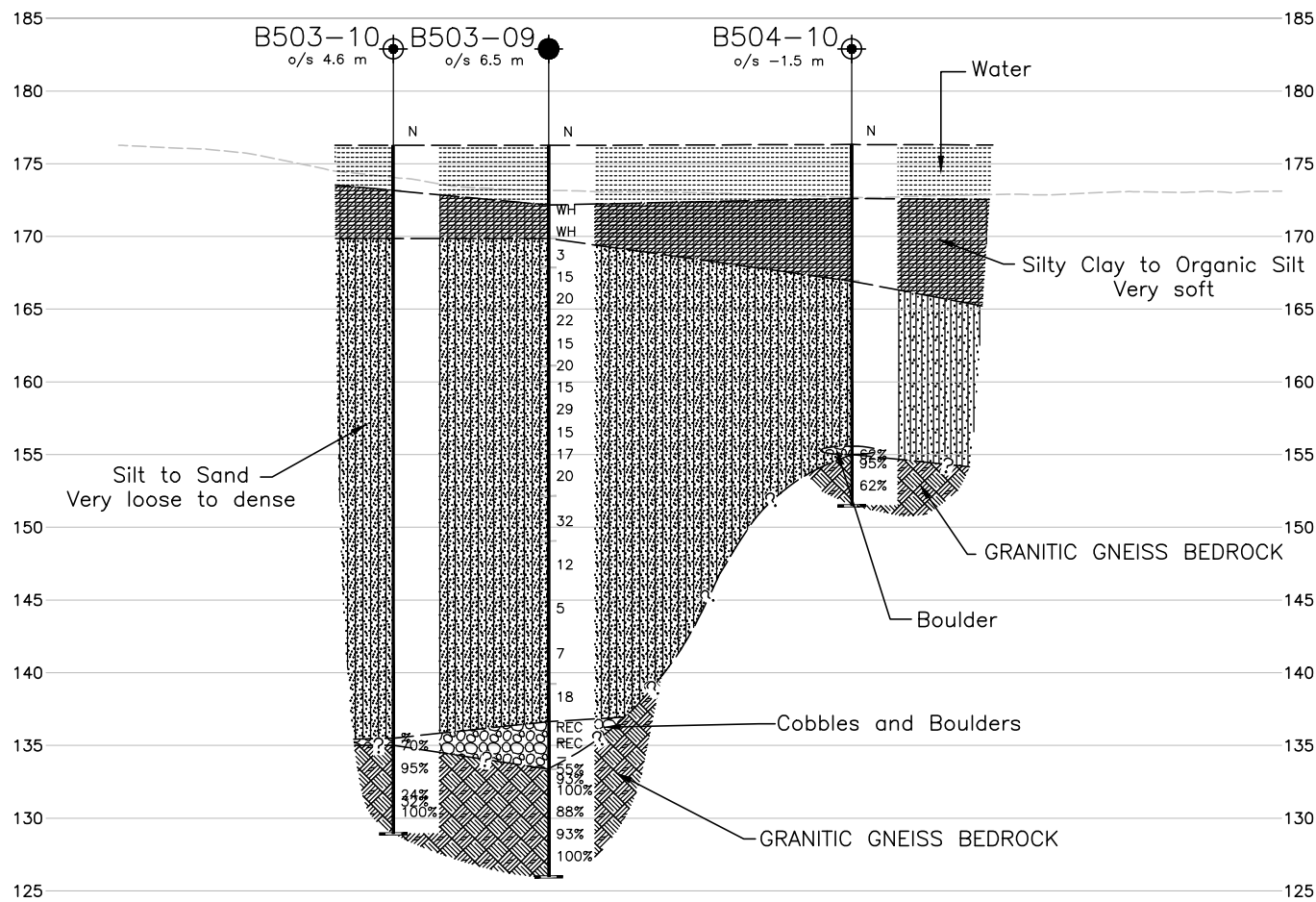
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

NO.	DATE	BY	REVISION
Geocres No. 41H-156			
HWY. 69		PROJECT NO. 09-1111-6014	DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015	SITE: 44-462/2
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC	DWG. 3



B-B' 1 SBL SOUTH ABUTMENT CROSS-SECTION B-B'

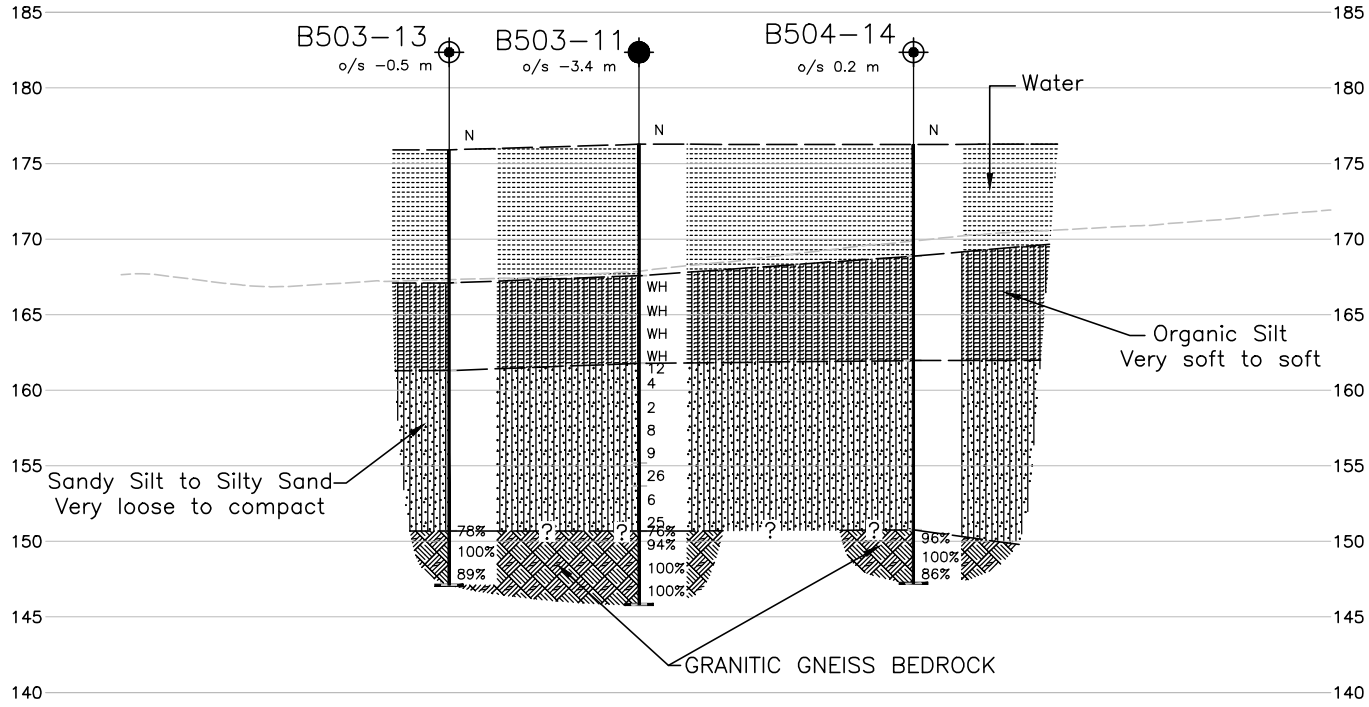
SCALE  
5 0 5 10 m



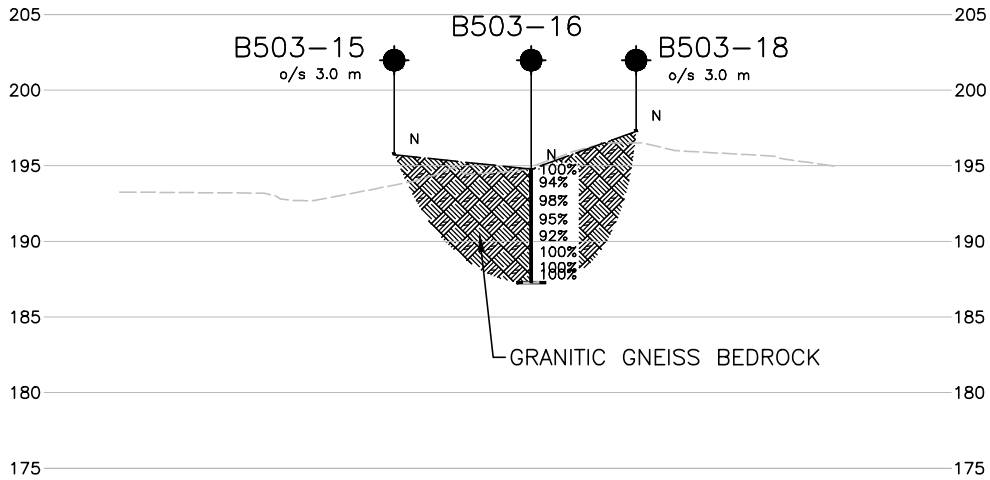
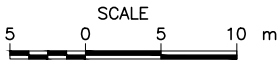
C-C' 1 SBL SOUTH PIER CROSS-SECTION C-C'

SCALE  
5 0 5 10 m

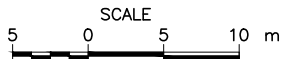




**D-D'**  
1 SBL NORTH PIER CROSS-SECTION D-D'



**E-E'**  
1 SBL NORTH ABUTMENT CROSS-SECTION E-E'

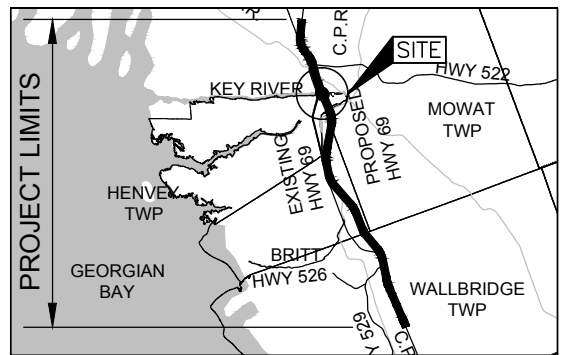


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WP No.5148-08-01

HIGHWAY 69  
KEY RIVER SBL BRIDGE  
SOIL STRATA

SHEET



KEY PLAN

SCALE



LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
B503-11	176.3	5084185.8	222514.4
B503-13	175.9	5084188.3	222501.8
B503-15	195.8	5084233.4	222486.8
B503-16	194.8	5084230.8	222496.0
B503-18	197.4	5084234.1	222502.8
B504-14	176.3	5084190.2	222532.4

NOTES

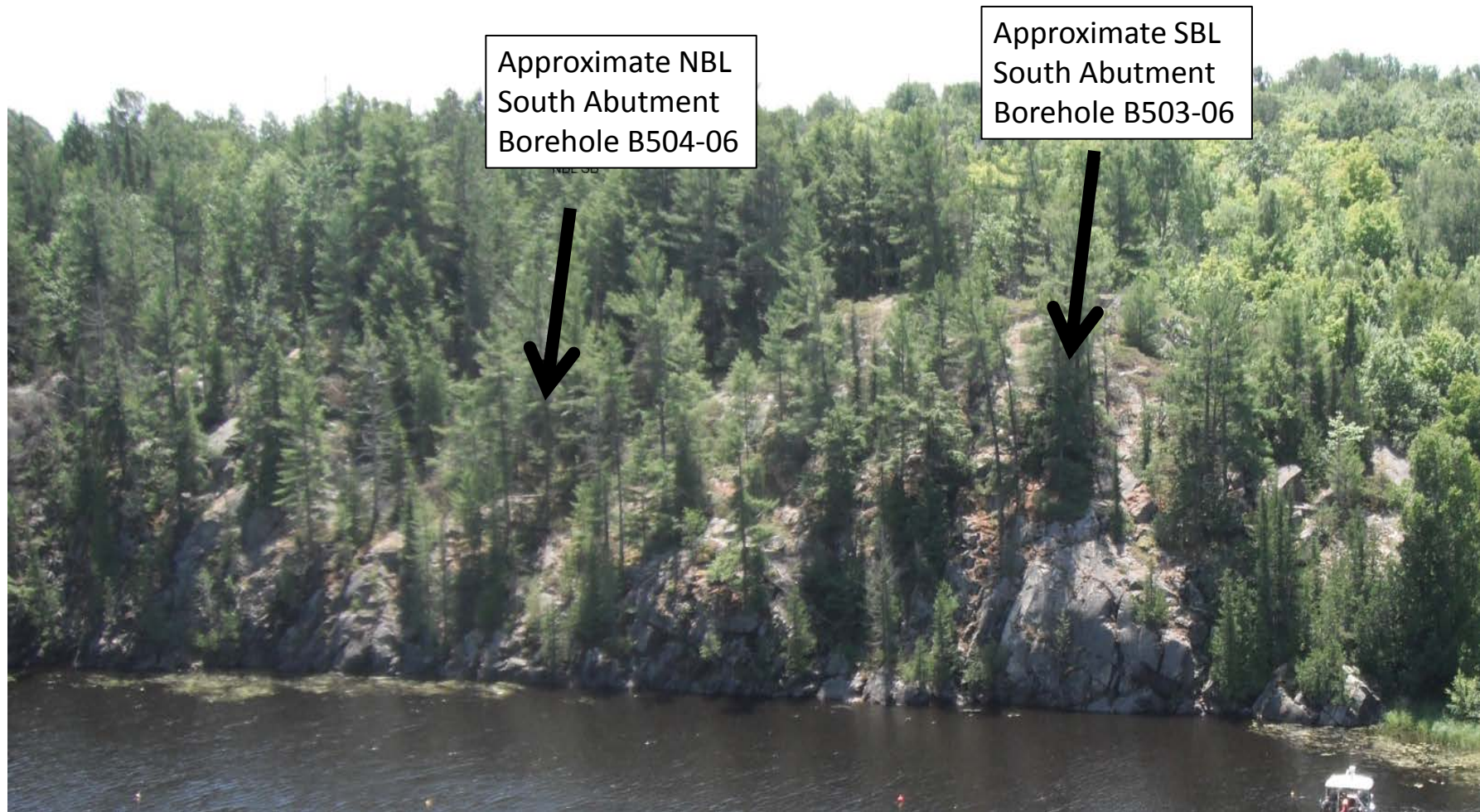
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.


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.

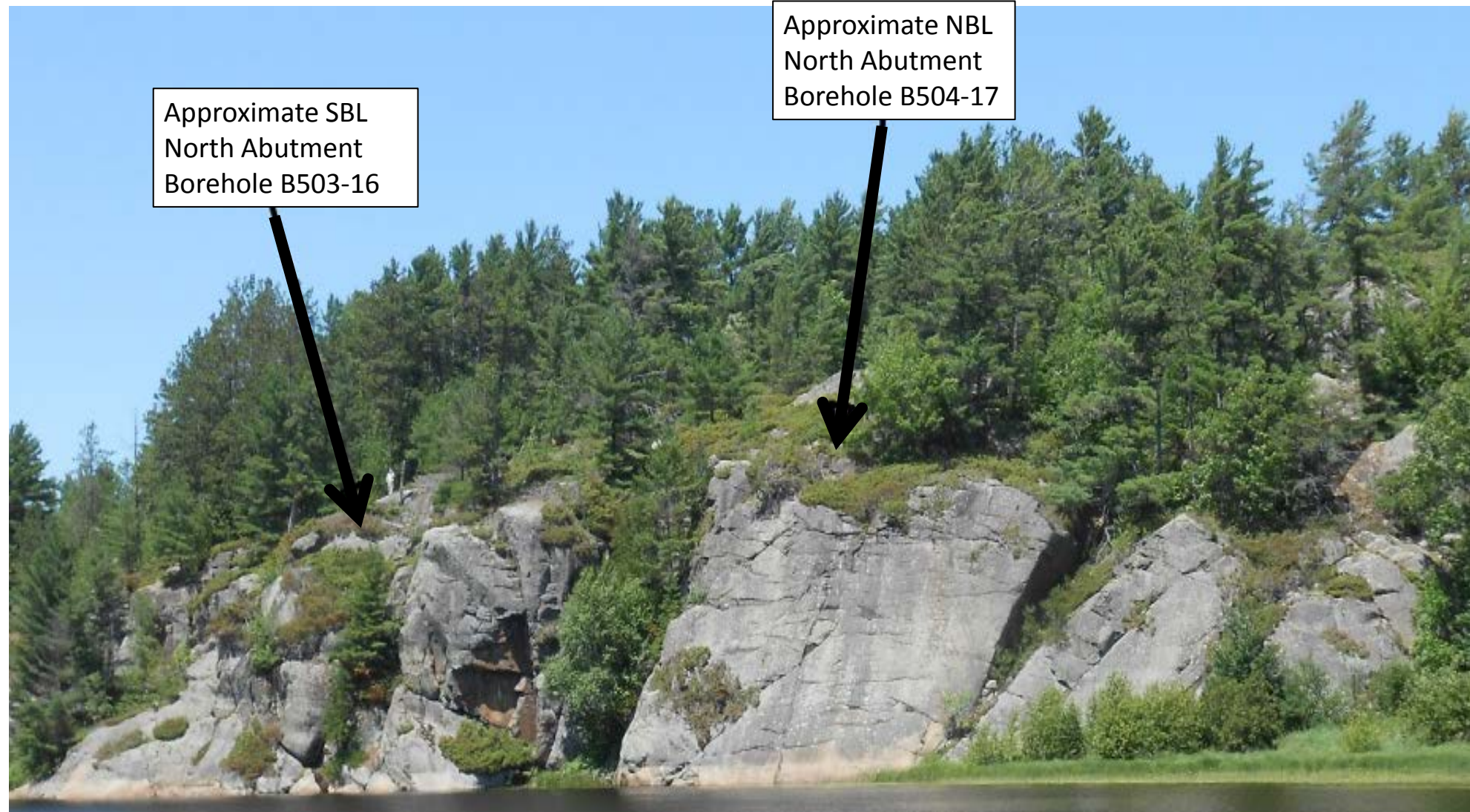


Geocres No. 41H-156			
HWY. 69	PROJECT NO. 09-1111-6014		DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015	SITE: 44-462/2
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC	DWG. 4



PROJECT				
Highway 69 - Key River NBL and SBL				
TITLE				
<b>KEY RIVER NBL AND SBL PHOTOGRAPH OF SOUTH SHORE ROCK OUTCROP</b>				
	PROJECT No. 09-1111-6014			FILE No. ----
	DESIGN	ARB	April 2015	SCALE AS SHOWN
	CADD	--		REV.
	CHECK	AB	April 2015	<b>FIGURE 1</b>
	REVIEW			





