



**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**for**

**MAGNETAWAN RIVER NORTHBOUND BRIDGE**

**HIGHWAY 69**

**SITE NO. 44-457/1**

**W.P. 5134-08-01**

**MAGNETAWAN FIRST NATION, ONTARIO**

PETO MacCALLUM LTD.  
165 CARTWRIGHT AVENUE  
TORONTO, ONTARIO  
M6A 1V5  
Phone: (416) 785-5110  
Fax: (416) 785-5120  
Email: toronto@petomaccallum.com

**Distribution:**

- 5 cc: AECOM for distribution to MTO, Project Manager  
+ one digital copy (PDF)
- 1 cc: AECOM for distribution to MTO, Pavements and  
Foundations Section + one digital copy (PDF)  
and Drawing (AutoCAD)
- 2 cc: AECOM + one digital copy (PDF)
- 1 cc: PML Kitchener
- 1 cc: PML Toronto

PML Ref.: 09TF042-MRN  
Index No.: 357FIR and 358FDR  
GEOCRES No.: 41H-142  
October 29, 2014



**FOUNDATION INVESTIGATION REPORT**  
**for**  
**MAGNETAWAN RIVER NORTHBOUND BRIDGE**  
**HIGHWAY 69**  
**SITE NO. 44-457/1**  
**W.P. 5134-08-01**  
**MAGNETAWAN FIRST NATION, ONTARIO**

PETO MacCALLUM LTD.  
165 CARTWRIGHT AVENUE  
TORONTO, ONTARIO  
M6A 1V5  
Phone: (416) 785-5110  
Fax: (416) 785-5120  
Email: toronto@petomaccallum.com

**Distribution:**

- 5 cc: AECOM for distribution to MTO, Project Manager  
+ one digital copy (PDF)
- 1 cc: AECOM for distribution to MTO, Pavements and  
Foundations Section + one digital copy (PDF)  
and Drawing (AutoCAD)
- 2 cc: AECOM + one digital copy (PDF)
- 1 cc: PML Kitchener
- 1 cc: PML Toronto

PML Ref.: 09TF042-MRN  
Index No.: 357FIR  
GEOCRES No.: 41H-142  
October 29, 2014



## TABLE OF CONTENTS

1. INTRODUCTION .....	1
2. SITE DESCRIPTION AND GEOLOGY .....	1
3. INVESTIGATION PROCEDURES .....	2
4. SUMMARISED SUBSURFACE CONDITIONS.....	5
4.1 Topsoil .....	5
4.2 Sandy/Silty Soils .....	6
4.3 Clayey Silt .....	6
4.4 Bedrock .....	6
4.4.1 South Abutment .....	7
4.4.2 South Pier .....	8
4.4.3 North Pier .....	8
4.4.4 North Abutment .....	9
4.4.5 Approaches .....	10
4.5 Groundwater .....	10
5. CLOSURE .....	11

Table A – Rock Core Description

Figures MRN-GS-1 and MRN-GS-2 – Results of Grain Size Distribution Analysis

Figure MRN-PC-1 – Plasticity Chart

Explanation of Terms Used in Report

Record of Borehole Sheets

Drawings MRN-1 and MRN-2 – Borehole Locations and Soil Strata

Appendix A – Site Photographs

Appendix B – Rock Core Photographs

**FOUNDATION INVESTIGATION REPORT**

for  
Magnetawan River Northbound Bridge  
Highway 69  
Site No. 44-457/1  
W.P. 5134-08-01  
Magnetawan First Nation, Ontario

---

**1. INTRODUCTION**

This report summarises the results of a foundation investigation carried out for the proposed construction of a bridge to carry Highway 69 (New) northbound traffic over the Magnetawan River in Magnetawan First Nation, Ontario. The investigation was conducted for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The bridge is at approximate Station 21+624, Highway 69 chainage, in Magnetawan First Nation (ref. General Arrangement Drawing 1 'Hwy. 69 – NBL Magnetawan River Crossing' prepared by AECOM in May 2012).

The report provides subsurface information pertaining to the proposed structure and approaches within about 20 m of the abutments.

All elevations in this report are expressed in meters.

**2. SITE DESCRIPTION AND GEOLOGY**

The site is situated about 90 km south of Sudbury in a wooded region with open swampy areas. Land use includes limited farming and forestry exploration. Highway 69 (New) is oriented in the south-north direction at the bridge location, about 260 m east of the existing Highway 69. The main activity near the Magnetawan River crossing is related to tourism and recreation, with numerous fishing and hunting lodges, camps, marinas and hotels. Site photographs are included in Appendix A.



The Magnetawan River is about 70 m wide and flows to the west at the site. The water level in the river is normally near elevation 179.0. Subject to seasonal variations and weather dependent precipitation, this water level was measured at elevation 177.2 on July 4 and at elevation 176.7 on July 24, 2013. The top of the bridge deck is at approximate elevation 194.0, some 15 m above the river level.

The study area is located in the physiographic region known as the Georgian Bay Fringe that includes a bedrock plain comprising exposed bedrock knobs, subordinate glacial till moraine and a peat / muck organic terrain over bedrock.

The topography is irregular in detail with extensive rock outcrops. Soil cover over the rock outcrops is typically less than 1 m. The soils were deposited by glacial Lake Algonquin and later partly by Lake Nipissing. Numerous boulders are present at the site.

Metasedimentary rocks of the Huronian Supergroup and gneisses of the Grenville Province underlie the alignment. The area has undergone considerable folding, intrusive activity, regional metamorphism and faulting. The bedrock in the immediate vicinity of the site is at shallow depths ranging from the surface to about 1.5 m.

### **3. INVESTIGATION PROCEDURES**

The field work for this study was carried out during the period of July 2 to October 8, 2013 and comprised 37 boreholes drilled to depths of 0.0 to 9.0 m at the locations shown on the attached Drawing MRN-1. It is noted that the boreholes put down at each foundation element have a prefix reflecting the corresponding working point shown on the General Arrangement drawing. Further details are summarised in the following table.



LOCATION	BOREHOLE No.	DEPTH (m)		
		AUGER / CONE	ROCK CORE	TOTAL
South Approach	N-1	0.7	–	0.7
South Abutment	1N-1	0.1	–	0.1
	1N-2	0.2	3.0	3.2
	1N-3	0.5	–	0.5
	1N-4	0.5	3.2	3.7
	1N-5	0.1	–	0.1
	1N-6	0.0	3.1	3.1
	1N-7	0.3	–	0.3
	1N-8	0.1	3.1	3.2
	1N-9	0.1	–	0.1
South Pier	2N-1	1.5	–	1.5
	2N-2	1.4	3.5	4.9
	2N-3	1.7	–	1.7
	2N-4	1.5	3.0	4.5
	2N-5	1.4	–	1.4
	2N-6	0.2	3.9	4.1
	2N-7	1.3	–	1.3
	2N-8	1.5	3.3	4.8
	2N-9	0.6	–	0.6
North Pier	3N-1	0.0	3.8	3.8
	3N-2	0.3	–	0.3
	3N-3	0.9	3.3	4.2
	3N-4	0.3	–	0.3
	3N-5	0.1	–	0.1
	3N-6	0.2	–	0.2
	3N-7	0.3	3.8	4.1
	3N-8	0.0	–	0.0
	3N-9	0.5	3.3	3.8
North Abutment	4N-1	0.1	–	0.1
	4N-2	0.0	3.8	3.8
	4N-3	0.0	9.0	9.0
	4N-4	0.0	3.1	3.1
	4N-5	0.0	3.5	3.5
	4N-6	0.0	–	0.0
	4N-7	0.0	3.7	3.7
	4N-8	0.0	–	0.0
North Approach	N-2	0.0	–	0.0



The working points of the structure were staked in the field and surveyed by exp Services Inc. The locations of and ground surface elevations at the boreholes were established in relation to the working points by Peto MacCallum Ltd.

Most boreholes were advanced manually, using Hilti equipment or continuous flight solid stem augers, powered by a track-mounted D-53 drill rig, supplied and operated by specialist drilling contractors, working under the full-time supervision of a member of our engineering staff. A total of 17 boreholes (within the foundation elements) were extended 3.0 to 9.0 m into bedrock using NQ diamond rock coring equipment supplemented by wash boring techniques.

Representative samples of the soils were recovered at 0.75 m depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. The results of the field tests and observations are reported on the Record of Borehole sheets.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open borehole. Upon completion of drilling, the boreholes were backfilled with bentonite/cement grout in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. The soil samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determination. A grain size distribution analysis was performed on a selected soil sample. The laboratory test results are appended.



#### **4. SUMMARISED SUBSURFACE CONDITIONS**

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, bedrock descriptions, inferred stratigraphy, standard penetration test data and groundwater observations.

The borehole locations, stratigraphic profile and cross-sections prepared from the borehole data are shown on Drawings MRN-1 and MRN-2. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil, sandy/silty soils and/or clayey silt over bedrock or exposed bedrock. Cobbles and boulders were encountered in 6 boreholes. The bedrock surface was contacted at depths of 0.0 to 1.7 m (elevation 177.8 to 196.6). The water level in the river was at elevation 176.7 to 177.2 in July 2013.

It is noted that the steep rock faces present at the site may have a negative impact on the precision of the founding surfaces. The strata encountered are summarised below.