Approximate SBL  
North Abutment  
Borehole B503-16

Approximate NBL  
North Abutment  
Borehole B504-17

PROJECT

Highway 69 - Key River NBL and SBL

TITLE

**KEY RIVER NBL AND SBL  
PHOTOGRAPH OF NORTH SHORE ROCK  
OUTCROP**



PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	ARB	April 2015	SCALE	AS SHOWN
CADD	--		REV.	
CHECK	AB	April 2015	<b>FIGURE 2</b>	
REVIEW				





# **APPENDIX A**

## **Record of Boreholes and Drillholes**



## LIST OF SYMBOLS

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

### I. GENERAL

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

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

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

### (a) Index Properties (continued)

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

### (b) Hydraulic Properties

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

### (c) Consolidation (one-dimensional)

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

### (d) Shear Strength

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

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

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$
$$\text{shear strength} = (\text{compressive strength})/2$$



## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

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

#### Dynamic Cone Penetration Resistance; $N_d$ :

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
$SO_4$	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

### V. MINOR SOIL CONSTITUENTS

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



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

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

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

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

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

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

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

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

### GRAIN SIZE

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

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

### CORE CONDITION

#### Total Core Recovery (TCR)

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

#### Solid Core Recovery (SCR)

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

#### Rock Quality Designation (RQD)

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

### DISCONTINUITY DATA

#### Fracture Index

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

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° 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 <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-01</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084113.5 ; E 222545.0</u>		ORIGINATED BY <u>LK</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>November 18 and 22 to 23, 2012</u>		CHECKED BY <u>MCK/AB</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 (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			W <sub>p</sub>	W	W <sub>L</sub>		
								SHEAR STRENGTH kPa							WATER CONTENT (%)				
							○ UNCONFINED      + FIELD VANE												
							● QUICK TRIAXIAL    × REMOULDED												
175.5	WATER SURFACE															GR	SA	SI	CL
0.0	WATER																		
173.2																			
2.3	ORGANIC SILT, trace sand Very soft to soft Brown to brownish grey Wet		1	SS	WH														
			2	SS	WH														
			3	SS	WH														
			4	SS	WH														
			5	SS	WH														
			6	SS	WH														
167.3																			
8.2	Silty SAND to SAND, some silt, trace gravel Loose to compact Grey Wet		7	SS	5														
			8	SS	5														
			9	SS	9														
			10	SS	4														
			11	SS	12														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: B503-01**

SHEET 1 OF 1

LOCATION: N 5084113.5 ; E 222545.0

DRILLING DATE: November 23, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D55

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY				R.Q.D. %	FRACT. INDEX PER 0.25	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K, cm/sec	Dip w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	Dip	Point Load Index (MPa)	RMC -Q' AVG.	NOTES									
				DEPTH (m)				TOTAL CORE %	SOLID CORE %	%	B Angle														DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	Dip	Point Load Index (MPa)	RMC -Q' AVG.	
		Continued from Record of Borehole B503-1		153.16																													
	NW Casing	Fresh, foliated, medium crystalline, slightly porous, medium strong to strong, grey and black GRANITIC GNEISS		22.37																													
23					1											JN,PL,RO	1.5	1					15.29 MPa (Axial)										
																JN,PL,RO	1.5	1	4														
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
24					2											JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1	6				12.59 MPa UC = 140 MPa										
25	NQRC November 23, 2012															JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
26					3											JN,PL,RO	1.5	1	6				12.90 MPa (Axial)										
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
																JN,PL,RO	1.5	1															
		END OF DRILLHOLE		149.03																													
				26.50																													
27																																	
28																																	
29																																	
30																																	
31																																	
32																																	

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: LK

CHECKED: MCK/AB

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15



PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-02</b>		SHEET 1 OF 4		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084155.6 ; E 222527.3</u>		ORIGINATED BY <u>LK</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>November 10 to 13, 2012</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT  <b>γ</b> kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w <sub>p</sub>	w	w <sub>L</sub>		GR SA SI CL						
								○ UNCONFINED      + FIELD VANE	● QUICK TRIAXIAL      × REMOULDED	WATER CONTENT (%)													
175.5 0.0	WATER SURFACE WATER						20	40	60	80	100	20	40	60									
							175																
							174																
							173																
							172																
							171																
							170																
							169																
							168																
							167																
							166.0 9.5	ORGANIC SILT, trace to some sand Soft to firm Dark brown becoming grey below a depth of 15.2 m (Elev. 160.3 m) Wet					166										
							165																
							164	2	+														
							163																
							162	2	+														
							161	3	+														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



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

PROJECT		RECORD OF BOREHOLE		No B503-02		SHEET 4 OF 4		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084155.6 ; E 222527.3		ORIGINATED BY		LK									
DIST		HWY 69		BOREHOLE TYPE		100 mm I.D. HW Casing, Wash Boring		COMPILED BY									
JFC/MR		DATE		November 10 to 13, 2012		CHECKED BY		MCK/AB									
DUM Geodetic																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
129.1	46.4	Diabase (Fault Zone) (BEDROCK)					130										
		Bedrock cored from depths of 46.4 m to 50.2 m.  For bedrock coring details refer to Record of Drillhole B503-2.	1	RC	REC 100%		129										RQD = 0%
			2	RC	REC 100%		128										RQD = 0%
			3	RC	REC 100%		127										
							126										RQD = 0%
125.3	50.2	END OF BOREHOLE															

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

[illegible]

1 : 50



LOGGED: LK

CHECKED: MCK/AB



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15




+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No B503-06</b>		SHEET 1 OF 1		<b>METRIC</b>													
W.P. 5148-08-01		LOCATION N 5084078.4 ; E 222559.4		ORIGINATED BY TM/SP															
DIST HWY 69		BOREHOLE TYPE Portable Hilti DD 250E		COMPILED BY JFC/MR															
DATUM Geodetic		DATE July 28 to 31, 2014		CHECKED BY MCK/AB															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)						
193.9 0.0	GROUND SURFACE Granitic Gneiss (BEDROCK)  Bedrock cored from depths of 0.0 m to 9.4 m.  For bedrock coring details refer to Record of Drillhole B503-06.		1	RC	REC 100%													193	
			2	RC	REC 100%													192	
			3	RC	REC 100%													191	
			4	RC	REC 100%													190	
			5	RC	REC 100%													189	
			6	RC	REC 100%													188	
			7	RC	REC 100%													187	
			8	RC	REC 100%													186	
			9	RC	REC 100%													185	
			10	RC	REC 100%														
			11	RC	REC 100%														
			12	RC	REC 100%														
184.5 9.4	END OF BOREHOLE  NOTE:  1. Water level in open corehole at a depth of 9.3 m below ground surface (Elev. 184.6 m) on August 6, 2014.																		

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: B503-06**

SHEET 1 OF 1

LOCATION: N 5084078.4 ; E 222559.4

DRILLING DATE: July 28 to 31, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25	B Angle °	DIP w.r.t. CORE AXIS °	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K, cm/sec 10 <sup>-9</sup>	T 10 <sup>-9</sup>	C 10 <sup>-9</sup>	Diametral Point Load Index (MPa)	RMC -Q <sup>+</sup> AVG.	NOTES
0		GROUND SURFACE		193.90																		
		Slightly weathered, foliated, grey and pink, coarse grained, faintly porous, strong to very strong GRANITIC GNEISS		0.00	1																	
1					2								F0, PL, RO	1.5	1							7.92 MPa
2					3								F0, UN, RO, Fe SO	3	1							
					4								JN, UN, RO, Fe SO JN, PL, RO, Fe SO	3	1							
3					5																	
4					6																	
5					7																	
6					8																	
7					9								JN, UN, RO JN, PL, RO, Fe SO	3	1	4						
8					10								JN, PL, RO, Fe SO	1.5	1							7.87 MPa
9					11								JN, UN, RO	3	1							
		END OF DRILLHOLE		184.51	12																	
				9.39																		
10																						

DEPTH SCALE

1 : 50



LOGGED: TM/SP

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15




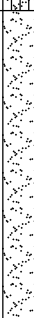

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B503-09		SHEET 2 OF 4		METRIC														
W.P. 5148-08-01		LOCATION N 5084126.4 ; E 222541.4		ORIGINATED BY LK																
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring		COMPILED BY JFC/MR																
DATUM Geodetic		DATE August 8 to 12, 2014		CHECKED BY MCK/AB																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ kN/m <sup>3</sup>	GR	SA	SI	CL
							20 40 60 80 100													
161.2 15.1	SILT and SAND, trace clay, trace gravel Compact Grey Wet		8A 8B	SS	20		161													
								160												
			9	SS	15															
								159												
			10	SS	29			158												
								157												
			11	SS	15			156												
								155												
			12	SS	17		154													
							153													
			13	SS	20		152													
							151													
152.2 24.1	SAND, some silt, trace clay Dense Grey Wet		14	SS	32		150													
								149												
								148												
149.1 27.2	Sandy SILT, trace clay Loose to compact Grey Wet		15	SS	12		147													

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15


PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-09</b>		SHEET 3 OF 4		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084126.4 ; E 222541.4</u>		ORIGINATED BY <u>LK</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>August 8 to 12, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED	20	40	60	80	100	W <sub>p</sub>	W		W <sub>L</sub>				
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	Sandy SILT, trace clay Loose to compact Grey Wet																				
			16	SS	5								○					0	29	66	5
			17	SS	7																
139.3																					
37.0	SAND, trace clay, trace silt, trace gravel Compact Grey Wet		18	SS	18								○					1	95	2	2

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA-GDT 11/24/15

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No B503-09</b>				SHEET 4 OF 4		<b>METRIC</b>								
W.P. 5148-08-01		LOCATION N 5084126.4 ; E 222541.4				ORIGINATED BY LK										
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC/MR										
DATUM Geodetic		DATE August 8 to 12, 2014				CHECKED BY MCK/AB										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100					
	Granitic Gneiss (BEDROCK)		3	RC	REC 100%											
	Bedrock cored from depths of 42.9 m to 50.3 m.		4	RC	REC 100%											
	For bedrock coring details refer to Record of Drillhole B503-09.		5	RC	REC 100%											
			6	RC	REC 100%											
126.0	END OF BOREHOLE															
50.3																



PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: B503-09**

SHEET 1 OF 1

LOCATION: N 5084126.4 ; E 222541.4

DRILLING DATE: August 8 to 12, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY TOTAL CORE %	R.Q.D. SOLID CORE %	FRACT. INDEX PER 0.25	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B503-09		133.37 42.89															
43	HW Casing	Slightly weathered, massive, dark grey and red, medium grained, faintly porous, moderately strong GRANITIC GNEISS			1							JN,UN,RO SA	3	2					
												JN,UN,RO SO	3	1					
					2							JN,UN,RO	3	1					
												JN,UN,RO SO	3	1					
44															3				
					3							JN,UN,RO	3	1	9				UC = 28.4 MPa
												JN,UN,RO	3	1					
												JN,PL,RO	1.5	1					
												VN,PL,RO	1.5	1					
45												JN,PL,RO SO	1.5	1					
												JN,PL,RO	1.5	1					(Axial)
46					4							VN,PL,RO SA	1.5	2	4				UC = 21.3 MPa
												VN,PL,RO SA	1.5	2	4				
47	HW Casing	Slightly weathered, massive, dark grey and red, medium grained, faintly porous, moderately strong GRANITIC GNEISS										JN,PL,RO	1.5	1					
					5							JN,PL,RO	1.5	1					
												JN,PL,RO SO	1.5	1					
												JN,UN,RO	3	1					
												VN,PL,RO	1.5	1					
												JN,PL,RO	1.5	1					
					6							JN,UN,RO SA	3	2					(Axial)
												JN,UN,RO	3	1					
48															4				
49																			
50																			
51		END OF DRILLHOLE		125.97 50.29															
52																			

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-10</b>		SHEET 2 OF 4		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084124.1 ; E 222530.8</u>		ORIGINATED BY <u>LK</u>			
DIST <u>        </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>July 28 to 31, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			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 <sub>p</sub>	W							W <sub>L</sub>
								20	40	60	80	100	20							40
	--- CONTINUED FROM PREVIOUS PAGE ---						161													
	Inferred Silty SAND						160													
							159													
							158													
							157													
							156													
							155													
							154													
							153													
							152													
							151													
							150													
							149													
							148													
							147													

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15


PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-10</b>		SHEET 3 OF 4		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084124.1 ; E 222530.8</u>		ORIGINATED BY <u>LK</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>July 28 to 31, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED				W <sub>p</sub>	W	W <sub>L</sub>						
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100	20	40	60						
	Inferred Silty SAND																				
	Mixture of soil and COBBLES / BOULDERS																				

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE		No B503-10		SHEET 4 OF 4		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084124.1 ; E 222530.8		ORIGINATED BY		LK									
DIST		HWY 69		BOREHOLE TYPE		100 mm I.D. HW Casing, Wash Boring		COMPILED BY									
JFC/MR		DATE		Geodetic		July 28 to 31, 2014		CHECKED BY									
MCK/AB																	
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										
							20	40	60	80	100	20	40	60			
129.0	Granitic Gneiss (BEDROCK)		5	RC	REC 100%		131										RQD = 32%
	Bedrock cored from depths of 24.1 m to 29.3 m.  For bedrock coring details refer to Record of Drillhole B504-10.		6	RC	REC 100%		130										
47.3	END OF BOREHOLE						129										
	NOTE:  1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																

PROJECT: 09-1111-6014

## RECORD OF DRILLHOLE: B503-10

SHEET 1 OF 1

LOCATION: N 5084124.1 ;E 222530.8

DRILLING DATE: July 31, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

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 B503-10		135.52									
41	NW Casing	COBBLES and BOULDERS		40.75	1								
		Slightly weathered, massive and brecciated, dark grey to red, fine to medium grained, faintly porous, medium strong GRANITIC GNEISS		135.01									
42				41.26	2								
43													
44					3								
45					4								
46					5								
47					6								
		END OF DRILLHOLE		128.93									
				47.34									
48													
49													
50													

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15



PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-11</b>		SHEET 2 OF 3		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084185.8 ; E 222514.4</u>		ORIGINATED BY <u>LK</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>July 26 to 28, 2014</u>		CHECKED BY <u>MCK/AB</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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w <sub>p</sub>	w	w <sub>L</sub>		GR	SA	SI	CL
								20	40	60	80	100								
	---	CONTINUED FROM PREVIOUS PAGE ---																		
		Silty SAND, trace to some gravel, trace clay Very loose to compact Grey Moist to wet					161													
			6	SS	4		160											1 71 26 2		
			7	SS	2		159													
							158													
			8	SS	8		157											12 63 25 0		
			9	SS	9		156													
155.2																				
21.1		SILT and SAND, trace gravel Compact Grey Wet					155											1 46 53 0		
			10	SS	26		154													
153.7																				
22.6		Sandy SILT, trace to some gravel Loose to compact Grey Wet					153													
			11	SS	6		152													
			12	SS	25		151											10 28 62 0		
150.5																				
25.8		Granitic Gneiss (BEDROCK)					150											RQD = 76%		
		Bedrock cored from depths of 25.8 m to 30.5 m.	1	RC	REC 100%		149											RQD = 94%		
		For bedrock coring details refer to Record of Drillhole B503-11.	2	RC	REC 100%		148											RQD = 100%		
			3	RC	REC 100%		147													
			4	RC	REC 100%															

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: B503-11**

SHEET 1 OF 1

LOCATION: N 5084185.8 ; E 222514.4


DRILLING DATE: July 27 to 28, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

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 0.25	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec	Diameter Point Load Index (MPa)	RMC -Q' AVG.	NOTES										
								TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn														
																				B Angle	DIP w.r.t. CORE AXIS	PO	K	10	10	10	2	4	8
		Continued from Record of Borehole B503-11		150.52																									
26	HW Casing	Fresh to slightly weathered, foliated, grey, coarse grained, faintly porous, medium strong to very strong GRANITIC GNEISS		25.76	1															8.21 MPa									
27				2																									
28				3																									
29				4																									
30	HQRC July 27, 2014																			8.23 MPa									
		END OF DRILLHOLE		145.83																									
31				30.45																									
32																													
33																													
34																													
35																													

DEPTH SCALE

1 : 50




LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No B503-12</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. <u>5148-08-01</u>		LOCATION <u>N 5084192.2 ; E 222511.4</u>		ORIGINATED BY <u>LK</u>			
DIST <u>        </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC/MR</u>			
DATUM <u>Geodetic</u>		DATE <u>July 19 and 20, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  <b>γ</b> kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	w <sub>p</sub>	w		w <sub>L</sub>			
176.1 0.0	WATER SURFACE WATER																	

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE		No B503-12		SHEET 2 OF 2		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084192.2 ; E 222511.4		ORIGINATED BY		LK									
DIST _____ HWY 69		BOREHOLE TYPE		100 mm I.D. HW Casing, Wash Boring		COMPILED BY		JFC/MR									
DATUM Geodetic		DATE		July 19 and 20, 2014		CHECKED BY		MCK/AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
	Inferred Silty SAND to Sandy SILT No sample taken between depths of 8.1 m and 23.4 m.						161										
							160										
	Cobbles and Boulders encountered below a depth of 17.1 m (Elev. 159.2 m)						159										
							158										
							157										
							156										
							155										
	Boulder encountered at a depth of 21.9 m (Elev. 154.2 m).						154										
							153										
152.7 23.4	Granitic Gneiss (BEDROCK)  Bedrock cored from depths of 23.4 m to 27.1 m.  For bedrock coring details refer to Record of Drillhole B503-12.		1	RC	REC 100%		152									RQD = 97%	
			2	RC	REC 100%		151									RQD = 98%	
			3	RC	REC 98%		150									RQD = 87%	
149.0 27.1	END OF BOREHOLE  NOTE:  1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

LOGGED: LK  
CHECKED: MCK/AB



PROJECT 09-1111-6014		RECORD OF BOREHOLE No B503-13		SHEET 2 OF 3		METRIC							
W.P. 5148-08-01		LOCATION N 5084188.3 ; E 222501.8		ORIGINATED BY LK									
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring		COMPILED BY JFC/MR									
DATUM Geodetic		DATE July 24 to 25, 2014		CHECKED BY MCK/AB									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20 40 60					
150.7	Inferred Silty SAND to SILT and SAND No sample taken between depths of 8.8 m and 25.2 m.												
25.2	Granitic Gneiss (BEDROCK)  Bedrock cored from depths of 25.2 m to 28.8 m.  For bedrock coring details refer to Record of Drillhole B503-13.		1	RC	REC 100%								RQD = 78%
			2	RC	REC 100%								RQD = 100%
			3	RC	REC 89%								RQD = 89%
147.1	END OF BOREHOLE												
28.8													

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No B503-13</b>				SHEET 3 OF 3		<b>METRIC</b>													
W.P. 5148-08-01		LOCATION N 5084188.3 ; E 222501.8				ORIGINATED BY LK															
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC/MR															
DATUM Geodetic		DATE July 24 to 25, 2014				CHECKED BY MCK/AB															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa													
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>					<div style="display: flex; justify-content: space-between;"> <span>20 40 60</span> <span>20 40 60</span> </div>									
NOTE:  1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																					



PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: B503-13**

SHEET 1 OF 1

LOCATION: N 5084188.3 ; E 222501.8

DRILLING DATE: July 24 to 25, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	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 <b>NOTE:</b> For additional abbreviations refer to list of abbreviations & symbols.										NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25	B Angle	DIP w.r.t CORE AXIS	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
								TOTAL CORE %	SOLID CORE %					TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K <sub>1</sub>	K <sub>2</sub>	K <sub>3</sub>	K <sub>4</sub>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
		Continued from Record of Borehole B503-13		150.69																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15




+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE		No B503-16		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084230.8 ; E 222496.0		ORIGINATED BY		TM									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY									
JFC/MR		DATE		July 23 to 24, 2014		CHECKED BY		MCK/AB									
DATUM		Geodetic															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
194.8	GROUND SURFACE						20	40	60	80	100						GR SA SI CL
0.0	Granitic Gneiss (BEDROCK)		1	RC	REC 100%												RQD = 100%
	Bedrock cored from depths of 0.0 m to 7.5 m.		2	RC	REC 100%												RQD = 94%
	For bedrock coring details refer to Record of Drillhole B503-16.		3	RC	REC 100%												RQD = 98%
			4	RC	REC 100%												RQD = 95%
			5	RC	REC 100%												RQD = 92%
			6	RC	REC 100%												RQD = 100%
			7	RC	REC 100%												RQD = 100%
			8	RC	REC 100%												RQD = 100%
187.3	END OF BOREHOLE																
7.5	NOTE:  1. Water level in open corehole at a depth of 4.4 m below ground surface (Elev. 190.4 m) on the morning of July 25, 2014.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: OGS Inc

[illegible]

CHECKED: MCK/AB

GTARCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE






+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT		RECORD OF BOREHOLE		No B504-10		SHEET 1 OF 2		METRIC						
W.P. 09-1111-6014		LOCATION		N 5084119.3 ; E 222562.6		ORIGINATED BY		LK						
DIST		HWY 69		BOREHOLE TYPE		100 mm I.D. HW Casing, Wash Boring		COMPILED BY						
JFC		DATUM		Geodetic		DATE		August 7, 2014						
						CHECKED BY		MCK/AB						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
176.3 0.0	WATER SURFACE WATER							20 40 60 80 100	20 40 60					
172.6 3.7	Inferred ORGANIC SILT No sample taken between depths of 3.7 m and 21.3 m.							20 40 60 80 100	20 40 60					
166.9 9.4	Inferred SAND to GRAVELLY SAND							20 40 60 80 100	20 40 60					
							176							
							175							
							174							
							173							
							172							
							171							
							170							
							169							
							168							
							167							
							166							
							165							
							164							
							163							
							162							

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: B504-10**

SHEET 1 OF 1

LOCATION: N 5084119.3 ; E 222562.6


DRILLING DATE: August 7, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

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 0.25	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				Diametal 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								
																				JN - Joint	BD - Bedding				PL - Planar	PO - Polished	MB - Mechanical Break
		Continued from Record of Borehole B504-10		155.01																							
22	HW Casing	Slightly weathered, massive, grey to dark grey, medium to coarse grained, faintly porous, medium strong to strong GRANITIC GNEISS		21.31	1																						
23	HQRC August 7, 2014				2																						
24					3																						
25		END OF DRILLHOLE		151.48 24.84																							
26																											
27																											
28																											
29																											
30																											
31																											

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No B504-14</b>				SHEET 3 OF 3		<b>METRIC</b>													
W.P. 5147-08-01		LOCATION N 5084190.2 :E 222532.4				ORIGINATED BY LK															
DIST HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC															
DATUM Geodetic		DATE July 25 to 26, 2014				CHECKED BY MCK/AB															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa													
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>					<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60</span> </div> <div style="display: flex; justify-content: space-between;"> <span>W<sub>p</sub></span> <span>W</span> <span>W<sub>L</sub></span> </div>									
NOTE:  1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																					

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

CHECKED: MCK/AB

G.W.P. <u>5377-02-00</u>		LOCATION <u>South Bank of Key River, Mowat Township, Co-ords: 5084177 N; 222522 E</u>	1 OF 4	ORIGINATED BY <u>JF</u>
DIST <u>54</u>	HWY <u>69</u>	BOREHOLE TYPE <u>Portable Drilling Equipment - Wash Boring</u>		COMPILED BY <u>SN</u>
DATUM <u>Geodetic</u>	DATE <u>16 February 2006</u>			CHECKED BY <u>IH</u>
PROJECT <u>Highway 69 Route Selection Study, from 3.5 km North of HWY 559 to 3.8 km North of HWY 522</u>				JOB NO. <u>TT53126</u>

[illegible]



# RECORD OF BOREHOLE No ST-40 (A)

G.W.P. 5377-02-00 LOCATION South Bank of Key River, Mowat Township, Co-ords: 5084177 N; 222522 E 2 OF 4  
 DIST 54 HWY 69 BOREHOLE TYPE Portable Drilling Equipment - Wash Boring ORIGINATED BY JF  
 DATUM Geodetic DATE 16 February 2006 COMPILED BY SN  
 PROJECT Highway 69 Route Selection Study, from 3.5 km North of HWY 559 to 3.8 km North of HWY 522 CHECKED BY IH  
 JOB NO. TT53126

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				20	40	60	80	100		
167.1	WATER														
8.8	CLAYEY SILT / SILTY CLAY trace sand, trace peat in upper portion of SS1 dark grey, very soft, wet MH-OH		1	SS	0			167							
								166							
								165							
								164							
								163							
								162							
								161							
								160							
161.6	End of Borehole														
14.3	Groundwater in open borehole on completion: at surface  Dynamic Cone Penetration Test was conducted below 14.3 m depth.														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

For SS2:  
w<sub>n</sub>=124%,  
w<sub>L</sub>=59, w<sub>p</sub>=42  
0 2 68 30

3 OF 4

G.W.P. 5377-02-00	LOCATION <u>South Bank of Key River, Mowat Township, Co-ords: 5084177 N; 222522 E</u>	ORIGINATED BY <u>JF</u>
DIST <u>54</u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Drilling Equipment - Wash Boring</u>	COMPILED BY <u>SN</u>
DATUM <u>Geodetic</u>	DATE <u>16 February 2006</u>	CHECKED BY <u>IH</u>
PROJECT <u>Highway 69 Route Selection Study, from 3.5 km North of HWY 559 to 3.8 km North of HWY 522</u>		JOB NO. <u>TT53126</u>

[illegible]

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

# RECORD OF BOREHOLE No ST-40 (A)

G.W.P. 5377-02-00	LOCATION South Bank of Key River, Mowat Township, Co-ords: 5084177 N; 222522 E	4 OF 4	ORIGINATED BY JF
DIST 54 HWY 69	BOREHOLE TYPE Portable Drilling Equipment - Wash Boring	COMPILED BY SN	
DATUM Geodetic	DATE 16 February 2006	CHECKED BY IH	
PROJECT Highway 69 Route Selection Study, from 3.5 km North of HWY 559 to 3.8 km North of HWY 522			JOB NO. TT53126

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	DEPTH  m	ELEVATION SCALE  m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL		
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE					W <sub>p</sub>	W	W <sub>L</sub>								
											20	40	60	80	100						
151.7																					
24.2	<div>End of DCPT</div> <div>Refusal to Dynamic Cone Penetration Test at 24.2 m depth due to possible bedrock</div> <div>Borehole ST-40 (A) was drilled at 28 m south of ST-40.</div> <div>Borehole was backfilled with bentonite.</div>							151													DCPT blow count = 100/15 cm at 24.2 m



# APPENDIX B

## Laboratory Test Results and Bedrock Core Photographs

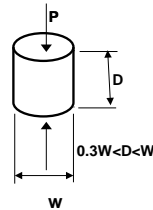
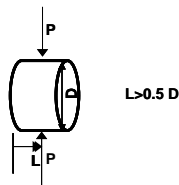
**TABLE B1**  
**POINT LOAD TEST RESULTS ON ROCK SAMPLES**

Foundation Element	Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core <sup>(2)</sup> Diameter (mm)	Is (50mm) (MPa)	Approx. UCS Value <sup>(1)</sup> (MPa)
South Abutment / Approach	B503-06	2	1.2	192.7	Granitic Gneiss	Diametral	105	63	7.9	111
	B503-06	8	5.8	188.1	Granitic Gneiss	Axial	51	63	6.5	91
	B503-06	9	7.7	186.2	Granitic Gneiss	Diametral	89	63	7.9	110
South Pier (Pier 1)	B503-01	1	23.1	152.4	Granitic Gneiss	Axial	19	47	15.3	214
	B503-01	2	24.2	151.3	Granitic Gneiss	Diametral	95	41	12.6	176
	B503-01	3	25.1	150.4	Granitic Gneiss	Axial	20	47	12.9	181
	B503-09	3	44.9	131.4	Granitic Gneiss	Diametral	90	63	1.1	15
	B503-09	4	46.3	130.0	Granitic Gneiss	Axial	60	63	1.4	20
	B503-09	4	47.2	129.1	Granitic Gneiss	Diametral	100	63	1.7	24
	B503-09	6	49.7	126.6	Granitic Gneiss	Axial	30	63	2.1	29
	B503-10	2	43.3	133.0	Granitic Gneiss	Diametral	80	63	1.8	25
	B504-10	2	23.3	153.0	Granitic Gneiss	Diametral	69	63	8.6	120
North Pier (Pier 2)	B503-11	1	26.4	149.9	Granitic Gneiss	Diametral	69	63	8.2	115
	B503-11	3	29.4	146.9	Granitic Gneiss	Diametral	114	63	8.2	115
	B503-12	1	24.5	151.6	Granitic Gneiss	Diametral	115	63	0.9	13
	B503-13	1	26.5	149.4	Granitic Gneiss	Diametral	102	63	8.2	114
	B503-13	2	27.2	148.7	Granitic Gneiss	Axial	55	63	7.6	107
	B503-13	2	27.8	148.1	Granitic Gneiss	Diametral	80	63	8.8	123
	B504-14	1	25.8	150.5	Granitic Gneiss	Diametral	115	63	7.9	110
	B504-14	2	27.7	148.6	Granitic Gneiss	Diametral	96	63	5.9	83
	B504-14	2	27.7	148.6	Granitic Gneiss	Axial	52	63	8.3	116
North Abutment / Approach	B503-16	1	0.8	194.0	Granitic Gneiss	Diametral	107	56	7.3	103
	B503-16	2	0.8	194.0	Granitic Gneiss	Axial	55	56	7.9	110
	B503-16	2	0.9	193.9	Granitic Gneiss	Diametral	95	56	4.8	67
	B503-16	7	6.6	188.2	Granitic Gneiss	Axial	42	56	9.3	130

<sup>(1)</sup>  $I_{s50} \times K$ , 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  $K = 14$  has been used based on 9 UCS tests for both the SBL and NBL bridges.

#### DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis  
(planes of weakness)



#### AXIAL SPECIMEN SHAPE REQUIREMENTS

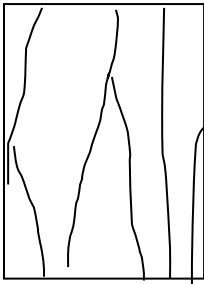
note: Axial tests are parallel to core axis  
(planes of weakness)

**TABLE B2-1**  
**SUMMARY OF UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS**  
**KEY RIVER SBL BRIDGE**  
**HIGHWAY 69 GWP 5404-05-00; WP 5148-08-01**

<b>Borehole Number (Core Run)</b>	<b>Sample Depth (m)</b>	<b>Sample Elevation (m)</b>	<b>Rock Type</b>	<b>Core Diameter (mm)</b>	<b>Uniaxial Compressive Strength (MPa)</b>
B503-01	24.4	151.1	Granitic Gneiss	47.1	140.3
B503-06	5.6	188.3	Granitic Gneiss	62.9	88.1
B503-09	44.7	131.6	Granitic Gneiss	63.2	28.4
B503-09	47.0	129.3	Granitic Gneiss	63.1	21.3
B503-12	25.3	150.8	Granitic Gneiss	63.0	100.5
B503-16	6.0	188.8	Granitic Gneiss	57.0	103.0

Compiled By: MT/ABReviewed By: JMAC

**TABLE B2-2**  
**UNCONFINED COMPRESSION TEST (UC)**  
**ASTM D 7012-07**

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B503-01	SAMPLE DEPTH, m	24.32-24.50
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.35
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	11.09	WATER CONTENT, (specimen) %	0.26
SAMPLE DIAMETER, cm	4.71	UNIT WEIGHT, kN/m <sup>3</sup>	29.36
SAMPLE AREA, cm <sup>2</sup>	17.44	DRY UNIT WT., kN/m <sup>3</sup>	29.28
SAMPLE VOLUME, cm <sup>3</sup>	193.39	SPECIFIC GRAVITY	-
WET WEIGHT, g	579.11	VOID RATIO	-
DRY WEIGHT, g	577.61		
VISUAL INSPECTION		FAILURE SKETCH	
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	140.3
REMARKS:	DATE:		12/13/2012
PREPARED BY: AB	REVIEWED BY:		JPD/JMAC

**TABLE B2-3**  
**UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS**  
**ASTM D7012**

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	7
BOREHOLE NUMBER	B503-06	SAMPLE DEPTH, m	5.50-5.73

TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.29

SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	14.37	WATER CONTENT, (specimen) %	0.08
SAMPLE DIAMETER, cm	6.29	UNIT WEIGHT, kN/m <sup>3</sup>	26.56
SAMPLE AREA, cm <sup>2</sup>	31.04	DRY UNIT WT., kN/m <sup>3</sup>	26.54
SAMPLE VOLUME, cm <sup>3</sup>	446.07	SPECIFIC GRAVITY	-
WET WEIGHT, g	1208.40	VOID RATIO	-
DRY WEIGHT, g	1207.43		

**VISUAL INSPECTION**

**FAILURE SKETCH**



TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	88.1

REMARKS:

DATE:

04/22/15

PREPARED BY: AB

REVIEWED BY: JPD/JMAC

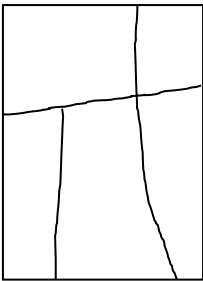


**TABLE B2-4**  
**UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS**  
**ASTM D7012**

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	3
BOREHOLE NUMBER	B503-09	SAMPLE DEPTH, m	44.62-44.80

TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.22

SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	14.01	WATER CONTENT, (specimen) %	1.36
SAMPLE DIAMETER, cm	6.32	UNIT WEIGHT, kN/m <sup>3</sup>	26.09
SAMPLE AREA, cm <sup>2</sup>	31.37	DRY UNIT WT., kN/m <sup>3</sup>	25.74
SAMPLE VOLUME, cm <sup>3</sup>	439.47	SPECIFIC GRAVITY	-
WET WEIGHT, g	1169.40	VOID RATIO	-
DRY WEIGHT, g	1153.71		

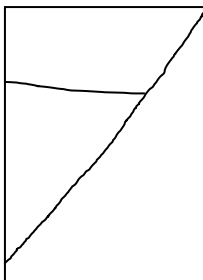
VISUAL INSPECTION	FAILURE SKETCH
	

TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	28.4

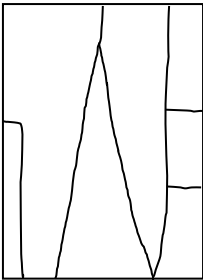
REMARKS: \_\_\_\_\_ DATE: 04/23/15

PREPARED BY: AB \_\_\_\_\_ REVIEWED BY: JPD/JMAC

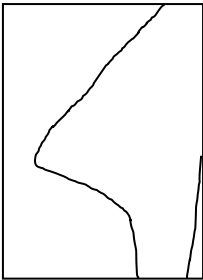
**TABLE B2-5**  
**UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS**  
**ASTM D7012**