##### **4.1 Topsoil**

Surficial topsoil was present in boreholes N-1, 1N-1 to 1N-5, 1N-7 to 1N-9, 2N-1 to 2N-9, 3N-2 to 3N-5, 3N-7, 3N-9 and 4N-1. The silty/sandy topsoil was typically 100 to 300 mm in thickness, increasing to 900 mm in borehole 3N-3 and 500 mm in borehole 3N-9, and penetrated at elevation 178.3 to 194.0. It is noteworthy that the topsoil contained cobbles and boulders in boreholes 3N-3, 3N-4, 3N-6 and 3N-9 advanced at the north pier.





## **4.2 Sandy/Silty Soils**

Cohesionless soils of varying granulometric composition (sand, silty sand, sandy silt) were present at the surface in borehole 3N-6 and overlain by the topsoil at depths of 0.1 to 0.2 m (elevation 178.3 to 187.9) in boreholes N-1, 1N-3, 1N-7, 2N-1 to 2N-5, 2N-7 to 2N-9 and 3N-2. Very loose to compact in relative density (SPT-'N' values of 1 to 19), the sandy/silty soils were 0.1 to 1.2 m thick and penetrated at depths of 0.2 to 1.4 m (elevation 177.8 to 187.7). It is worth noting that cobbles and boulders were encountered in the sand in boreholes N-1, 3N-2 and 3N-6.

The results of grain size distribution analysis performed on a sample of the silty sand are presented in Figure MRN-GS-1.

## **4.3 Clayey Silt**

Underlying the topsoil at 0.2 m depth (elevation 186.1) in borehole 1N-4 or sandy/silty soils at depths of 0.7 to 1.1 m depth (elevation 178.3 to 179.2) in boreholes 2N-1, 2N-3 to 2N-5 and 2N-8 was a cohesive deposit of clayey silt. This deposit was firm to stiff in consistency as assessed using the results of standard penetration tests. The deposit had a thickness of 300 to 900 mm and was penetrated at depths of 0.5 to 1.7 m (elevation 177.8 to 185.8).

The results of Atterberg limits testing and grain size distribution analyses conducted on two cohesive samples are presented in respective Figures MNR-PC-1 and MNR-GS-2. The clayey silt had a liquid limit of 32, plastic limit of 19, its plasticity index being 13.

## **4.4 Bedrock**

Bedrock was contacted or inferred by refusal at depths of 0.0 to 1.7 m (elevation 177.8 to 196.6). The bedrock comprises a grey / light grey and pink granitic gneiss.



The measured core recovery varied between 44 and 100%. The RQD determined from the rock cores was in a range of 33 to 100%, thus indicating a poor to excellent quality rock. The rock quality was very poor (RQD of 0%) in a few core samples in boreholes 2N-6, 3N-3, 4N-2, 4N-3 and 4N-5.

The rock cores retrieved from boreholes 1N-2, 1N-4, 1N-6, 1N-8, 2N-2, 2N-4, 2N-6, 2N-8, 3N-1, 3N-3, 3N-7, 3N-9, 4N-2 to 4N-5 and 4N-7 are described on the corresponding Record of Borehole sheets. A detailed description of the rock cores in boreholes 1N-2, 2N-2, 4N-3 and 4N-4 is given in Table A, appended. Photographs of the rock cores are shown in Appendix B.

#### 4.4.1 South Abutment

The bedrock surface was contacted or inferred at depths of 0.0 to 0.5 m (elevation 185.8 to 188.1) in boreholes 1N-1 to 1N-9. The depth to and surface elevation of the bedrock identified in the boreholes drilled at the south abutment are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
South Abutment	1N-1	0.1	188.0
	1N-2	0.2	187.8*
	1N-3	0.5	186.4
	1N-4	0.5	185.8*
	1N-5	0.1	187.6
	1N-6	0.0	188.1*
	1N-7	0.3	187.7
	1N-8	0.1	187.2*
	1N-9	0.1	186.6

\* confirmed by rock coring

The bedrock surface has a maximum relief of 2.3 m and slopes down to the southeast at angles of 2 to 8° (up to 13° on the east side of the abutment between pairs of boreholes 1N-3 and 1N-8, 1N-4 and 1N-9). The bedrock comprises a light grey to pink slightly to moderately weathered high strength granitic gneiss.

The measured core recovery varied between 90 and 100%. The RQD determined from the rock cores was in a range of 83 to 100%, thus indicating a good to excellent quality rock.



#### 4.4.2 South Pier

The bedrock surface was contacted or inferred at depths of 0.2 to 1.7 m (elevation 177.8 to 179.4) in boreholes 2N-1 to 2N-9. The depth to and surface elevation of the bedrock identified in the boreholes drilled at the pier are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
South Pier	2N-1	1.5	178.8
	2N-2	1.4	178.6*
	2N-3	1.7	178.1
	2N-4	1.5	177.8*
	2N-5	1.4	178.2
	2N-6	0.2	179.4*
	2N-7	1.3	178.6
	2N-8	1.5	177.9*
	2N-9	0.6	177.8

\* confirmed by rock coring

The bedrock surface has a maximum relief of 1.6 m and slopes down to the east at angles of 1 to 7° (up to 16° at the west end of the pier between borehole 2N-6 and boreholes 2N-1 and 2N-7). The bedrock comprises a grey to pink slightly to moderately weathered high strength granitic gneiss.

The measured core recovery varied between 59 and 100%. The RQD determined from the rock cores was in a range of 74 to 100%, thus indicating a fair to excellent quality rock, with the exception of the upper 0.5 m core sample in borehole 2N-6 where the rock quality was very poor (RQD of 0%).

#### 4.4.3 North Pier

The bedrock surface was contacted or inferred at depths of 0.0 to 0.9 m (elevation 178.5 to 181.3) in boreholes 3N-1 to 3N-9. The depth to and surface elevation of the bedrock identified in the boreholes drilled at the pier are summarised in the following table.



Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
North Pier	3N-1	0.0	178.5*
	3N-2	0.3	179.1
	3N-3	0.9	179.3*
	3N-4	0.3	179.9
	3N-5	0.1	180.0
	3N-6	0.2	180.7
	3N-7	0.3	180.6*
	3N-8	0.0	181.2
	3N-9	0.5	181.3*

\* confirmed by rock coring

The bedrock surface has a maximum relief of 2.8 m and slopes down to the south at angles of 4 to 14° (up to 30° at both ends of the pier between pairs of boreholes 3N-1 and 3N-4, 3N-3 and 3N-6). The bedrock comprises a grey / light grey to pink slightly to moderately weathered high strength granitic gneiss.

The measured core recovery varied between 49 and 100%. The RQD determined from the rock cores was in a range of 33 to 100%, thus indicating a poor to excellent quality rock, with the exception of the upper 0.3 m core sample in borehole 3N-3 where the rock quality was very poor (RQD of 0%).

#### 4.4.4 North Abutment

The bedrock surface was contacted or inferred at depths of 0.0 to 0.1 m (elevation 194.0 to 195.9) in boreholes 4N-1 to 4N-8. The depth to and surface elevation of the bedrock identified in the boreholes drilled at the east abutment are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
North Abutment	4N-1	0.1	194.0
	4N-2	0.0	194.4*
	4N-3	0.0	195.3*
	4N-4	0.0	195.7*
	4N-5	0.0	194.3*
	4N-6	0.0	195.1
	4N-7	0.0	195.7*
	4N-8	0.0	195.9

\* confirmed by rock coring



The bedrock surface has a maximum relief of 1.9 m and slopes down to the southwest at angles of 2 to 7° (up to 16° on the west side of the abutment between boreholes 4N-2 and 4N-6). The bedrock comprises a light grey to pink moderately weathered to unweathered high strength granitic gneiss.

The measured core recovery varied between 75 and 100% (locally 44% due to partial retrieval). The RQD determined from the rock cores was in a typical range of 50 to 100%, thus indicating a fair to excellent quality rock, with the exception of three core samples in boreholes 4N-2, 4N-3 and 4N-5 where the rock quality was very poor (RQD of 0%) – the upper 0.6 m thick zone in borehole 4N-5 and two core samples 0.7 and 0.5 m in length encountered at depths of 1.5 and 2.4 m (elevation 192.8) in boreholes 4N-2 and 4N-3 respectively.

#### 4.4.5 Approaches

Bedrock was at 0.7 m depth (elevation 187.1) in borehole N-1 and at the ground surface (elevation 196.6) in borehole N-2 put down at the south and north approaches, respectively.

#### 4.5 Groundwater

No groundwater was observed in any of the boreholes during and upon completion of drilling. The groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

The water level in the Magnetawan River was measured at elevation 177.2 on July 4 and at elevation 176.7 on July 24, 2013. The normal water level in the river is at elevation 179.0.



## 5. CLOSURE

The field work was carried out under the supervision of Mr. F. Portela, Senior Technician, and direction of Mr. A. DeSira, MEng, P.Eng., Project Engineer. The equipment was supplied by Walker Drilling Ltd. and Landcore.