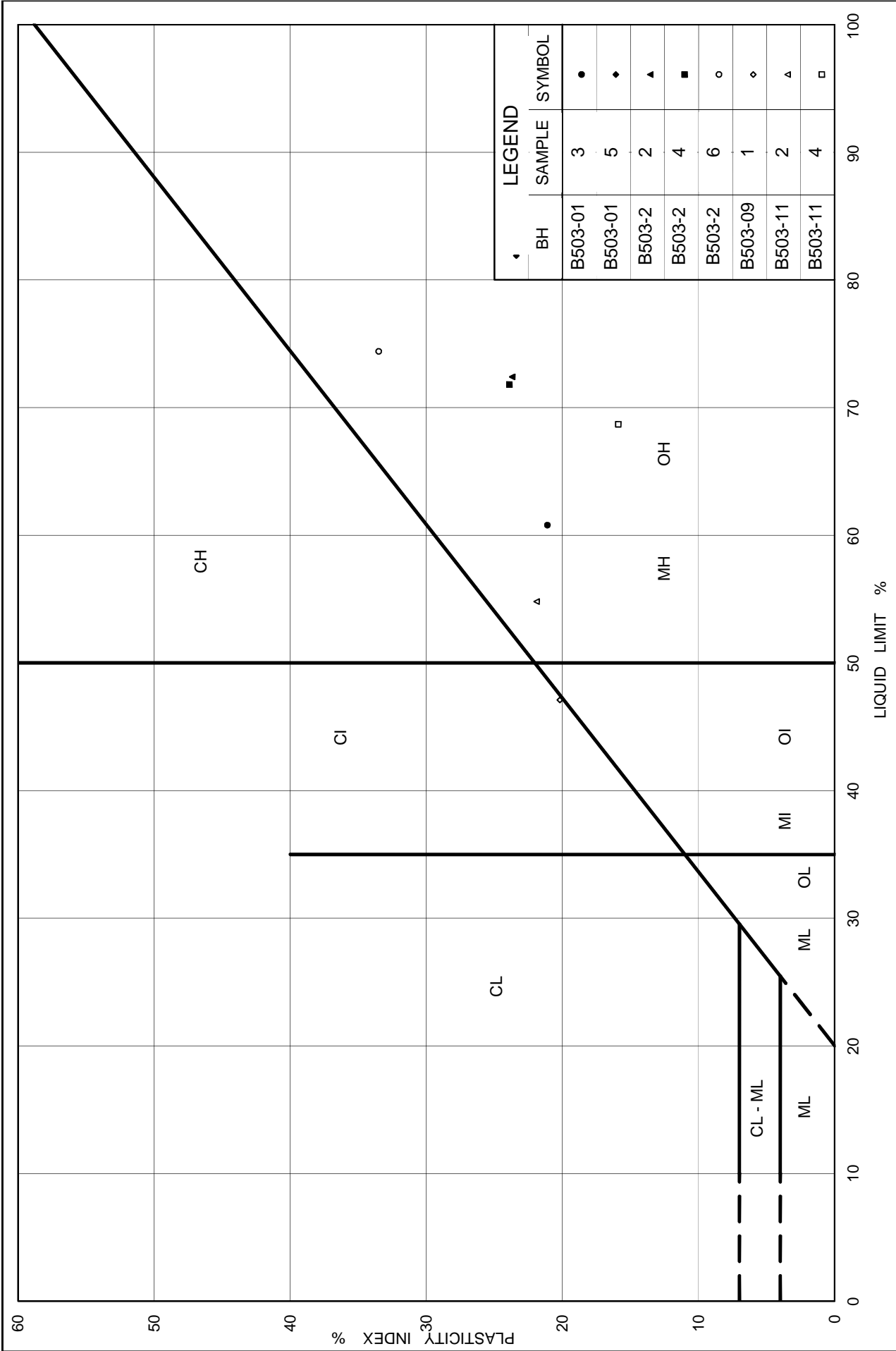
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	4
BOREHOLE NUMBER	B503-09	SAMPLE DEPTH, m	46.91-47.16
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.22
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	14.01	WATER CONTENT, (specimen) %	0.93
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m <sup>3</sup>	26.84
SAMPLE AREA, cm <sup>2</sup>	31.29	DRY UNIT WT., kN/m <sup>3</sup>	26.59
SAMPLE VOLUME, cm <sup>3</sup>	438.33	SPECIFIC GRAVITY	-
WET WEIGHT, g	1199.90	VOID RATIO	-
DRY WEIGHT, g	1188.84		
VISUAL INSPECTION		FAILURE SKETCH	
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	21.3

**TABLE B2-6**  
**UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS**  
**ASTM D7012**

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B503-12	SAMPLE DEPTH, m	25.18-25.44
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.26
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	14.23	WATER CONTENT, (specimen) %	0.31
SAMPLE DIAMETER, cm	6.30	UNIT WEIGHT, kN/m <sup>3</sup>	30.25
SAMPLE AREA, cm <sup>2</sup>	31.19	DRY UNIT WT., kN/m <sup>3</sup>	30.16
SAMPLE VOLUME, cm <sup>3</sup>	443.74	SPECIFIC GRAVITY	-
WET WEIGHT, g	1369.30	VOID RATIO	-
DRY WEIGHT, g	1365.07		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	100.5
REMARKS:	DATE:		04/23/15
PREPARED BY:	AB	REVIEWED BY:	JPD/JMAC

**TABLE B2-7**  
**UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS**  
**ASTM D7012**

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	6
BOREHOLE NUMBER	B503-16	SAMPLE DEPTH, m	5.85-6.13
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.26
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	12.85	WATER CONTENT, (specimen) %	0.18
SAMPLE DIAMETER, cm	5.70	UNIT WEIGHT, kN/m <sup>3</sup>	26.17
SAMPLE AREA, cm <sup>2</sup>	25.48	DRY UNIT WT., kN/m <sup>3</sup>	26.13
SAMPLE VOLUME, cm <sup>3</sup>	327.42	SPECIFIC GRAVITY	-
WET WEIGHT, g	874.20	VOID RATIO	-
DRY WEIGHT, g	872.63		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	103.0
REMARKS:	DATE:		04/23/15
PREPARED BY:	AB	REVIEWED BY:	JPD/JMAC





Ministry of Transportation

Figure No.B1

# PLASTICITY CHART

## Organic Silt to Organic Silty Clay

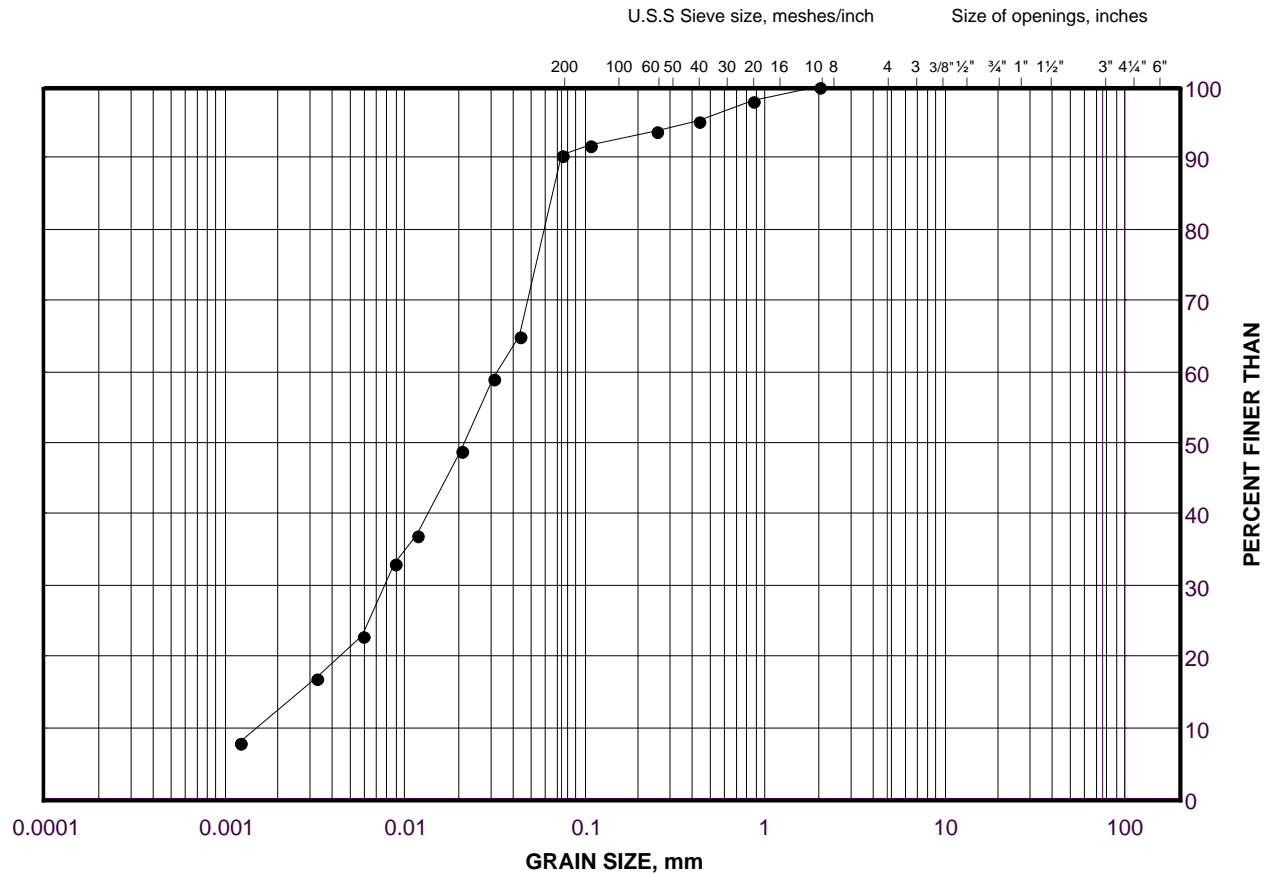
Project No. 09-1111-6014

Checked By: AB

# GRAIN SIZE DISTRIBUTION

Organic Silt

FIGURE B2



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

## LEGEND

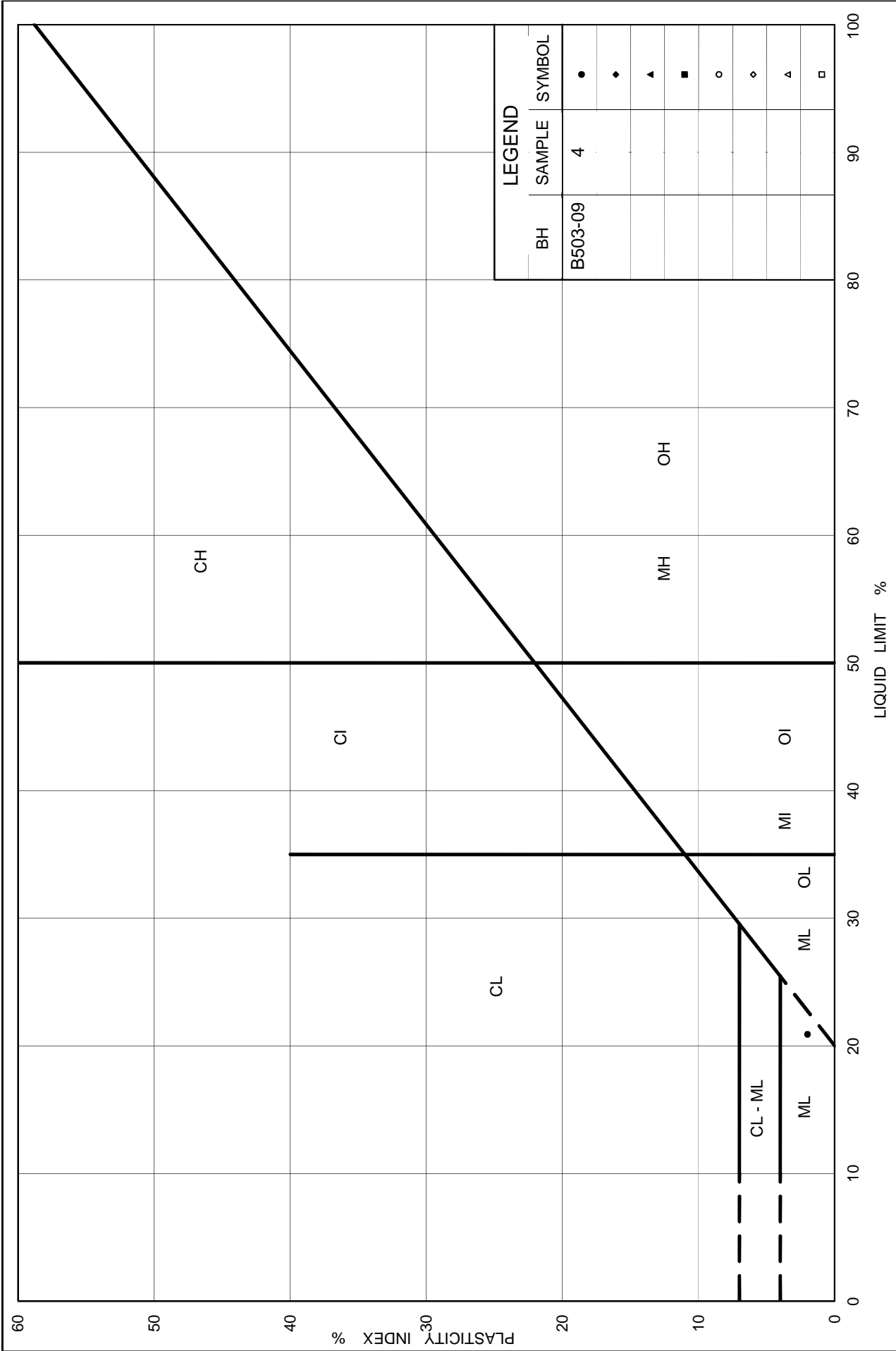
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	B503-01	4	170.1

Project Number: 09-1111-6014

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 01-May-15

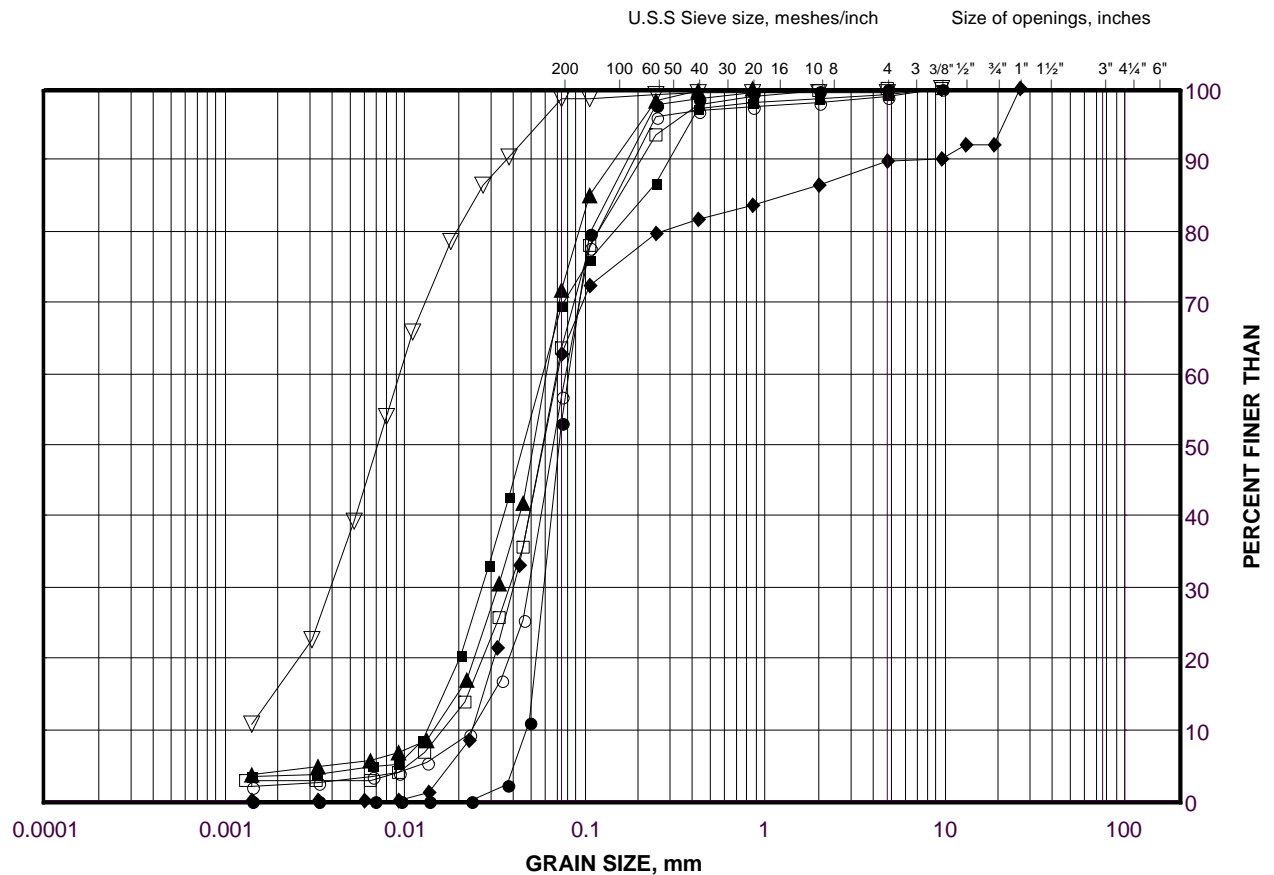


	<b>PLASTICITY CHART</b> Silt	Figure No.B3
		Project No. 09-1111-6014
		Checked By:

# GRAIN SIZE DISTRIBUTION

Silt to Silt and Sand

FIGURE B4-1



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B503-11	10	154.5
■	B503-09	11	156.6
◆	B503-11	12	151.3
▲	B503-09	16	144.5
▽	B503-09	6	164.3
○	B503-09	9	159.7
□	B503-02	9	152.0

Project Number: 09-1111-6014

Checked By: \_\_\_\_\_

**Golder Associates**

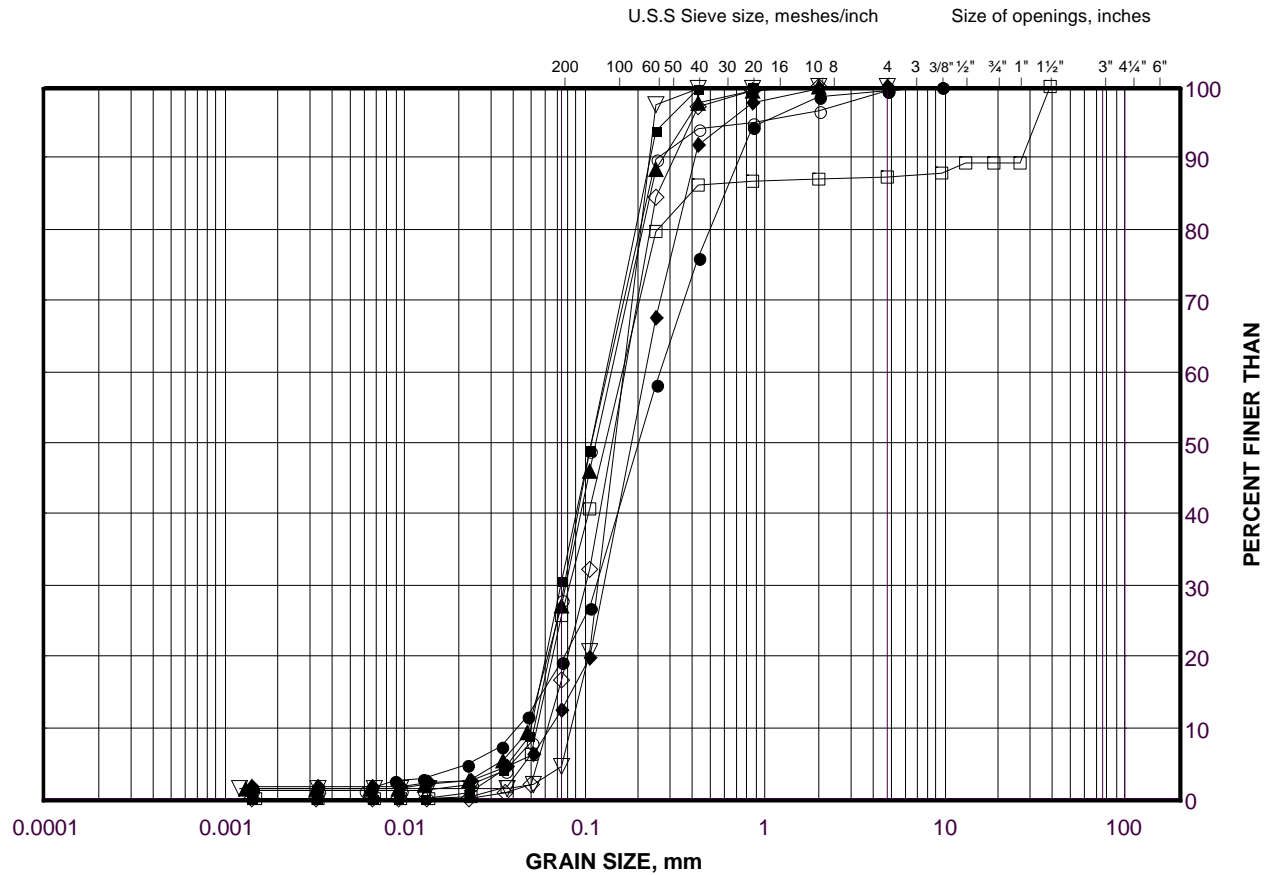
Date: 06-May-15



# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

FIGURE B4-2



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B503-02	12	146.0
■	B503-01	13	158.2
◆	B503-09	14	150.5
▲	B503-02	14	139.5
▽	B503-09	18	138.5
○	B503-11	6	160.5
□	B503-11	8	157.5
△	B503-01	9	164.3

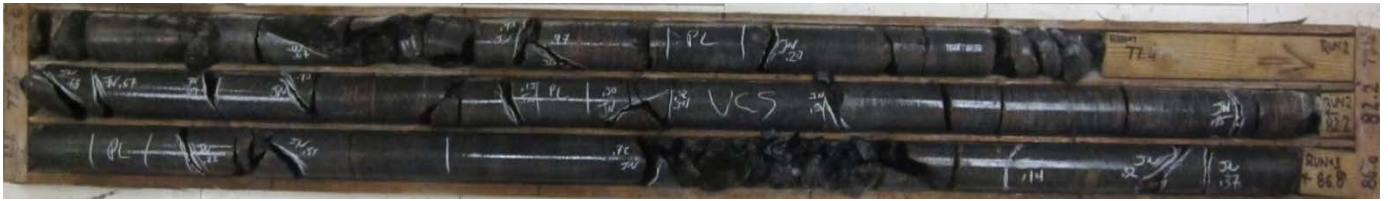
Project Number: 09-1111-6014

Checked By: \_\_\_\_\_

**Golder Associates**

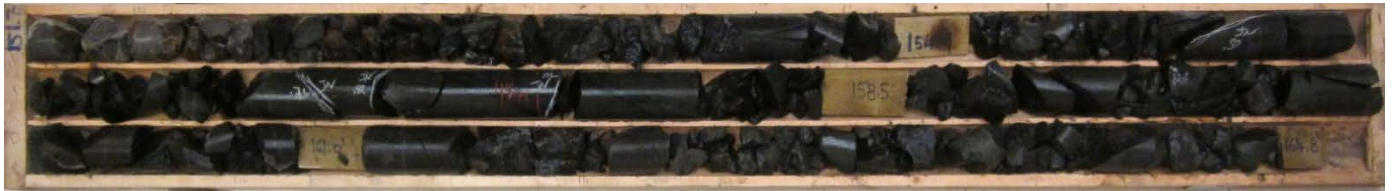
Date: 06-May-15

## Borehole B503-01

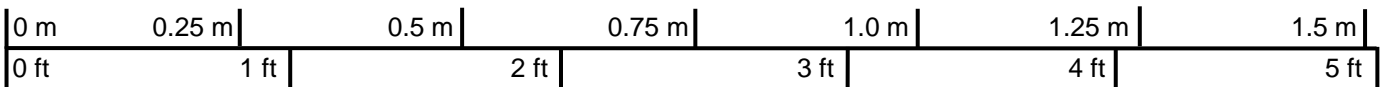


Box 1: 22.37 m – 26.45 m


## Borehole B503-02



Box 1: 46.39 m – 50.23 m



Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01		
TITLE		Bedrock Core Photograph – Borehole B503–01 & Borehole B503–02		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B5		

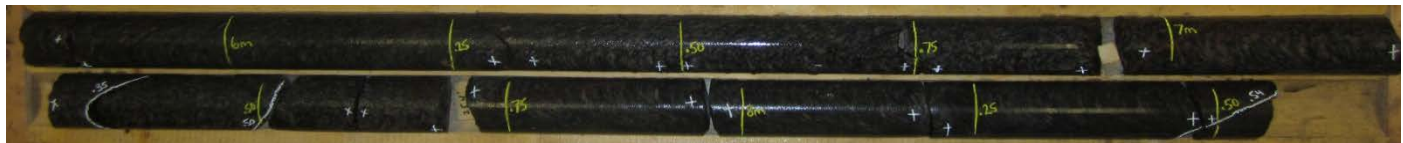
## Borehole B503-06



Box 1: 0.00 m – 2.80 m



Box 2: 2.80 m – 5.75 m




Box 3: 5.75 m – 8.54 m



Box 4: 8.54 m – 9.39 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		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01		
TITLE		Bedrock Core Photograph – Borehole B503-06		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		FIGURE B6		

## Borehole B503-09



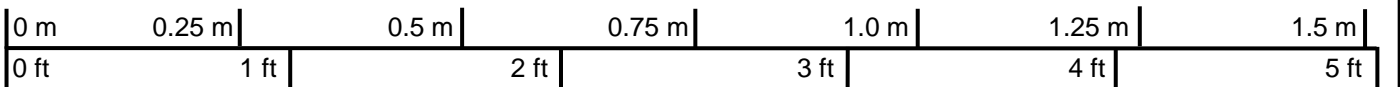
Box 1: 41.40 m – 44.93 m (Cobbles and boulders to 42.89 m)




Box 2: 44.93 m – 47.32 m



Box 3: 47.32 m – 50.29 m



Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01		
TITLE		Bedrock Core Photograph – Borehole B503–09		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B7		

## Borehole B503-10



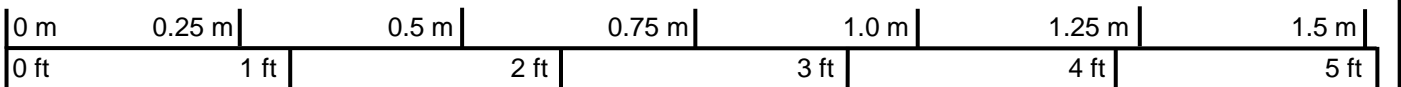
Box 1: 40.75 m – 43.29 m (Cobbles and Boulders to 41.26 m)




Box 2: 43.29 m – 45.11 m



Box 3: 45.11 m – 47.34 m

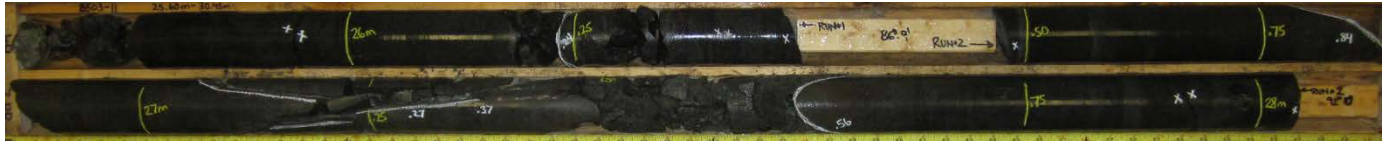


Scale

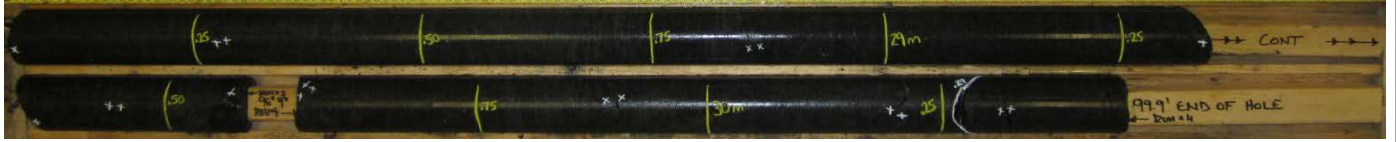
PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01			
TITLE		Bedrock Core Photograph – Borehole B503-10			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	MCK	MAR 15	SCALE NTS
		CADD	-- --		REV.
		CHECK	AB	APR 15	FIGURE B8
		REVIEW	JMAC	APR 15	



## Borehole B503-11



Box 1: 25.76 m – 28.04 m



Box 2: 28.04 m – 30.45 m

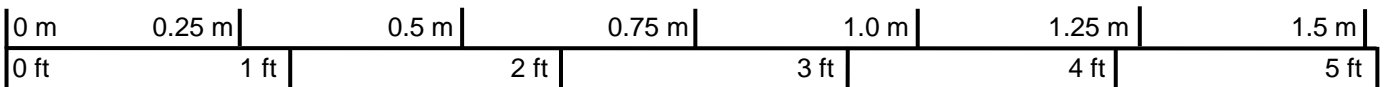
## Borehole B503-12




Box 1: 23.41 m – 25.60 m



Box 2: 25.60 m – 27.10 m



Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01			
TITLE		Bedrock Core Photograph – Borehole B503–11 & Borehole B503–12			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	MCK	MAR 15	SCALE NTS
		CADD	--		REV.
		CHECK	AB	APR 15	FIGURE B9
		REVIEW	JMAC	APR 15	

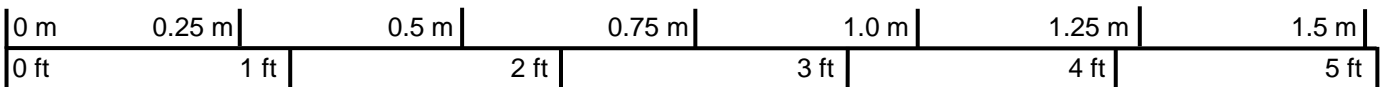
## Borehole B503-13




Box 1: 25.21 m – 28.07 m



Box 2: 28.07 m – 28.80 m



Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01		
TITLE		Bedrock Core Photograph – Borehole B503–13		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B10		

## Borehole B503-16



Box 1: 0.00 m – 2.72 m



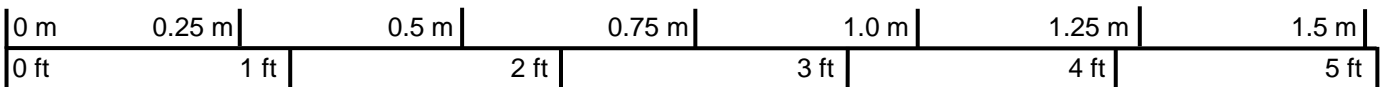
Box 2: 2.72 m – 5.48 m




Box 3: 5.48 m – 7.50 m



50 mm thick infilling of rootlets/organic matter at 2.0 m depth



Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01			
TITLE		Bedrock Core Photograph – Borehole B503–16			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	MCK	MAR 15	SCALE NTS
		CADD	-- --		REV.
		CHECK	AB	APR 15	FIGURE B11
		REVIEW	JMAC	APR 15	



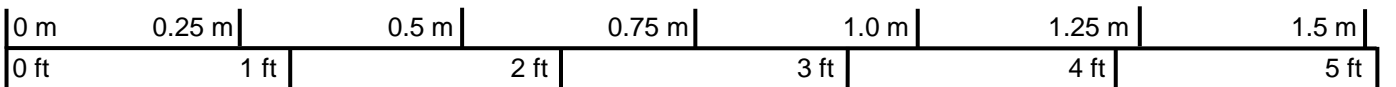
## Borehole B504-10




Box 1: 21.31 m – 23.57 m



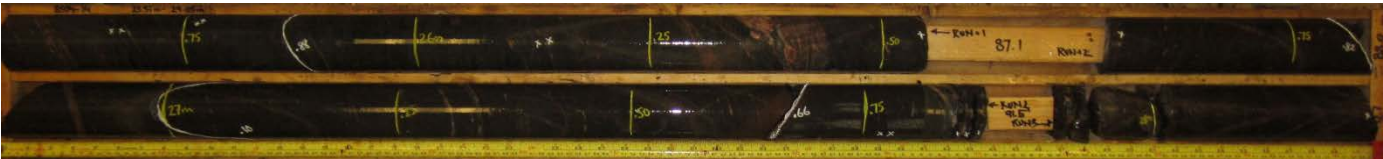
Box 2: 23.57 m – 24.84 m



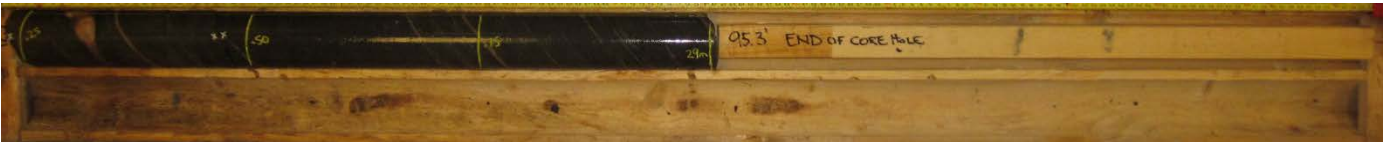
Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01		
TITLE		Bedrock Core Photograph – Borehole B504-10		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B12		

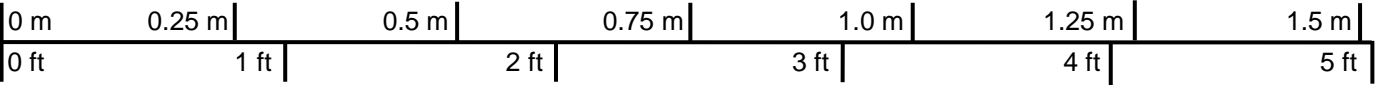
**Borehole B504-14**




Box 1: 25.51 m – 28.22 m



Box 2: 28.22 m – 29.05 m



Scale

PROJECT		KEY RIVER (SBL) Highway 69 GWP 5404-05-00; WP 5148-08-01		
TITLE		Bedrock Core Photograph – Borehole B504–14		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B13		



# APPENDIX C

## Drilling Photographs and Underwater Locates



**Photograph 1: Drilling with portable equipment at SBL north abutment**



**Photograph 2: Drilling with portable equipment at SBL south abutment**

PROJECT					
HIGHWAY 69 - KEY RIVER NBL AND SBL					
TITLE					
Drill Setup Photographs					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	MCK	MAR 15	SCALE	NTS	REV.
CADD	-- --		FIGURE C1		
CHECK	AB	APR 15			
REVIEW	JMAC	APR 15			





20140728 - Key River - Drilling  
over BH 503-10 SBL.



**Photograph 1: Drilling from barge at SBL south pier**

20140824 - Key River - steel posts  
welded and rope installed around  
the barge.



**Photograph 2: Drilling from barge at SBL north pier**

PROJECT					
HIGHWAY 69 - KEY RIVER NBL AND SBL					
TITLE					
Drill Setup Photographs					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	MCK	MAR 15	SCALE	NTS	REV.
CADD	-- --		FIGURE C2		
CHECK	AB	APR 15			
REVIEW	JMAC	APR 15			








**Photograph 1: Key River ASI Group Diver Locates first buoy on west side of river**



**Photograph 2: Key River ASI Group - Diver out of Water**

PROJECT								
HIGHWAY 69 - KEY RIVER NBL AND SBL								
TITLE								
Underwater Locates Photographs								
			PROJECT No. 09-1111-6014			FILE No. ----		
			DESIGN	MCK	MAR 15	SCALE	NTS	REV.
			CADD	-- --		FIGURE C3		
			CHECK	AB	APR 15			
			REVIEW	JMAC	APR 15			





# APPENDIX D

## Geophysical Logs, Bedrock Outcrop Photographs and Structural Analysis





GEOPHYSICAL RECORD OF BOREHOLE: B503-06

Project Number: 09-1111-6014  
Client: MTO  
Date: August 2014

Datum:	WGS84, UTM Zone 17N	Elevation:	193.895 m asl	Borehole Diameter:	71 mm	Water Level:	N/A	Location:	South Abuttment, SBL
Easting:	222,559.419 m	Depth Reference:	"0" at Ground	Casing Diameter:	N/A	Borehole Inclination:	Vertical	Log Date:	7-Aug-14
Northing:	5,084,078.418 m	Drilled Depth:	9.25 m bgs	Casing Depth:	N/A	Borehole Azimuth:	N/A	Logged By:	AR

0901802700

090

Dip (0-90)

Dip direction(0-360)