This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C.M.P. Nascimento, P.Eng., Project Manager, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



Grigory O. Degil, PhD, P.Eng.  
Senior Foundation Engineer

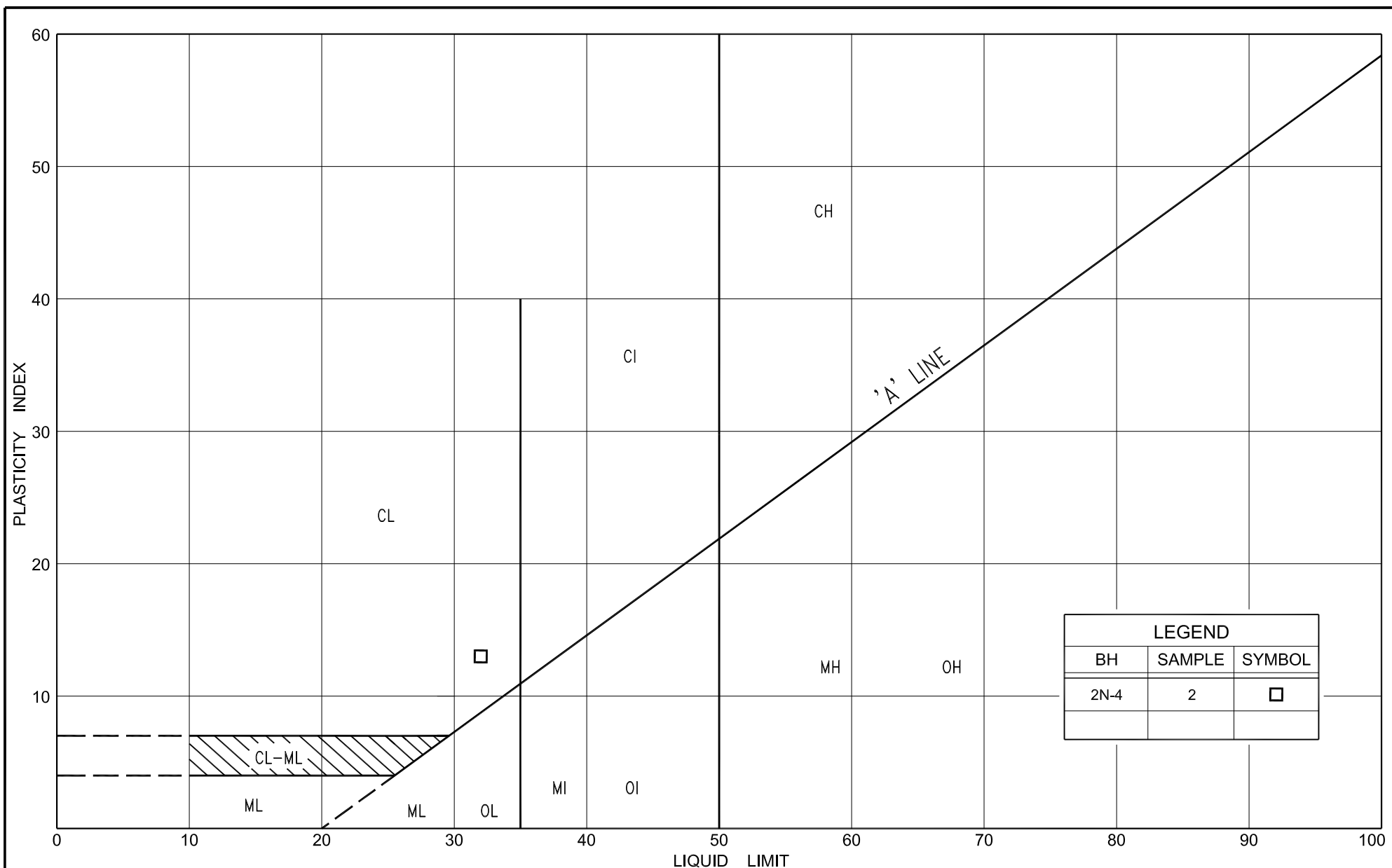


Carlos M.P. Nascimento, P.Eng.  
Project Manager



Brian R. Gray, MEng, P.Eng.  
MTO Designated Principal Contact

GD/CN/BRG:ak



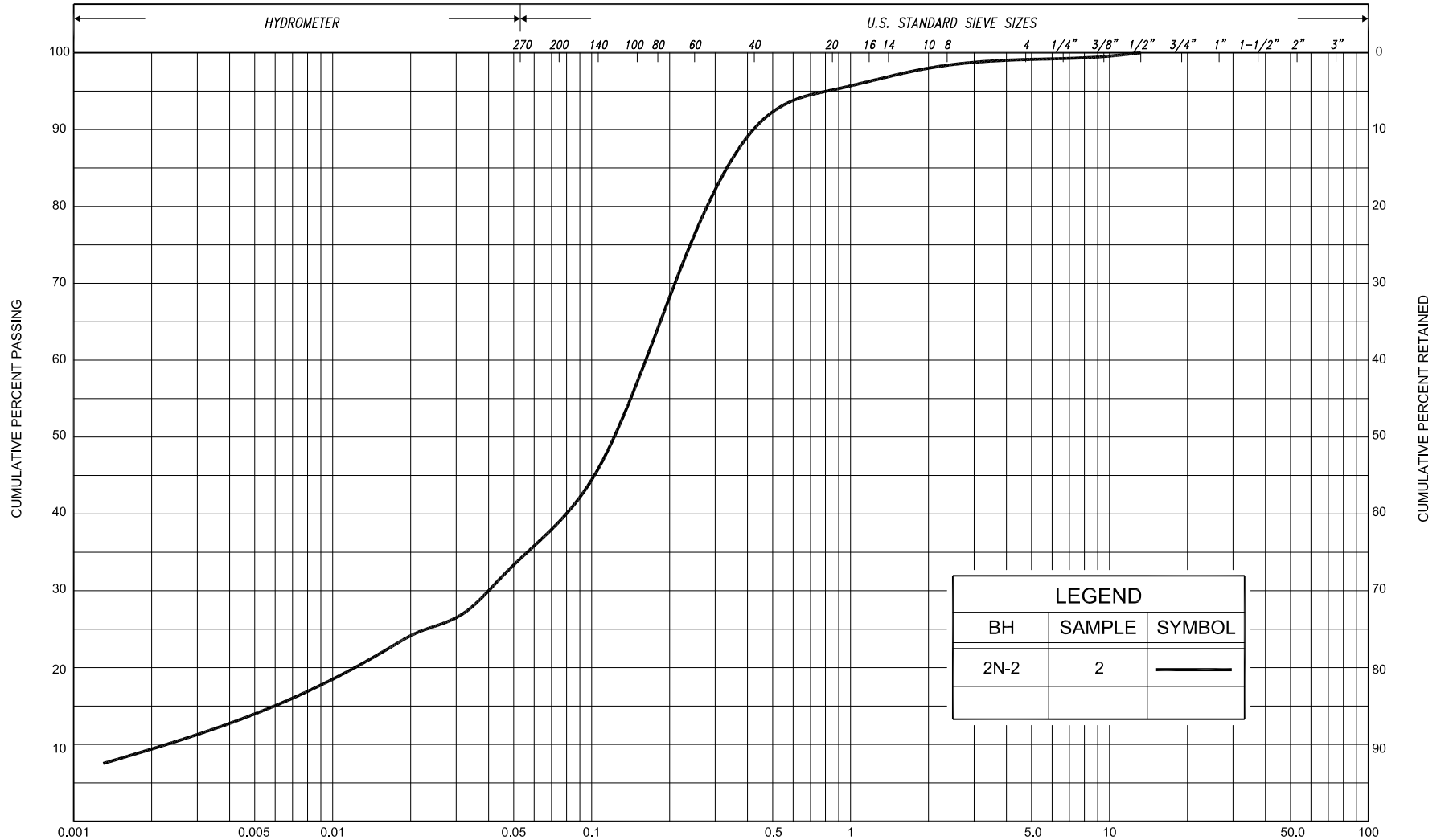
# PLASTICITY CHART

CLAYEY SILT, trace sand

FIG No. MRN-PC-1

HWY: 69

G.W.P. No. 5112-07-00



SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED		
				SAND											
CLAY	FINE		MEDIUM	COARSE	FINE		MEDIUM	COARSE		GRAVEL			COBBLES	M.I.T.	
	SILT				SAND										
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL						U.S. BUREAU
				SAND											