Trace of Fracture

Broken Zone / Undifferentiated

Major Open Joint / Fracture

Minor Open Joint / Fracture

Partially Open Joint / Fracture

Filled Fracture / Joint

Bedding / Banding / Foliation

Induced Fracture

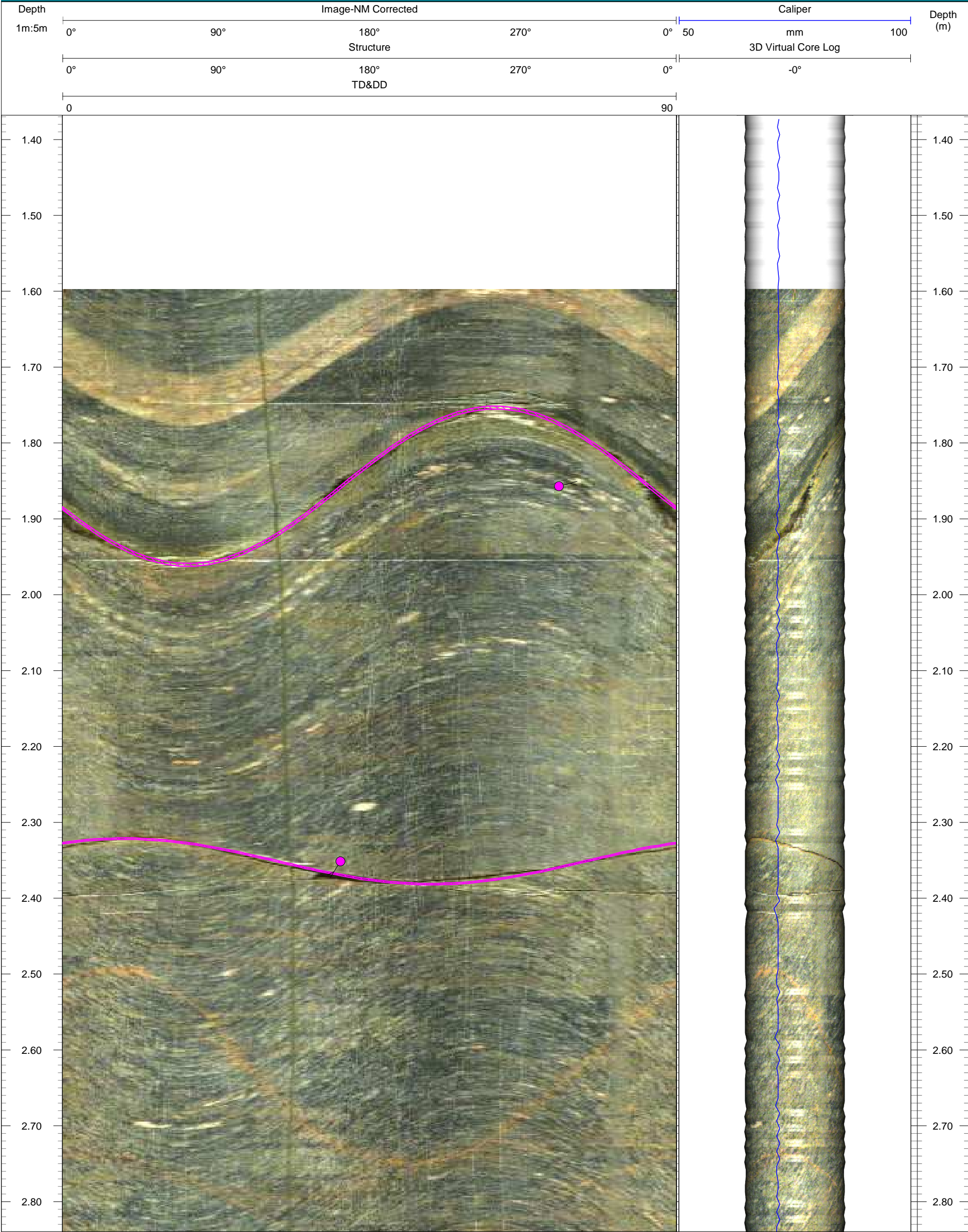
Enlarged Fracture

Contact

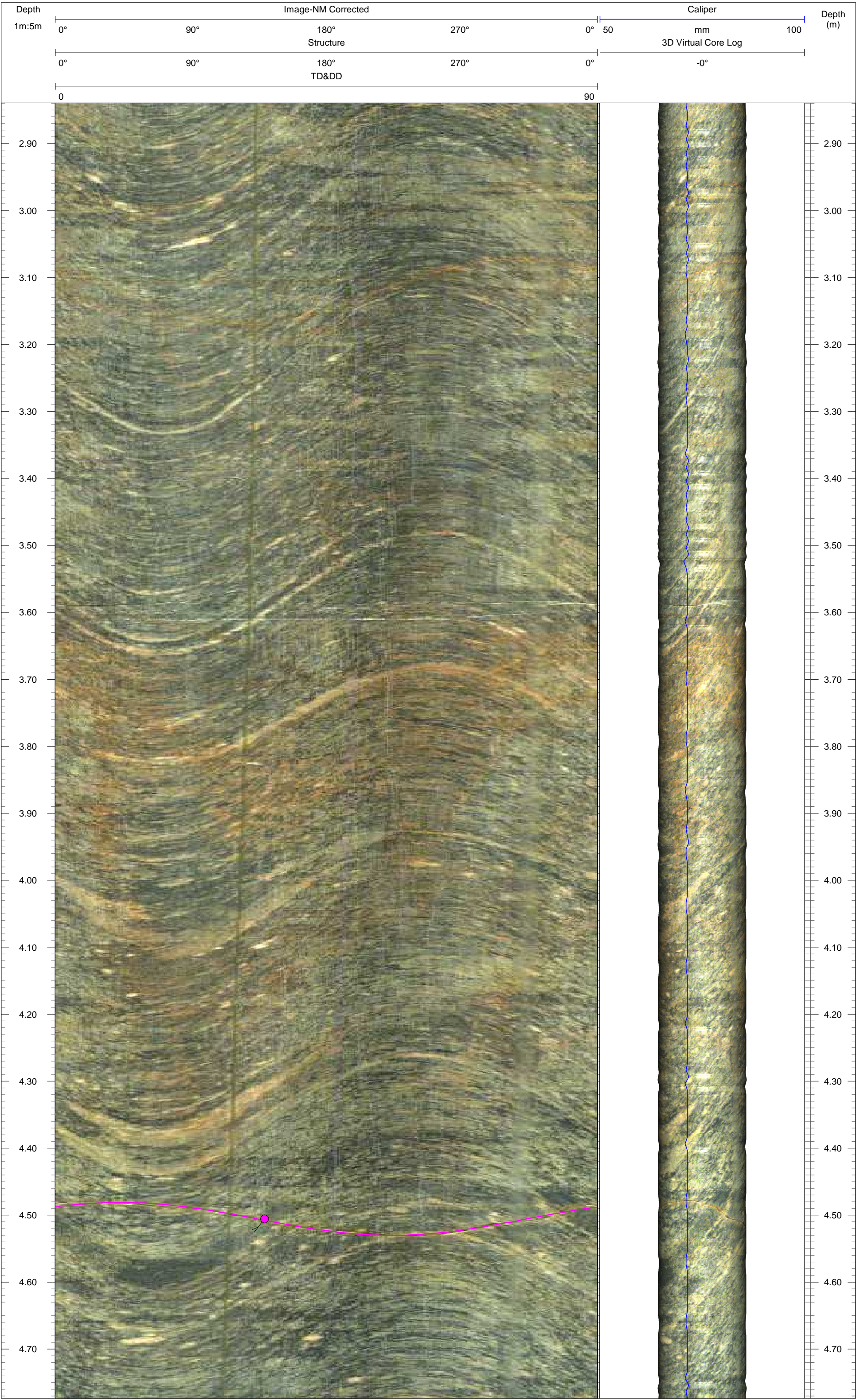
Casing

Water Table

Notes:



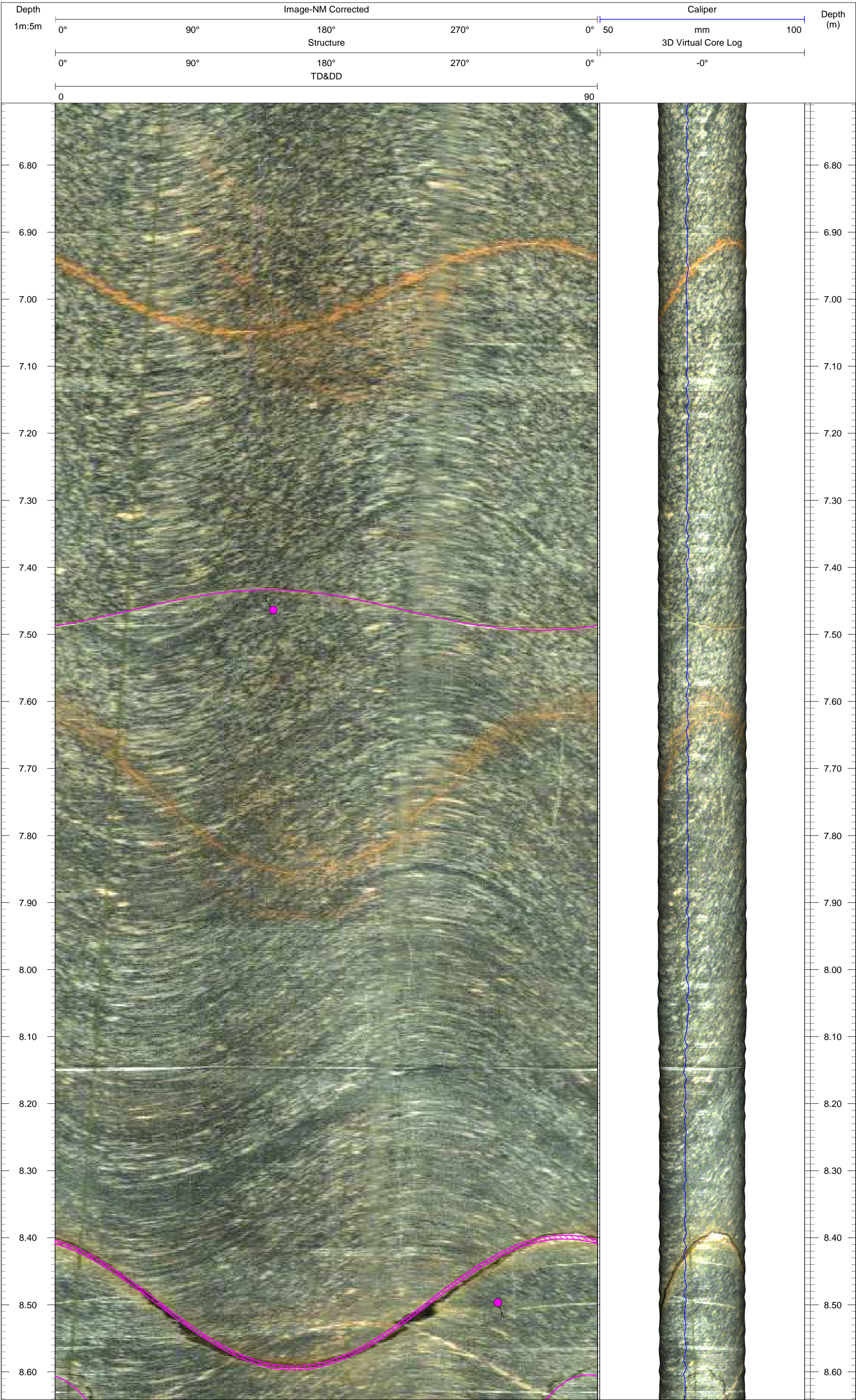


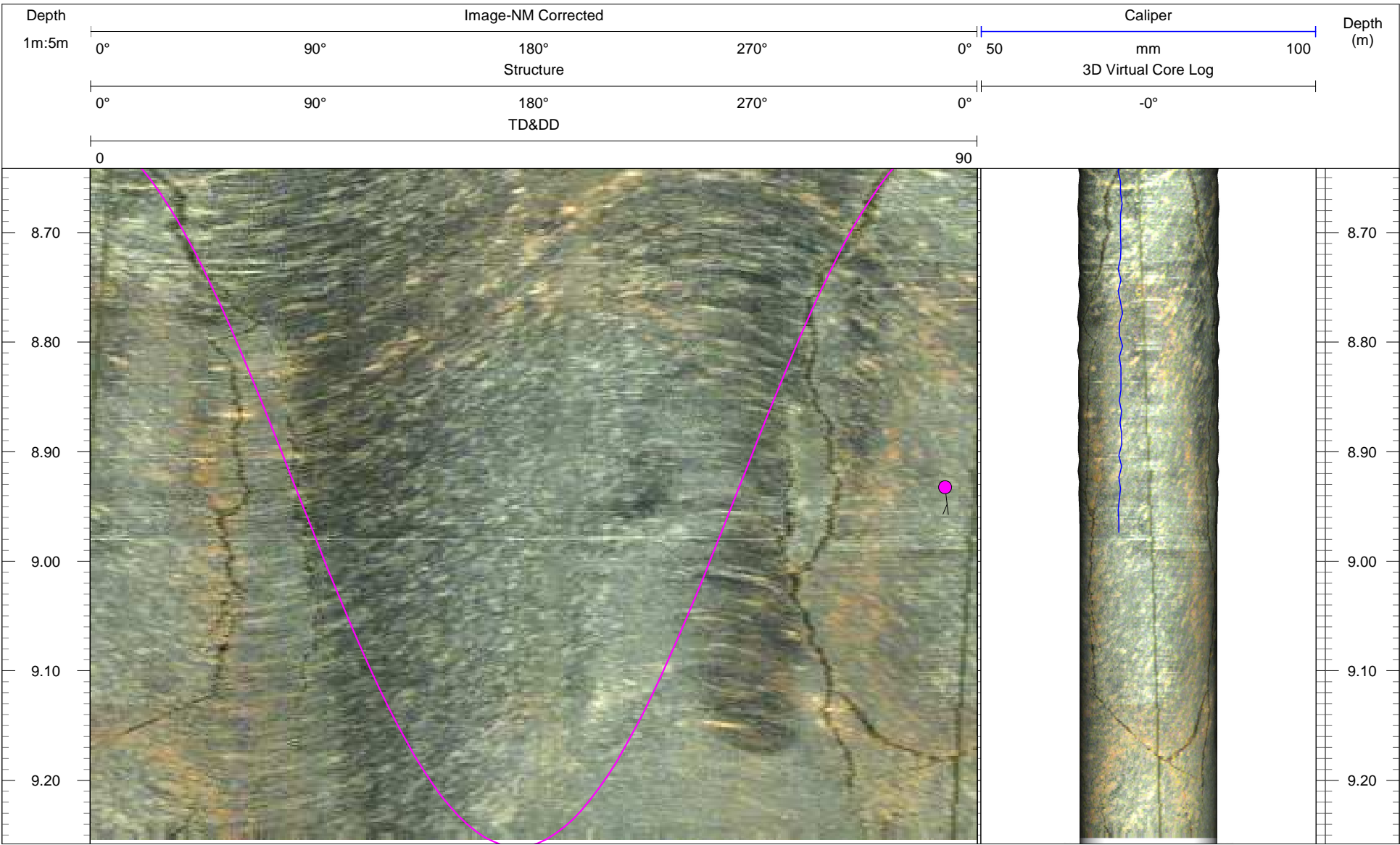
















GEOPHYSICAL RECORD OF BOREHOLE: B503-16

Project Number: 09-1111-6014  
Client: MTO  
Date: August 2014

Datum:	WGS84, UTM Zone 17N	Elevation:	194.770 m asl	Borehole Diameter:	65 mm	Water Level:	N/A	Location:	North Abuttment, SBL
Easting:	222,496.015 m	Depth Reference:	"0" at Ground	Casing Diameter:	N/A	Borehole Inclination:	Vertical	Log Date:	8-Aug-14
Northing:	5,084,230.758 m	Drilled Depth:	7.26 m bgs	Casing Depth:	N/A	Borehole Azimuth:	N/A	Logged By:	AR

0901802700

090

Dip (0-90)

Dip direction(0-360)