## GRAIN SIZE DISTRIBUTION

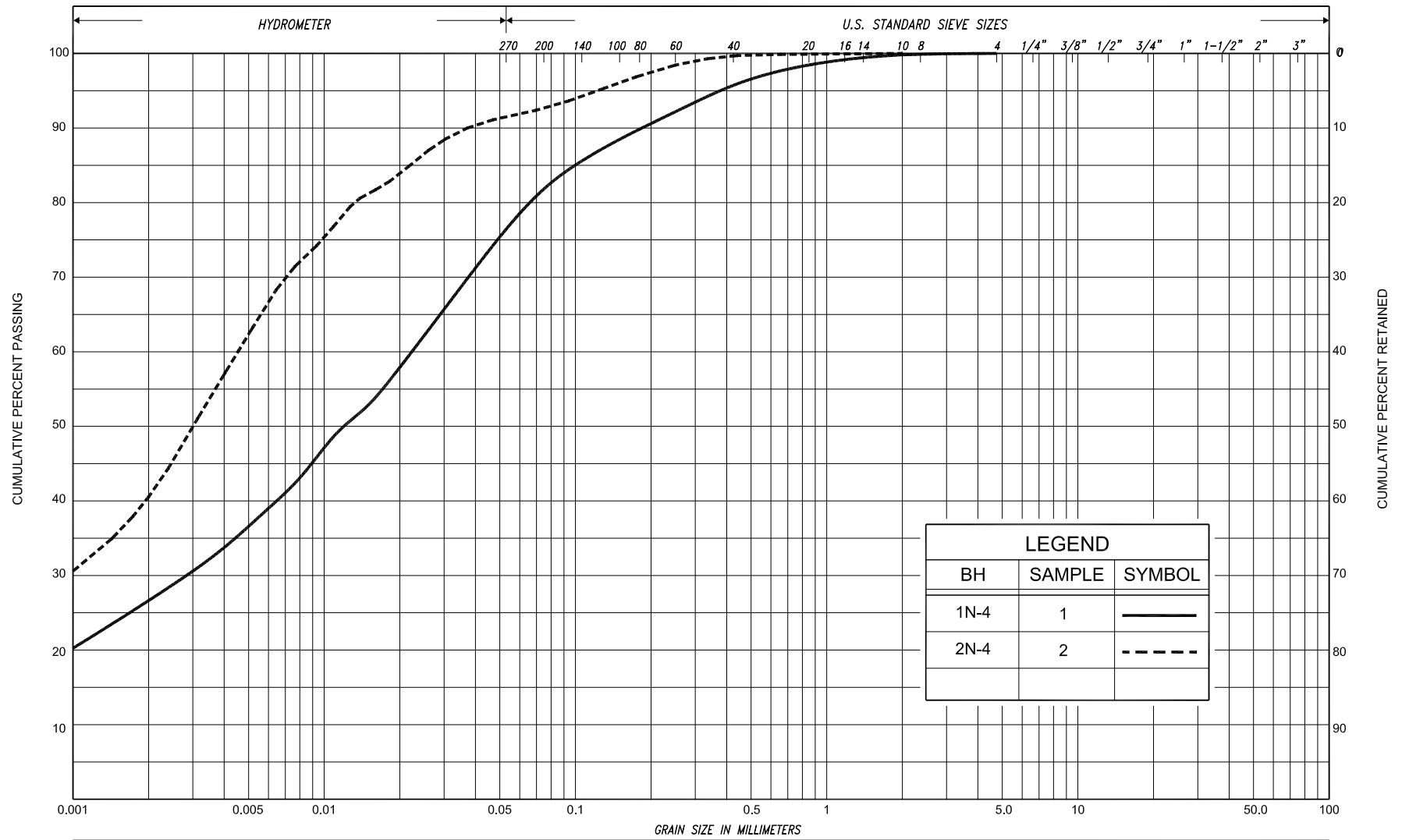
SILTY SAND, trace clay, trace gravel

FIG No. MRN-GS-1

HWY: 69

G.W.P. No. 5112-07-00





SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COB BLES	UNIFIED
				SAND								
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		GRAVEL			COBBLES	M.I.T.
	SILT			SAND								
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL				U.S. BUREAU
				SAND								



# GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace to some sand

FIG No. MRN-GS-2

HWY: 69

G.W.P. No. 5112-07-00

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**COMPOSITION:** SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m <sup>3</sup>	SEEPAGE FORCE
e	1, %	VOID RATIO						

# RECORD OF BOREHOLE No. N-1

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+515 CL

Coords: 5 070 922.5 N; 227 780.2 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

BOREHOLE TYPEContinuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

September 23, 2013

CHECKED BY C.N.

[illegible]

# RECORD OF BOREHOLE No. 1N-1

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+534.9, o/s 8.0m Lt.

Coords: 5 070 939.8 N; 227 767.6 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Manual Probing

COMPILED BY G.D.

**DATUM** Geodetic

DATE July 18, 2013

CHECKED BY C.N.

[illegible]

**RECORD OF BOREHOLE No. 1N-2**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+533.6, o/s 4.0m Lt.  
Coords: 5 070 939.6 N; 227 771.8 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 18, 2013

CHECKED BY C.N.

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			20	40	60	80	100					
188.1	Ground surface																
187.9 0.2	Topsoil Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality		1	RC NQ	REC = 98%		188										
							187										RQD = 84%
			2	RC NQ	REC = 100%		186										RQD = 100%
184.9 3.2	End of borehole						185										
	* Borehole charged with drilling water																

**RECORD OF BOREHOLE No. 1N-3**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+531.2, o/s 4.0m Rt.  
Coords: 5 070 939.3 N; 227 780.1 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Manual Probing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 18, 2013

CHECKED BY C.N.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
187.0	Ground surface					*											
186.8	Topsoil																
0.2	Silty sand, organics																
186.5	Brown Moist																
0.5	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry																

**RECORD OF BOREHOLE No. 1N-4**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+529.9, o/s 8.0m Rt.

Coords: 5 070 939.0 N; 227 784.3 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 17, 2013

CHECKED BY C.N.

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										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
186.4	Ground surface						20	40	60	80	100									
186.2	Topsoil		1	SS	8												0 18 55 27			
0.2	Clayey silt, some sand																			
185.9	organics																			
0.5	Firm Brown Moist		2	RC NQ	REC 90%												RQD 85%			
	Granitic Gneiss bedrock																			
	Slightly weathered																			
	High strength																			
	Good to excellent quality		3	RC NQ	REC 98%												RQD 98%			
			4	RC NQ	REC 100%												RQD 100%			
182.7	End of borehole																			
3.7																				
	* Borehole charged with drilling water																			

# RECORD OF BOREHOLE No. 1N-5

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+534.9 CL

Coords: 5 070 941.8 N; 227 775.3 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Manual Probing

COMPILED BY G.D.

**DATUM** Geodetic

DATE July 24, 2013

CHECKED BY C.N.

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
					DYNAMIC CONE PENETRATION RESISTANCE PLOT
					20    40    60    80    100
					SHEAR STRENGTH kPa
					○ UNCONFINED + FIELD VANE
					● QUICK TRIAXIAL × LAB VANE
					WATER CONTENT (%)
					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT
					w <sub>p</sub> w w <sub>L</sub>
					UNIT WEIGHT γ
					REMARKS & GRAIN SIZE DISTRIBUTION (%)
187.8 0.0	Ground surface			*	
187.7 0.1	Topsoil				
	End of borehole				
	Refusal on probable bedrock				
	* Borehole dry				



**RECORD OF BOREHOLE No. 1N-6**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+538.9, o/s 8.0m Lt.

Coords: 5 070 943.7 N; 227 766.6 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 17, 2013

CHECKED BY C.N.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
188.2	Ground surface																
0.0	Granitic Gneiss bedrock Slightly weathered High strength Excellent quality		1	RC NQ	REC 95%		188										RQD 95%
							187										
			2	RC NQ	REC 98%		186										RQD 98%
185.1	End of borehole																
3.1																	
	* Borehole charged with drilling water																

**RECORD OF BOREHOLE No. 1N-7**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+536.1, o/s 4.0m Lt.

Coords: 5 070 942.0 N; 227 771.2 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Manual Probing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 18, 2013

CHECKED BY C.N.

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			20	40	60	80	100					
188.1	Ground surface					*	188										
0.0	Topsoil																
187.8	Silty sand, organics																
0.3	Brown Moist																
	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry																

**RECORD OF BOREHOLE No. 1N-8**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+535.2, o/s 4.0m Rt.  
Coords: 5 070 942.6 N; 227 779.3 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 18, 2013

CHECKED BY C.N.

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			20	40	60	80	100					
187.4	Ground surface																
187.3 0.1	Topsoil Granitic Gneiss bedrock Slightly weathered High strength Good to excellent quality		1	RC NQ	REC = 92%		187										RQD = 83%
			2	RC NQ	REC = 100%		186 185										RQD = 97%
184.2 3.2	End of borehole																
	* Borehole charged with drilling water																

**RECORD OF BOREHOLE No. 1N-9**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+533.9, o/s 8.0m Rt.

Coords: 5 070 942.9 N; 227 783.3 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Manual Probing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 18, 2013

CHECKED BY C.N.

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			20	40	60	80	100					
186.8	Ground surface					*											GR SA SI CL
186.7 0.1	Topsoil End of borehole Refusal on probable bedrock																
	* Borehole dry																

## RECORD OF BOREHOLE No. 2N-1

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+584.1, o/s 6.0m Lt.

Coords: 5 070 998.1 N; 227 756.3 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

BOREHOLE TYPEContinuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

July 24, 2013

CHECKED BY C.N.

SOIL PROFILE			SAMPLES		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
180.3	Ground surface	[Strat Plot]			
180.2 0.1	Topsoil Sand, trace silt organics  Brown Moist	[Strat Plot]			
179.2 1.1 178.8 1.5	Clayey silt, trace sand organics  Mottled Moist brown/grey	[Strat Plot]	1	AS	-
	End of borehole Refusal on probable bedrock				
*	Borehole dry				

**RECORD OF BOREHOLE No. 2N-2**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+583.0, o/s 3.0m Lt.

Coords: 5 070 987.9 N; 227 759.5 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Continuous Flight Solid Stem Augers + 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 22, 2013

CHECKED BY C.N.