Trace of Fracture

Broken Zone / Undifferentiated

Major Open Joint / Fracture

Minor Open Joint / Fracture

Partially Open Joint / Fracture

Filled Fracture / Joint

Bedding / Banding / Foliation

Induced Fracture

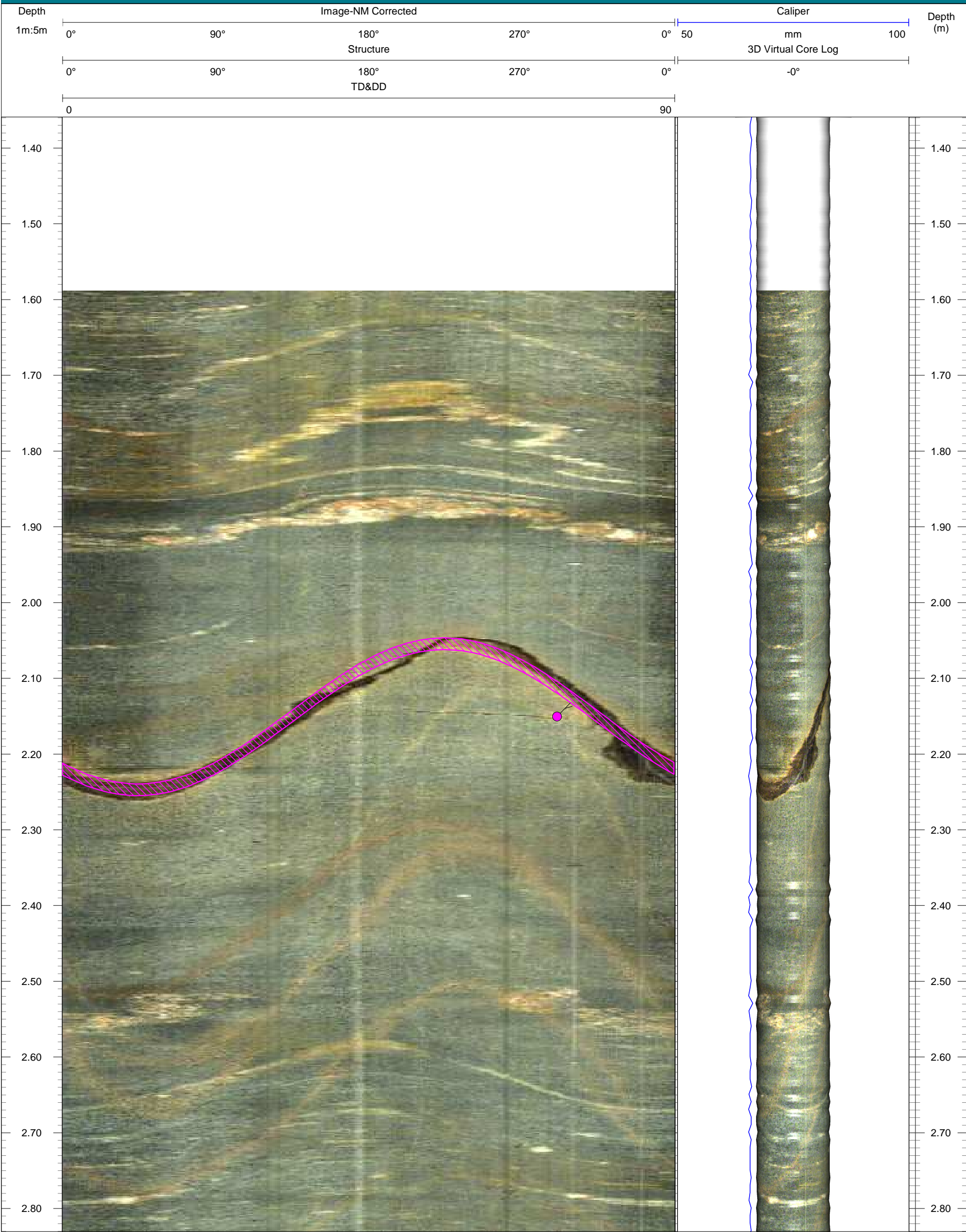
Enlarged Fracture

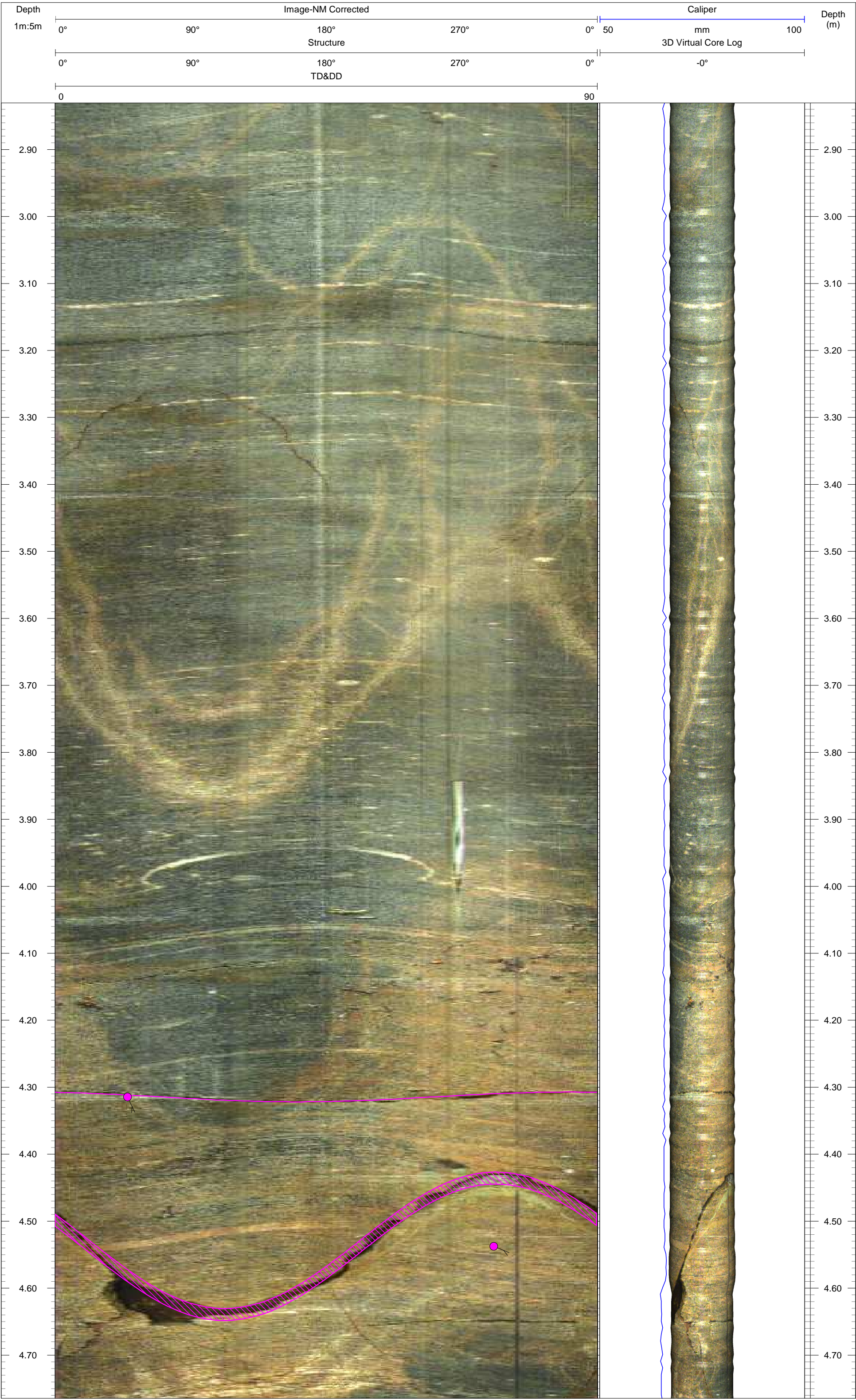
Contact

Casing

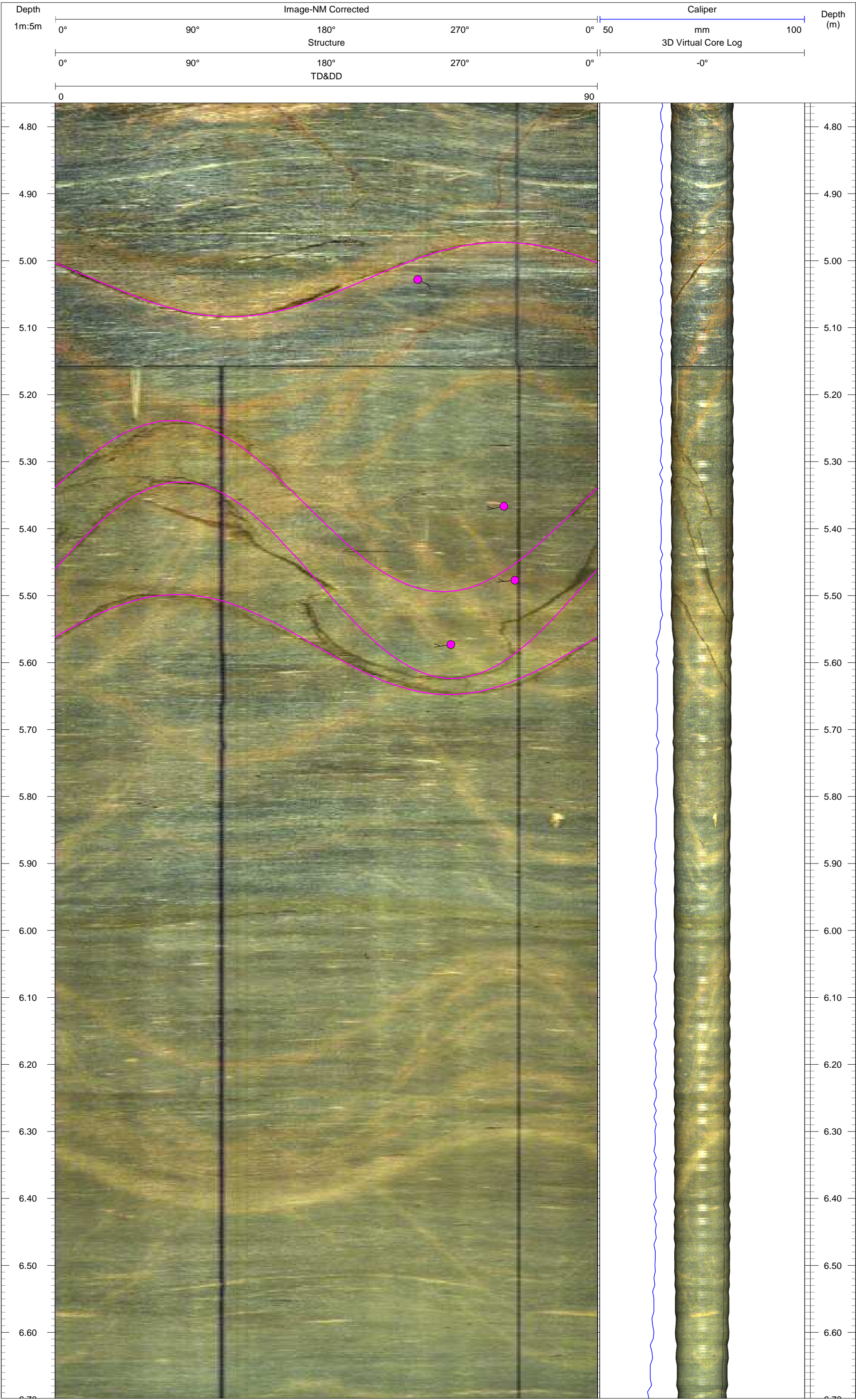
Water Table

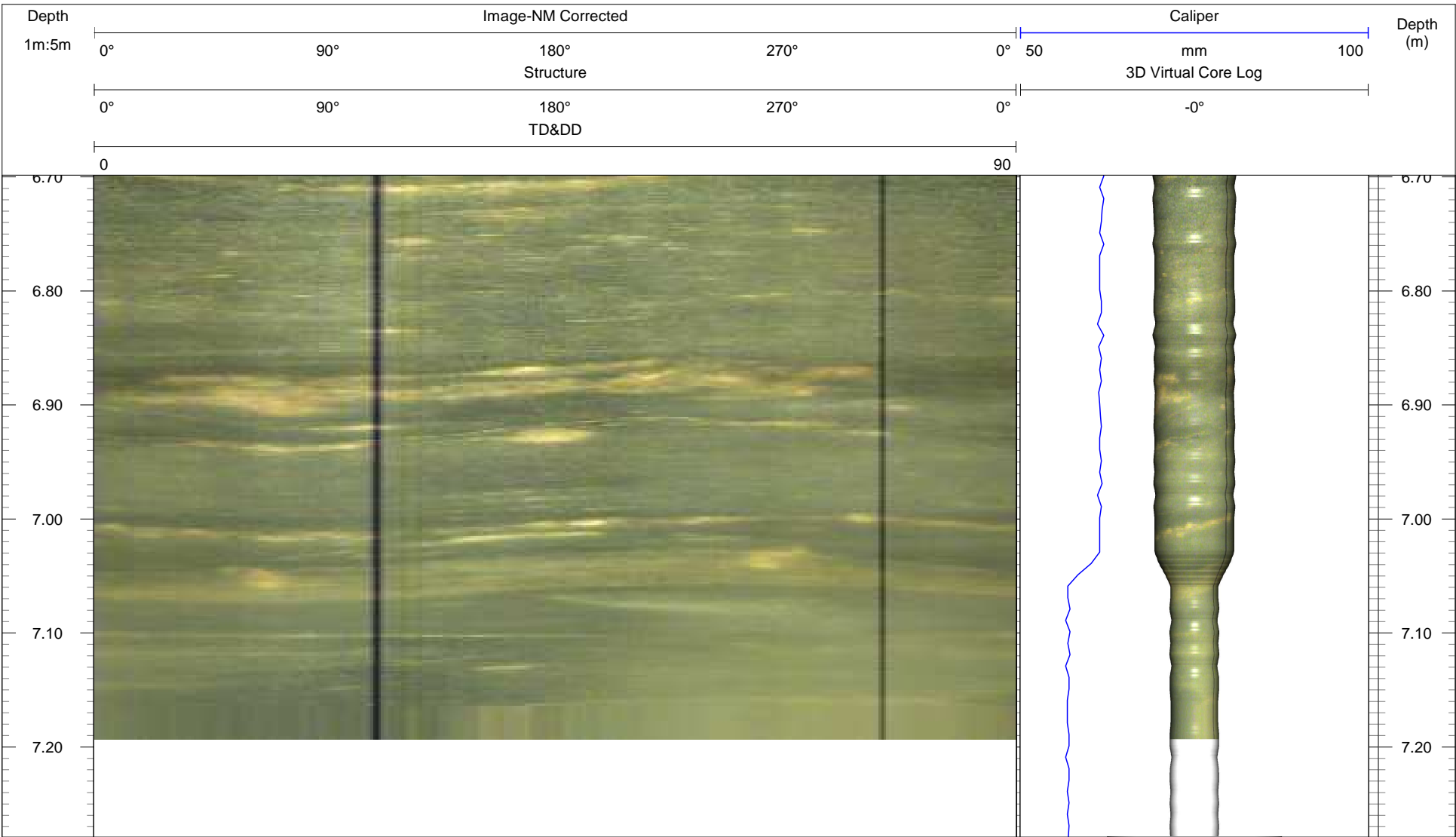
Notes:



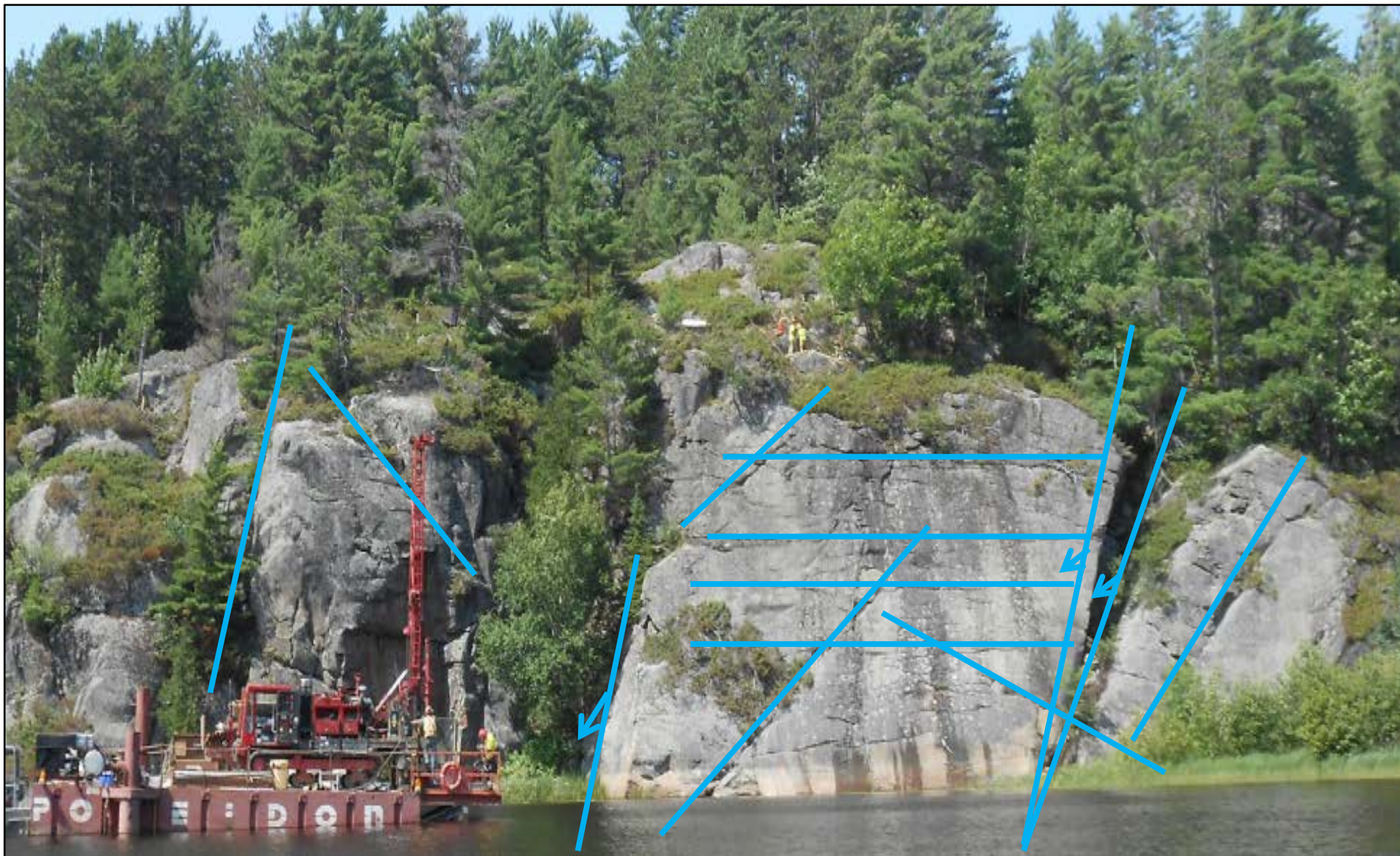












**North Wall of Bedrock Outcrop at NBL and SBL Structures**

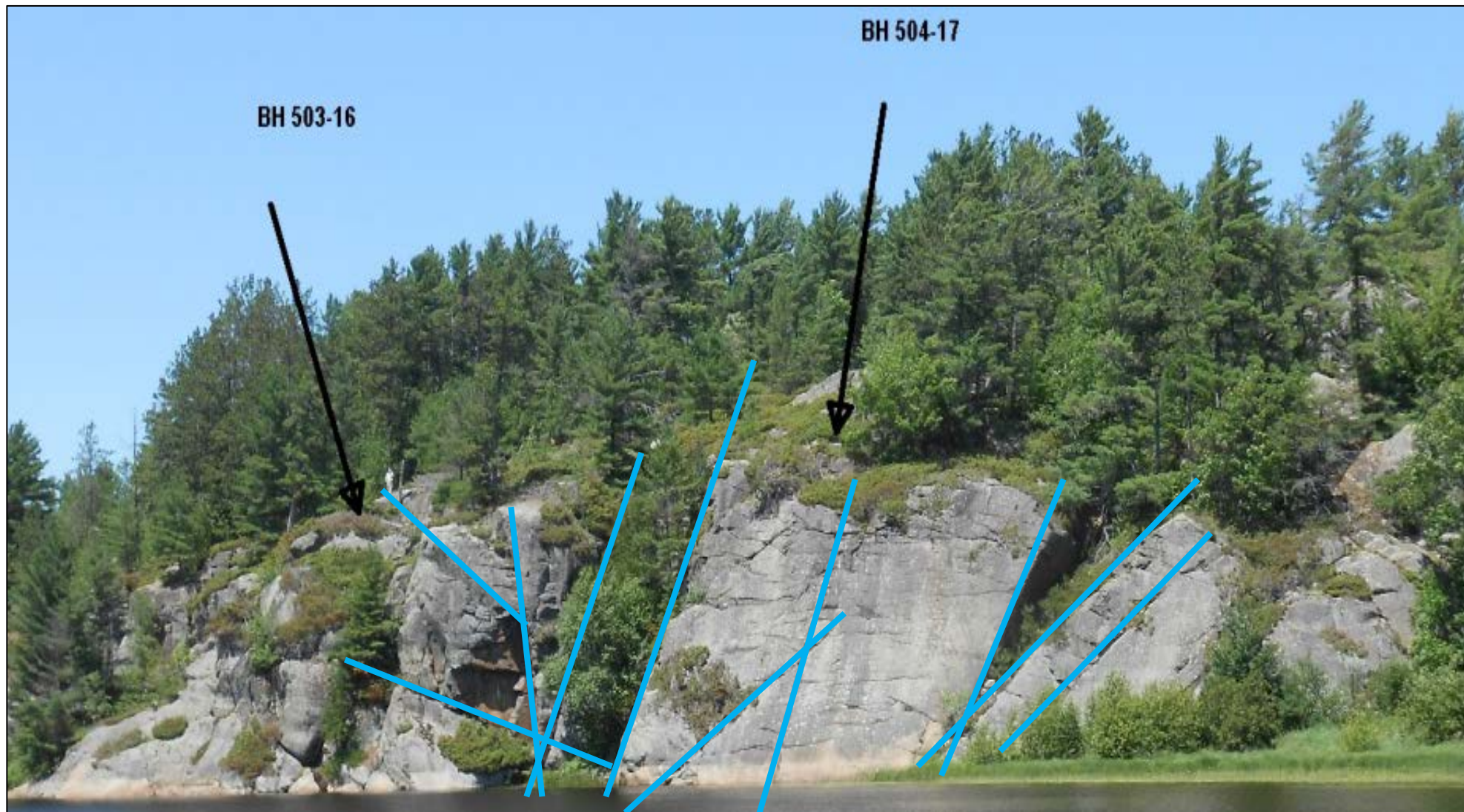
TITLE

**KEY RIVER BRIDGE – ABUTMENT AREAS  
JOINTS AND FEATURES  
NORTH ABUTMENTS**



PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	AB	April 2015	SCALE AS SHOWN	REV.
CADD	--			
CHECK	MT/JPD	April 2015	<b>FIGURE D1</b>	
REVIEW				