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/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						× LAB VANE		
180.0	Ground surface						20	40	60	80	100									
179.8 0.2	Topsoil		1	SS	5	179										1 60 30 9				
	Silty sand, trace clay organics to 0.9m																			
	Loose to Brown Moist compact		2	SS	19															
	trace gravel																			
178.6 1.4	Granitic Gneiss bedrock		3	RC NQ	REC 96%		178											RQD 92%		
	Slightly weathered to moderately weathered																			
	High strength		4	RC NQ	REC 87%	177										RQD 87%				
	Good to excellent quality																			
			5	RC NQ	REC 100%	176										RQD 100%				
175.1 4.9	End of borehole																			
	  <																			

**RECORD OF BOREHOLE No. 2N-3**

1 of 1

**METRIC**

**G.W.P.** 5112-07-00      **LOCATION** Hwy 69 NBL, Sta. 21+580.8, o/s 3.0m Rt.  
**DIST** Parry Sound      **HWY** 69      **BOREHOLE TYPE** Continuous Flight Solid Stem Augers      **ORIGINATED BY** F.P.  
**DATUM** Geodetic      **DATE** July 23, 2013      **COMPILED BY** G.D.  
**CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	$w_p$	w	$w_L$		
179.7	Ground surface																
179.5 0.2	Topsoil																
	Silty sand, trace clay organics		1	AS	-												
178.9 0.8	Brown Moist																
	Clayey silt, trace sand organics		2	AS	-												
178.0	Mottled Moist brown/grey																
1.7	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry																

**RECORD OF BOREHOLE No. 2N-4**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+579.7, o/s 6.0m Rt.

Coords: 5 070 987.2 N; 227 769.1 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Continuous Flight Solid Stem Augers + 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 23, 2013

CHECKED BY C.N.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W <sub>p</sub>	w	W <sub>L</sub>		
179.3	Ground surface															
179.1 0.2	Topsoil Sandy silt, organics Loose to Brown Moist compact		1	SS	5	179										
178.3 1.0	Clayey silt, trace sand organics		2	SS	12	178										0 7 52 41
177.8 1.5	Stiff Mottled Moist brown/grey Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality		3	RC	REC 88%	177										RQD 88%
			4	RC NQ	REC 100%	176										RQD 100%
			5	RC NQ	REC 98%	175										RQD 98%
174.8 4.5	End of borehole															
	* Borehole charged with drilling water															



**RECORD OF BOREHOLE No. 2N-5**

1 of 1

**METRIC**

**G.W.P.** 5112-07-00      **LOCATION** Hwy 69 NBL, Sta. 21+584.4 CL  
**DIST** Parry Sound      **HWY** 69      **BOREHOLE TYPE** Continuous Flight Solid Stem Augers      **ORIGINATED BY** F.P.  
**DATUM** Geodetic      **DATE** July 24, 2013      **COMPILED BY** G.D.  
**CHECKED BY** C.N.

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										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
179.6	Ground surface							20	40	60	80	100								
179.5 0.1	Topsoil		1	AS	-	179														
178.9 0.7	Sand, trace silt organics																			
	Brown Moist																			
178.2 1.4	Clayey silt, trace sand organics		2	AS	-															
	Mottled Moist brown/grey																			
	End of borehole																			
	Refusal on probable bedrock																			
	* Borehole dry																			

# RECORD OF BOREHOLE No. 2N-6

1 of 1

## METRIC

G.W.P. 5112-07-00

**LOCATION**

Hwy 69 NBL, Sta. 21+589.1, o/s 6.0m Lt.

Coords: 5 070 992.9 N; 227 754.9 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Continuous Flight Solid Stem Augers + 'N' Casing

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

July 22, 2013

CHECKED BY C.N.

[illegible]

**RECORD OF BOREHOLE No. 2N-7**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+588.0, o/s 3.0m Lt.  
Coords: 5 070 992.7 N; 227 758.1 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Continuous Flight Solid Stem Augers

COMPILED BY G.D.

DATUM Geodetic

DATE

July 24, 2013

CHECKED BY C.N.

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			20	40	60	80	100					
179.8	Ground surface																
179.6	Topsoil																
0.2	Sand, trace silt organics		1	AS	-		179										
	Brown Moist																
178.5	End of borehole																
1.3	Refusal on probable bedrock																
	* Borehole dry																

**RECORD OF BOREHOLE No. 2N-8**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+585.8, o/s 2.5m Rt.

Coords: 5 070 992.2 N; 227 764.5 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Continuous Flight Solid Stem Augers + 'N' Casing

COMPILED BY G.D.

DATUM Geodetic

DATE

July 23, 2013

CHECKED BY C.N.

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									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
179.3	Ground surface						20	40	60	80	100	20	40	60			
179.1	Topsoil																
0.2	Sandy silt		1	SS	1												
	Very loose Brown Moist to loose																
178.3			2	SS	5												
1.0	Clayey silt, trace sand organics																
177.8			3	RC	REC 100%												
1.5	Firm to Mottled Moist stiff brown/grey															RQD 78%	
	Granitic Gneiss bedrock																
	Slightly weathered to moderately weathered		4	RC NQ	REC 100%											RQD 100%	
	High strength																
	Good to excellent quality		5	RC NQ	REC 98%											RQD 98%	
174.5																	
4.8	End of borehole																
	* Borehole charged with drilling water																

# RECORD OF BOREHOLE No. 2N-9

1 of 1

**METRIC**

**G.W.P.** 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+584.7, o/s 6.0m Rt.  
Coords: 5 070 991.4 N; 227 767.8 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Continuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

July 24, 2013

**CHECKED BY** C.N.

[illegible]

# RECORD OF BOREHOLE No. 3N-1

1 of 1

METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+660.9, o/s 5.0m Lt.

Coords: 5 071 062.3 N; 227 733.9 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Hilti

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

July 02, 2013

CHECKED BY C.N.

[illegible]

## RECORD OF BOREHOLE No. 3N-2

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+661.0 CL

Coords: 5 071 063.9 N; 227 738.6 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

BOREHOLE TYPEContinuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

October 08, 2013

CHECKED BY C.N.

[illegible]

# RECORD OF BOREHOLE No. 3N-3

1 of 1

**METRIC**

**G.W.P.** 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+660.9, o/s 5.0m Rt.  
Coords: 5 071 065.5 N; 227 743.4 E

ORIGINATED BY F.P.

DIST Parry Sound HWY 69

**BOREHOLE TYPE**Hilti

COMPILED BY G.D.

**DATUM** Geodetic

DATE July 04, 2013

CHECKED BY C.N.

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER * CONDITIONS	ELEVATION SCALE
180.0	Ground surface		NUMBER  	TYPE  	"N" VALUES  
0.0	Topsoil with gravel cobbles and boulders		1	BS	-
Dark brown	Moist				
179.1	Granitic Gneiss bedrock		2	RC	REC 100%
0.9	Slightly weathered to moderately weathered		3	RC NQ	REC 95%
	High strength		4	RC NQ	REC 100%
	Very poor becoming fair to good quality		5	RC NQ	REC 75%
175.8	End of borehole				
4.2	* Borehole charged with drilling water				



# RECORD OF BOREHOLE No. 3N-4

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+663.5, o/s 5.0m Lt.

Coords: 5 071 064.7 N; 227 733.1 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

BOREHOLE TYPEContinuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

October 08, 2013

CHECKED BY C.N.

[illegible]

# RECORD OF BOREHOLE No. 3N-5

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+663.5 CL

Coords: 5 071 066.3 N; 227 737.8 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

BOREHOLE TYPEContinuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

October 08, 2013

CHECKED BY C.N.

[illegible]

# RECORD OF BOREHOLE No. 3N-6

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+663.5, o/s 5.0m Rt.

Coords: 5 071 067.9 N; 227 742.6 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

BOREHOLE TYPEContinuous Flight Solid Stem Augers

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

October 08, 2013

CHECKED BY C.N.

[illegible]

**RECORD OF BOREHOLE No. 3N-7**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+666.0, o/s 5.0m Lt.

Coords: 5 071 067.0 N; 227 732.3 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Hilti

COMPILED BY G.D.

DATUM Geodetic

DATE

July 03, 2013

CHECKED BY C.N.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
180.7	Ground surface						20	40	60	80	100					
0.0	Topsoil		1	BS	-											
180.4	Granitic Gneiss bedrock		2	RC	REC 67%	180										RQD 33%
0.3	Moderately weathered to slightly weathered		3	RC NQ	REC 70%	179										RQD 65%
	High strength		4	RC	REC 100%											RQD 100%
	Poor becoming fair to excellent quality		5	RC NQ	REC 69%	178										RQD 67%
			6	RC	REC 66%	177										RQD 66%
176.6			7	RC	REC 100%											RQD 83%
4.1	End of borehole															
	* Borehole charged with drilling water															

# RECORD OF BOREHOLE No. 3N-8

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+666.0 CL.

Coords: 5 071 068.7 N; 227 737.0 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Manual Probing

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

October 08, 2013

CHECKED BY C.N.

[illegible]

**RECORD OF BOREHOLE No. 3N-9**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+666.0, o/s 5.0m Rt.

Coords: 5 071 070.3 N; 227 741.7 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Hilti

COMPILED BY G.D.

DATUM Geodetic

DATE

July 05, 2013

CHECKED BY C.N.

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										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
181.6	Ground surface						20	40	60	80	100	20	40	60						
0.0	Topsoil with gravel cobbles and boulders																			
181.1	Dark Moist		1	RC	REC 100%		181									RQD 88%				
0.5	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality		2	RC	REC 98%		180									RQD 90%				
			3	RC NQ	REC 100%		179									RQD 100%				
			4	RC NQ	REC 100%		178									RQD 100%				
177.8	End of borehole																			
3.8																				
	* Borehole charged with drilling water																			

# RECORD OF BOREHOLE No. 4N-1

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+712.7, o/s 8.0m Lt.

Coords: 5 071 110.5 N; 227 713.4 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Manual Probing

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

August 19, 2013

CHECKED BY C.N.

[illegible]

# RECORD OF BOREHOLE No. 4N-2

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+711.4, o/s 4.0m Lt.

Coords: 5 071 110.7 N; 227 717.6 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Hilti

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

August 12 and 13, 2013

CHECKED BY C.N.

[illegible]



**RECORD OF BOREHOLE No. 4N-3**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+709.0, o/s 4.0m Rt.  
Coords: 5 071 111.3 N; 227 725.9 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Hilti

COMPILED BY G.D.

DATUM Geodetic

DATE

August 29/30 and September 04, 2013

CHECKED BY C.N.

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE										
195.2	Ground surface						20	40	60	80	100							
0.0	Granitic Gneiss bedrock Unweathered to slightly weathered High strength Good to excellent locally very poor to fair quality		1	RC NQ	REC 100%	*	195										RQD 100%	
			2	RC NQ	REC 97%		194											RQD 85%
			3	RC NQ	REC 98%		193											RQD 90%
			4	RC	REC 97%		192											RQD 0%
			5	RC	REC 92%													
			6	RC NQ	REC 100%		191											RQD 100%
			7	RC NQ	REC 100%													
			8	RC NQ	REC 100%		190											RQD 100%
			9	RC	REC 98%													
			10	RC	REC 94%		189											RQD 94%
			11	RC NQ	REC 100%													
			12	RC NQ	REC 87%		188											RQD 87%
			13	RC NQ	REC 100%													
			14	RC	REC 96%		187											
186.2	End of borehole																	
9.0																		
	* Borehole charged with drilling water																	

**RECORD OF BOREHOLE No. 4N-4**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+708.2, o/s 8.0m Rt.  
Coords: 5 071 112.0 N; 227 730.0 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Hilti

COMPILED BY G.D.

DATUM Geodetic

DATE

August 13, 2013

CHECKED BY C.N.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
195.6	Ground surface																
0.0	Granitic Gneiss bedrock Unweathered to slightly weathered High strength Excellent becoming fair to good quality		1	RC NQ	REC 100%		195										RQD 96%
			2	RC NQ	REC 99%		194										RQD 98%
			3	RC NQ	REC 98%		193										RQD 98%
			4	RC	REC 100%												RQD 53%
192.5			5	RC	REC 80%												RQD 80%
3.1	End of borehole																
	* Borehole charged with drilling water																

# RECORD OF BOREHOLE No. 4N-5

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+716.7, o/s 8.0m Lt.

Coords: 5 071 114.3 N; 227 712.0 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Hilti

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

August 13, 2013

CHECKED BY C.N.

[illegible]

**RECORD OF BOREHOLE No. 4N-6**

1 of 1

**METRIC**

**G.W.P.** 5112-07-00      **LOCATION** Hwy 69 NBL, Sta. 21+713.9, o/s 4.0m Lt.  
**DIST** Parry Sound      **HWY** 69      **BOREHOLE TYPE** Manual Probing      **ORIGINATED BY** F.P.  
**DATUM** Geodetic      **DATE** August 19, 2013      **COMPILED BY** G.D.  
**CHECKED BY** C.N.

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 (%)				GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE					LAB VANE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
195.0	Ground surface					*																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

# RECORD OF BOREHOLE No. 4N-7

1 of 1

## METRIC

**G.W.P.** 5112-07-00

### LOCATION

Hwy 69 NBL, Sta. 21+713.0, o/s 4.0m Rt.

Coords: 5 071 115.0 N; 227 724.5 E

ORIGINATED BY F.P.

**DIST** Parry Sound

HWY 69

**BOREHOLE TYPE**Hilti

COMPILED BY G.D.

**DATUM** Geodetic

DATE \_\_\_\_\_

August 14, 2013

CHECKED BY C.N.

[illegible]

**RECORD OF BOREHOLE No. 4N-8**

1 of 1

**METRIC**

G.W.P. 5112-07-00

LOCATION

Hwy 69 NBL, Sta. 21+711.7. o/s 8.0m Rt.

Coords: 5 071 115.2 N; 227 728.7 E

ORIGINATED BY F.P.

DIST Parry Sound

HWY 69

BOREHOLE TYPE Manual Probing

COMPILED BY G.D.

DATUM Geodetic

DATE

August 19, 2013

CHECKED BY C.N.

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			20	40	60	80	100					
195.8	Ground surface					*											GR SA SI CL
0.0	Bedrock at surface																
	* Borehole dry																

**RECORD OF BOREHOLE No. N-2**

1 of 1

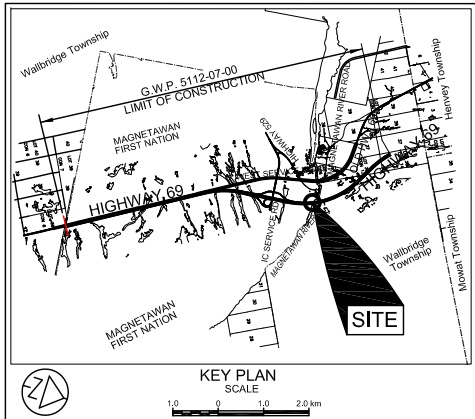
**METRIC**

**G.W.P.** 5112-07-00      **LOCATION** Hwy 69 NBL, Sta. 21+732.7 CL  
**DIST** Parry Sound      **HWY** 69      **BOREHOLE TYPE** Manual Probing      **ORIGINATED BY** F.P.  
**DATUM** Geodetic      **DATE** September 23, 2013      **COMPILED BY** G.D.  
**CHECKED BY** C.N.

SOIL PROFILE		SAMPLES				GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	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>		WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
								○ UNCONFINED                      + FIELD VANE ● QUICK TRIAXIAL                  × LAB VANE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
196.6	Ground surface					*		20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													



**PML Peto MacCallum Ltd.**  
CONSULTING ENGINEERS



LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- \* Borehole charged with drilling water
- WL at time of investigation July to Oct. 2013
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
N-1	187.8	5 070 922.5	227 780.2
1N-1	188.1	5 070 939.8	227 767.6
1N-2	188.0	5 070 939.6	227 771.8
1N-3	186.9	5 070 939.3	227 780.1
1N-4	186.3	5 070 939.0	227 784.3
1N-5	187.7	5 070 941.8	227 775.3
1N-6	188.1	5 070 943.7	227 766.6
1N-7	188.0	5 070 942.0	227 771.2
1N-8	187.3	5 070 942.6	227 779.3
1N-9	186.7	5 070 942.9	227 783.3
2N-1	180.3	5 070 998.1	227 756.3
2N-2	180.0	5 070 987.9	227 759.5
2N-3	179.8	5 070 987.4	227 765.9
2N-4	179.3	5 070 987.2	227 769.1
2N-5	179.6	5 070 990.0	227 762.0

(Legend Continues)