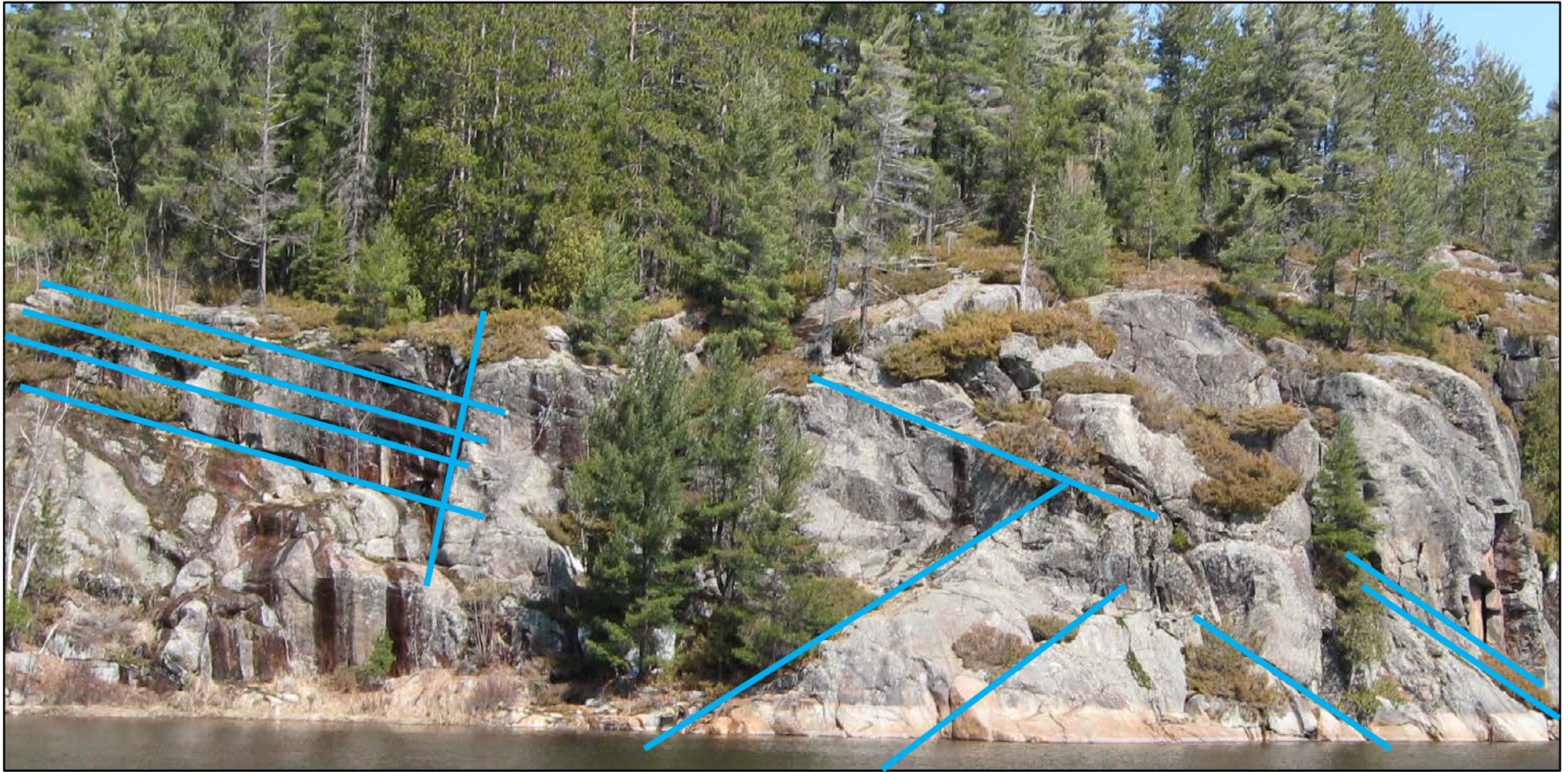


**North Wall of Bedrock Outcrop at NBL and SBL Structures**

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES NORTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D2		
CHECK	MT/JPD	April 2015			
REVIEW					







**North Wall of Bedrock Outcrop**

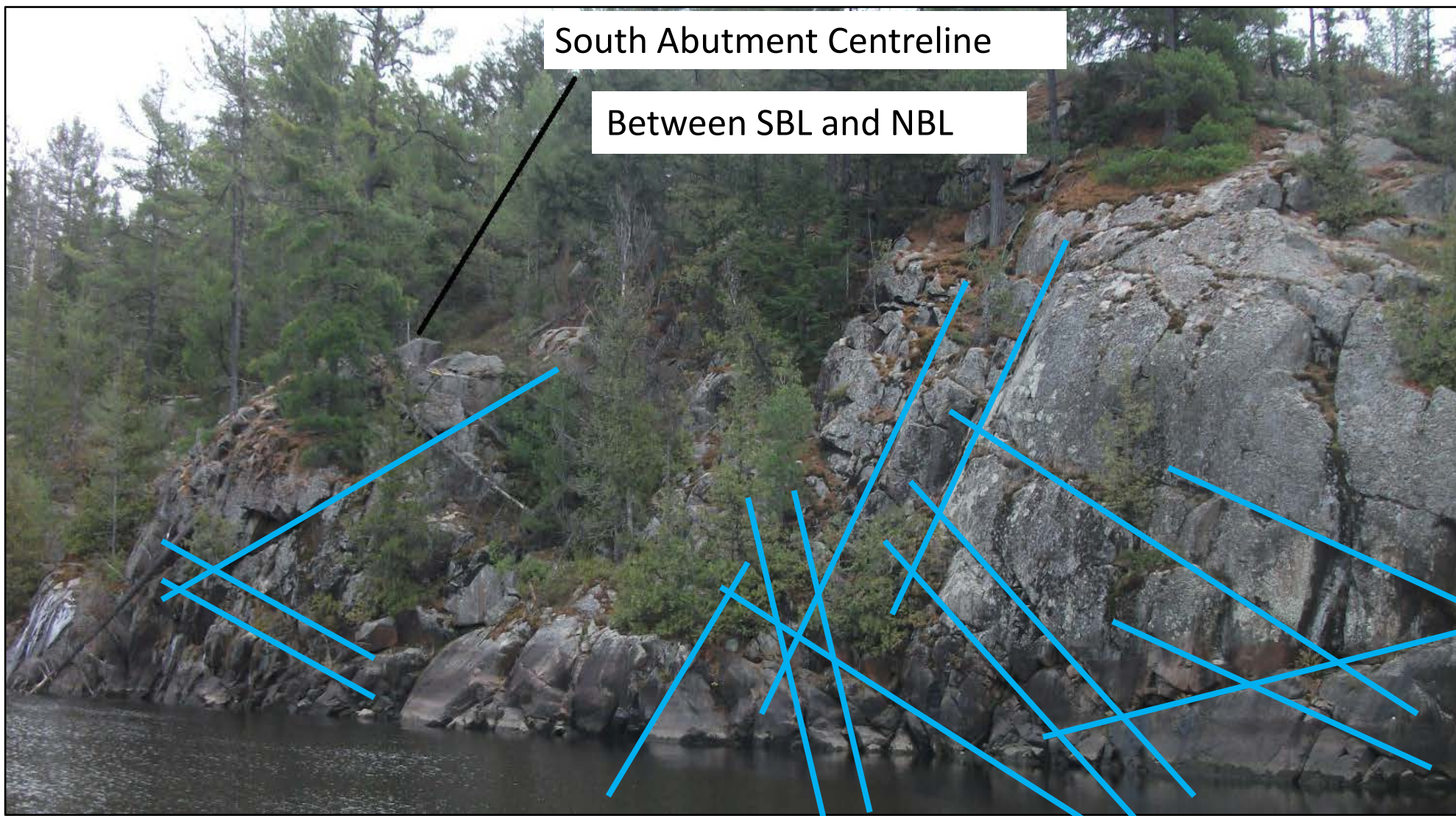
TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES NORTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D3		
CHECK	MT/JPD	April 2015			
REVIEW					





South Abutment Centreline

Between SBL and NBL

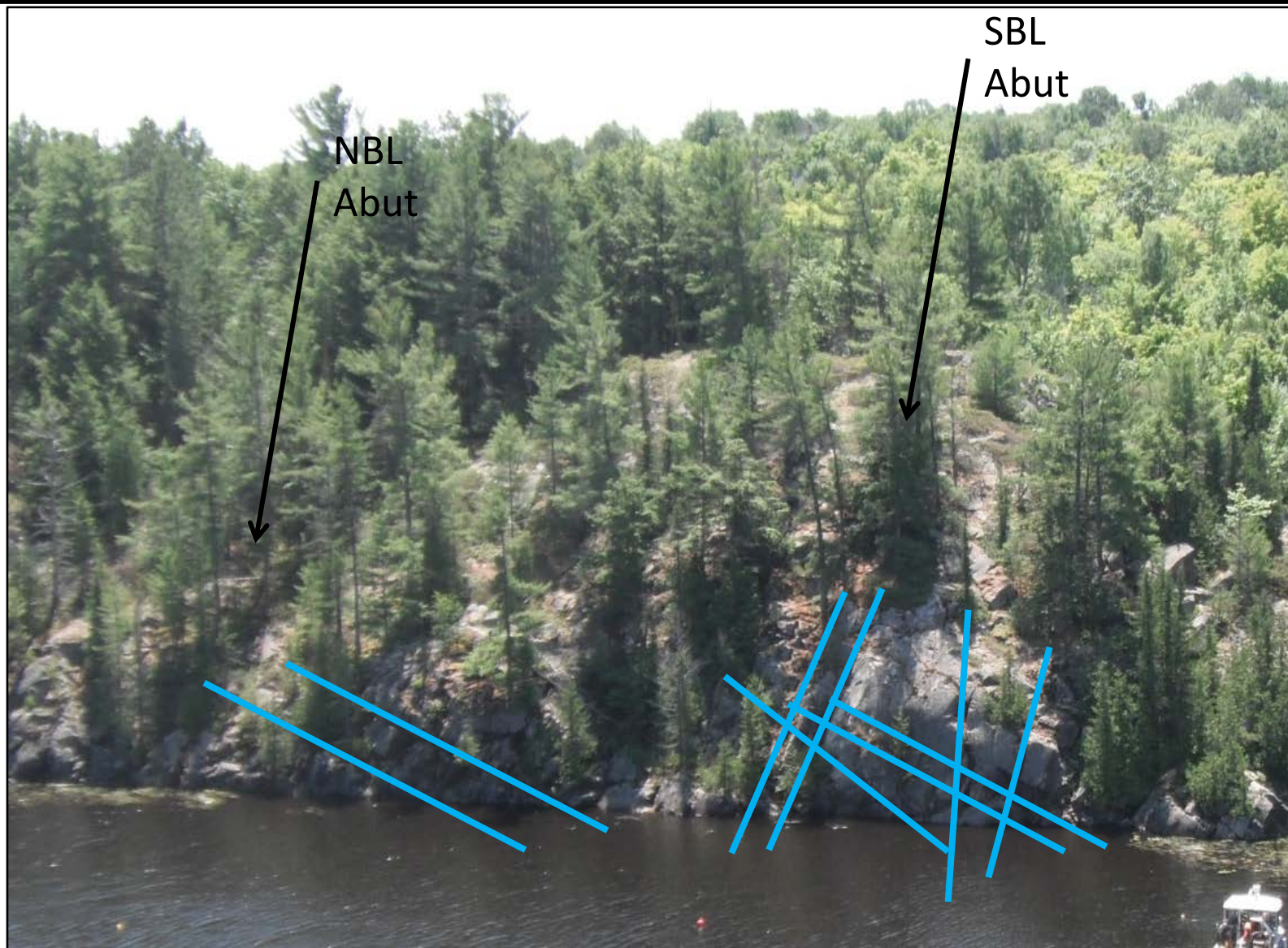


South Wall of Bedrock Outcrop at NBL and SBL Structures

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D4		
CHECK	MT/JPD	April 2015			
REVIEW					







**South Wall of Bedrock Outcrop at NBL and SBL Structures**


TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D5		
CHECK	MT/JPD	April 2015			
REVIEW					



South Abutments Approximate Locations



South Wall of Bedrock Outcrop at NBL and SBL Structures


TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
	PROJECT No. 09-1111-6014			FILE No. ----	
	DESIGN	AB	April 2015	SCALE	AS SHOWN
	CADD	--			REV.
	CHECK	MT/JPD	April 2015	FIGURE D6	
	REVIEW				



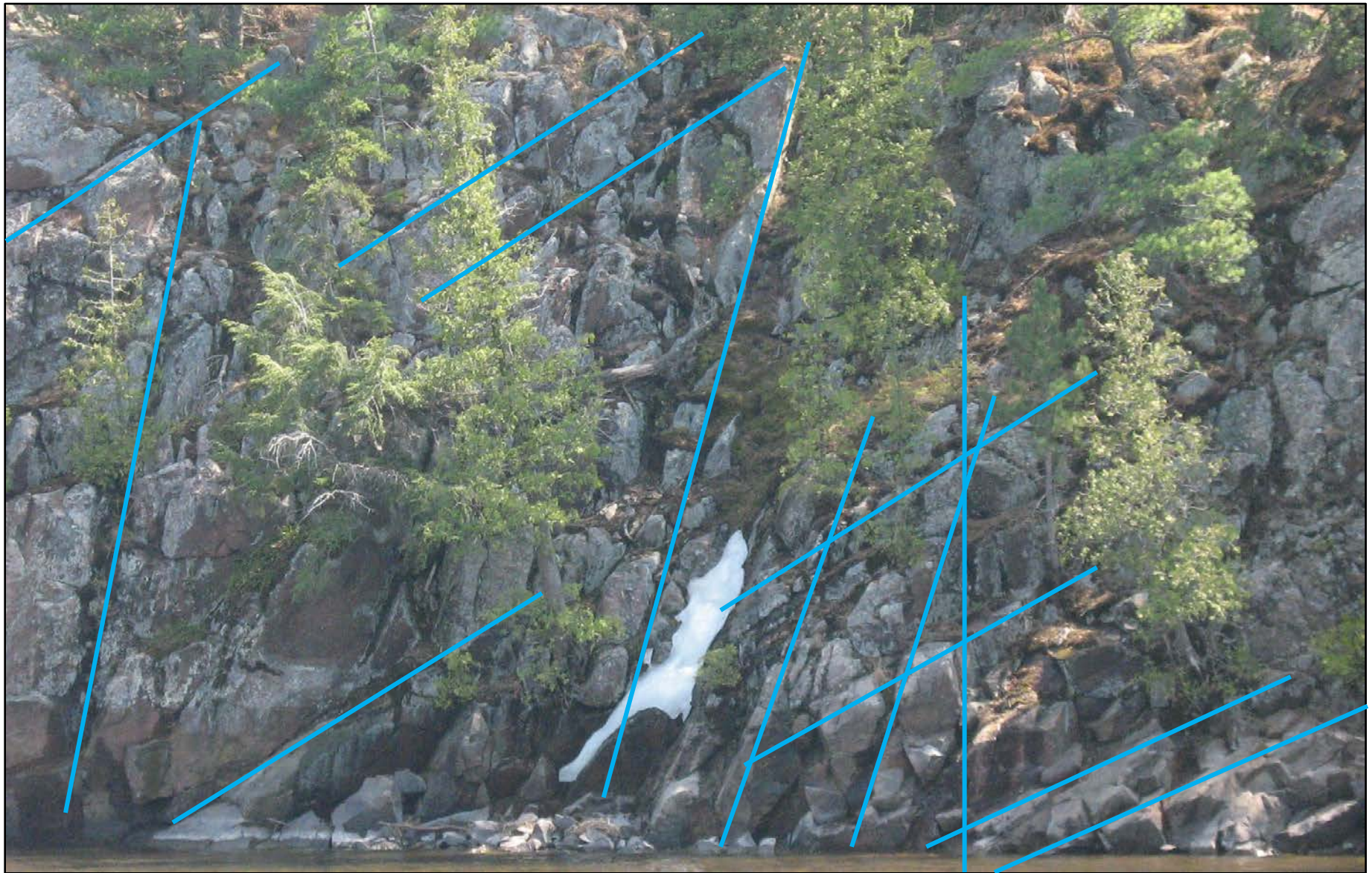


South Wall of Bedrock Outcrop

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--				
CHECK	MT/JPD	April 2015	FIGURE D7		
REVIEW					







**South Wall of Bedrock Outcrop**

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D8		
CHECK	MT/JPD	April 2015			
REVIEW					





At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

[solutions@golder.com](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**2390 Argentia Road**  
**Mississauga, Ontario, L5N 5Z7**  
**Canada**  
**T: +1 (905) 567 4444**