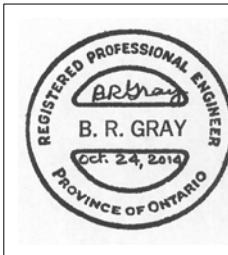
NOTE

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

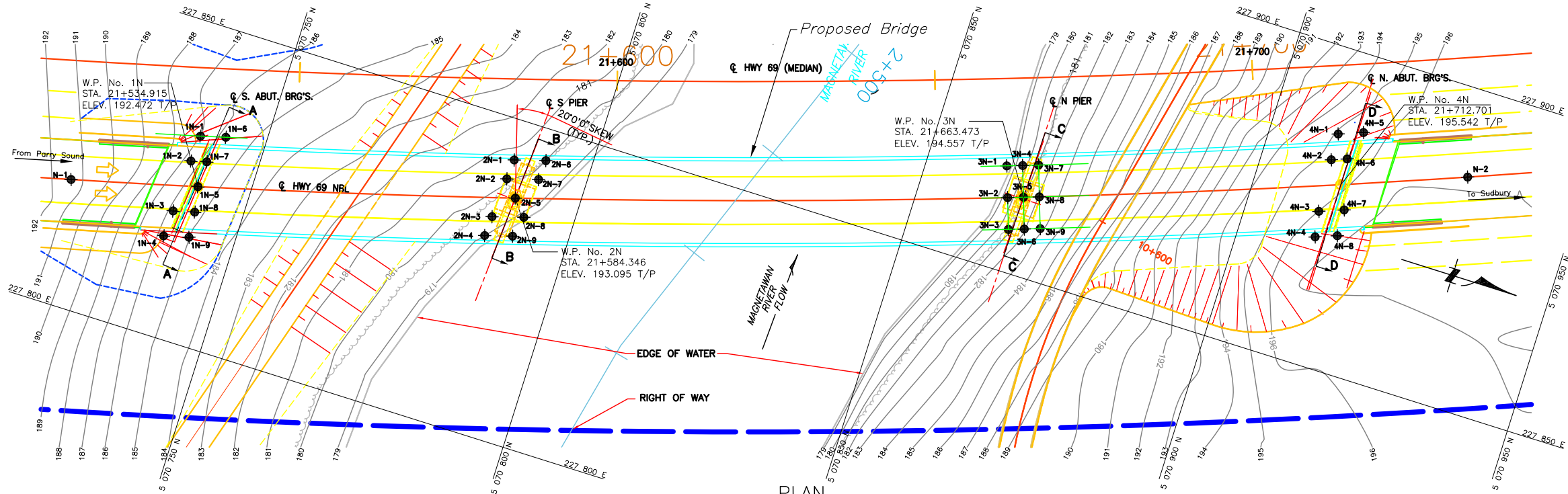
DATE	BY	DESCRIPTION

Geocres No. 41H-142

HWY No	69	DIST	54
SUBM'D	NA	CHECKED	GD
DATE	OCT. 24, 2014	SITE	44/457-1
DRAWN	NA	CHECKED	BRG
APPROVED	CN	DWG	MRN-1

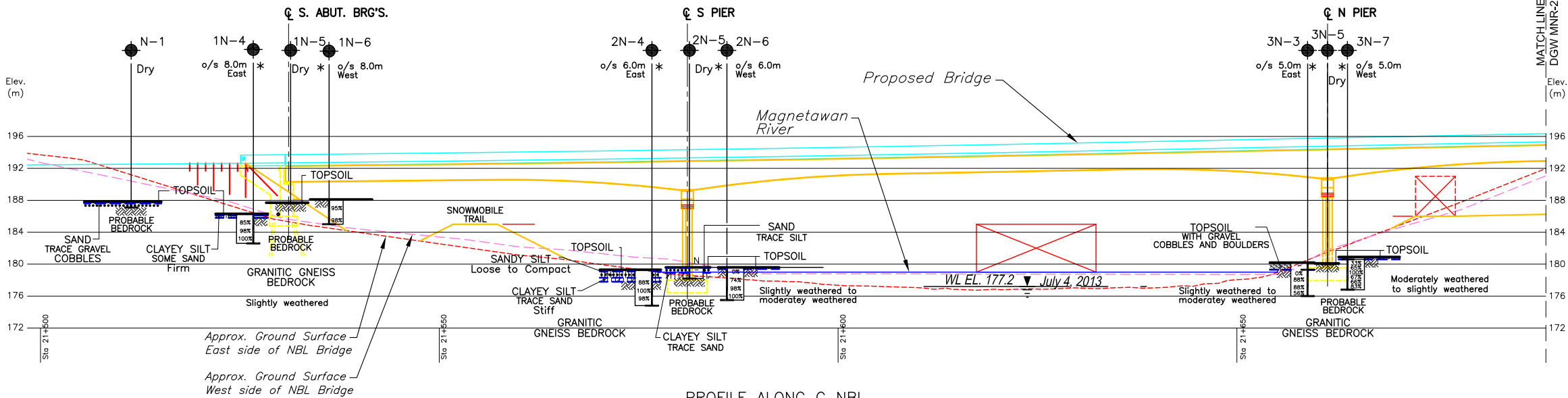


REF No. AECOM Drawings: C6-Hwy69 Base-PDR.dwg; C6-Hwy69 Des.dwg;



PLAN

SCALE



PROFILE ALONG C NBL

SCALE



(Legend Continued)

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
2N-6	179.6	5 070 992.9	227 754.9
2N-7	179.9	5 070 992.7	227 758.1
2N-8	179.4	5 070 992.2	227 764.5
2N-9	178.4	5 070 991.4	227 767.8
3N-1	178.5	5 071 062.3	227 733.9
3N-2	179.4	5 071 063.9	227 738.6
3N-3	180.2	5 071 065.5	227 743.4
3N-4	180.2	5 071 064.7	227 733.1
3N-5	180.1	5 071 066.3	227 737.8
3N-6	180.9	5 071 067.9	227 742.6
3N-7	180.9	5 071 067.0	227 732.3

(Legend Continues)

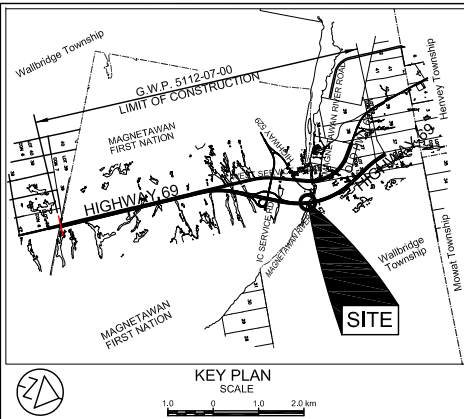
(Legend Continued)

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
3N-8	181.2	5 071 068.7	227 737.0
3N-9	181.8	5 071 070.3	227 741.7
4N-1	194.1	5 071 110.5	227 713.4
4N-2	194.4	5 071 110.7	227 717.6
4N-3	195.3	5 071 111.3	227 725.9
4N-4	195.7	5 071 112.0	227 730.0
4N-5	194.3	5 071 114.3	227 712.0
4N-6	195.1	5 071 113.1	227 716.7
4N-7	195.7	5 071 115.0	227 724.5
4N-8	195.9	5 071 115.2	227 728.7
N-2	196.6	5 071 132.0	227 713.8

NOTES:

- DRAWINGS MRN-1 AND MRN-2 SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
- REFER TO DRAWING MRN-2 FOR C NBL PROFILE (Continued) SECTIONS A-A TO D-D.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.





LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- \* Borehole charged with drilling water
- WL at time of investigation July to Oct. 2013
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
REFER TO DWG. MRN-1 FOR DETAILS			

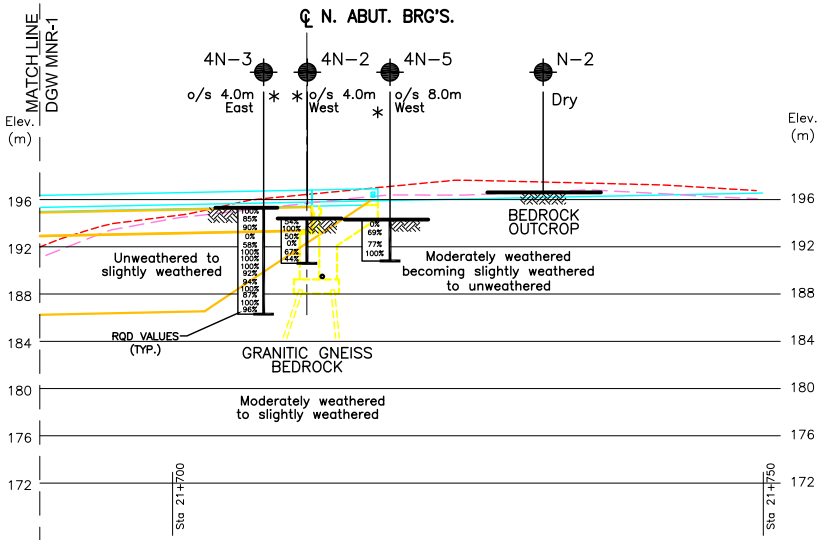
NOTE

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

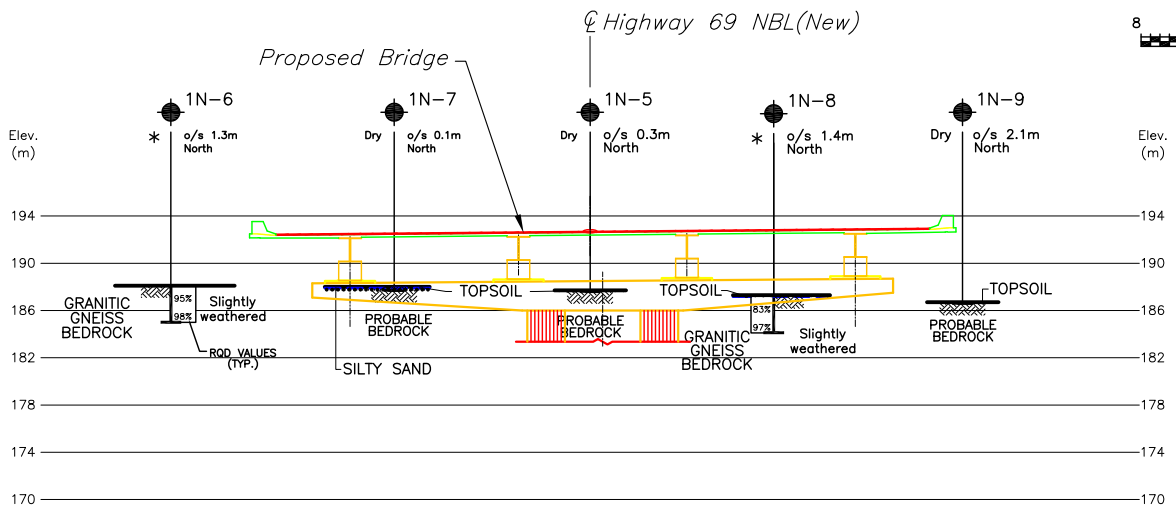
REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-142

HWY No 69	DIST 54
SUBM'D NA	CHECKED GD
DATE OCT. 24, 2014	SITE 44/457-1
DRAWN NA	CHECKED BRG
APPROVED CN	DWG MRN-2

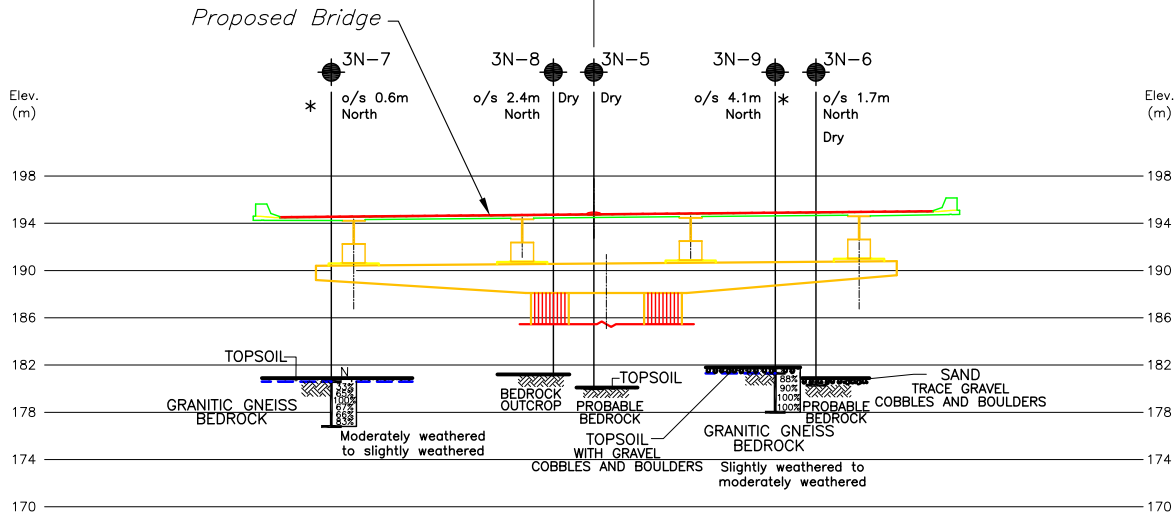


PROFILE ALONG Q NBL (Continued)

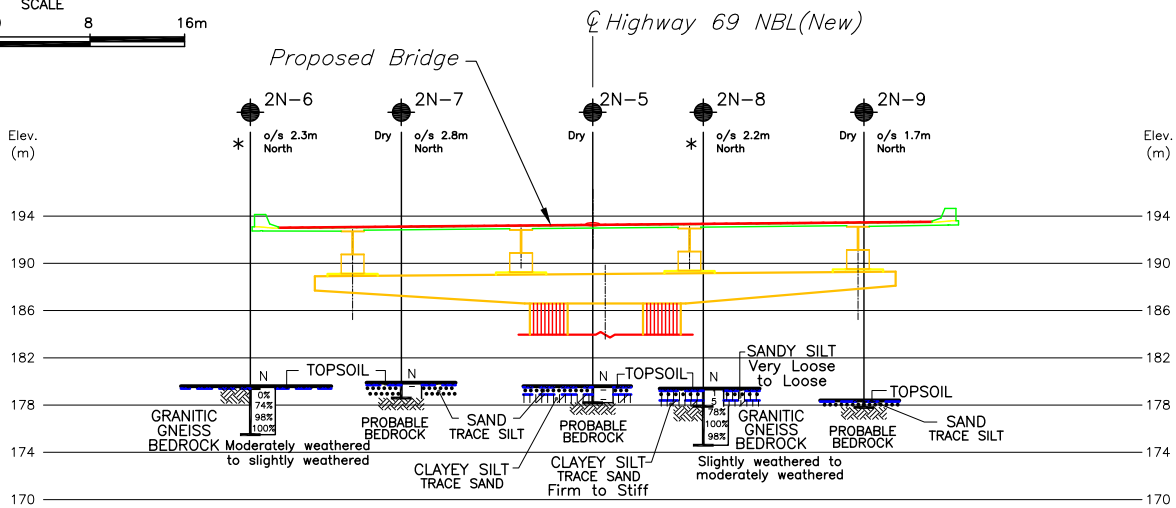


SECTION A-A

Q Highway 69 NBL(New)

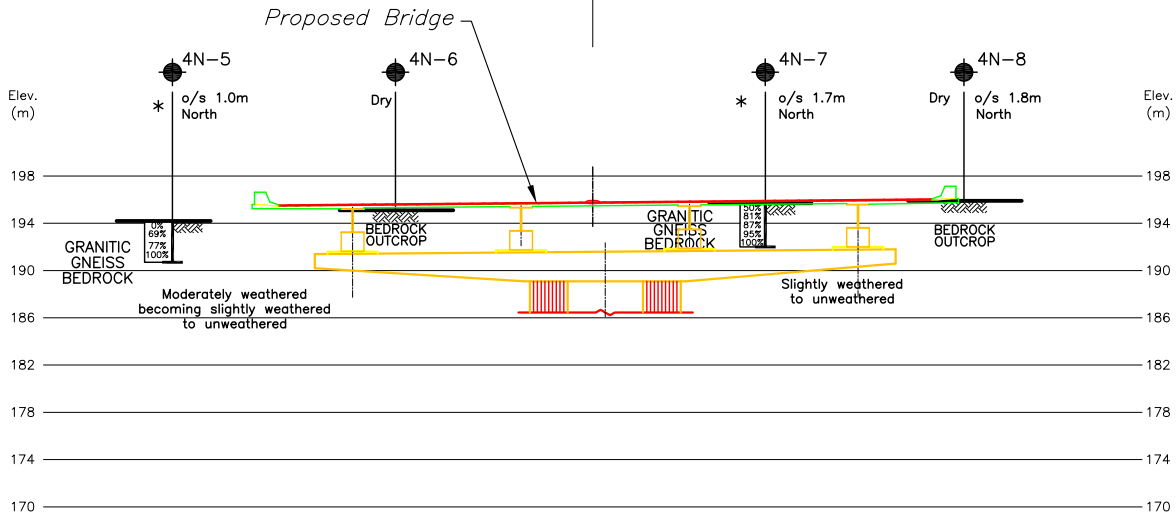


SECTION C-C

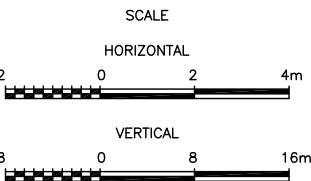


SECTION B-B

Q Highway 69 NBL(New)

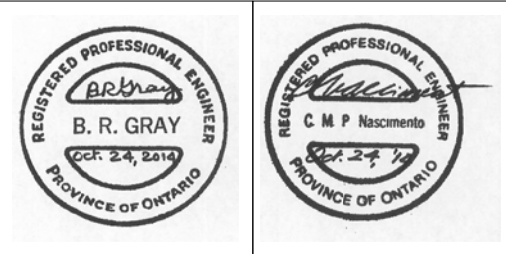


SECTION D-D



NOTES:

- DRAWINGS MRN-1 AND MRN-2 SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
- REFER TO DRAWING MRN-1 FOR BOREHOLE AND SECTION LOCATIONS AND CENTRELINE PROFILE.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



REF No. AECOM Drawings: C6-Hwy69 Base-PDR.dwg; C6-Hwy69 Des.dwg;



## **APPENDIX A**

### Site Photographs



**Photograph 1:** Facing south from the south abutment of the NBL structure.  
(July 17, 2013)





**Photograph 2:** Facing north towards the Magnetawan River from the south abutment of the NBL structure. (July 17, 2013)



**Photograph 3:** Drilling of borehole 2N-6 at the south pier of the NBL structure, facing east. (July 22, 2013)





**Photograph 4:** Facing west from the location of borehole 3N-7 at the north pier of the NBL structure. (July 3, 2013)



**Photograph 5:** Facing north from the location of borehole 4N-4 at the north abutment of the NBL structure. (August 12, 2013)



## **APPENDIX B**

### Rock Core Photographs





**Photograph 1:** Cores retrieved from borehole 1N-2. Rock cores 1 and 2 from 0.2 to 3.2 m depth. RQD values were 84 and 100%, indicating good to excellent rock quality.



**Photograph 2:** Cores retrieved from borehole 2N-2. Rock cores 3 to 5 from 1.4 to 4.9 m depth. RQD values ranged from 87 to 100%, indicating good to excellent rock quality.



**Photograph 3:** Cores retrieved from borehole 4N-3 (box 1 of 2). Rock cores 1 to 8 from 0.0 to 4.5 m depth. RQD values ranged from 0 to 100%, indicating good to excellent locally very poor to fair rock quality.



**Photograph 4:** Cores retrieved from borehole 4N-3 (box 2 of 2). Rock cores 8 to 14 from 4.5 to 9.0 m depth. RQD values ranged from 87 to 100%, indicating good to excellent rock quality.





**Photograph 5:** Cores retrieved from borehole 4N-4. Rock cores 1 to 5 from 0.0 to 3.1 m depth. RQD values ranged from 53 to 98%, indicating excellent becoming fair to good rock quality.



**FOUNDATION DESIGN REPORT**  
**for**  
**MAGNETAWAN RIVER NORTHBOUND BRIDGE**  
**HIGHWAY 69**  
**SITE NO. 44-457/1**  
**W.P. 5134-08-01**  
**MAGNETAWAN FIRST NATION, ONTARIO**

PETO MacCALLUM LTD.  
165 CARTWRIGHT AVENUE  
TORONTO, ONTARIO  
M6A 1V5  
Phone: (416) 785-5110  
Fax: (416) 785-5120  
Email: toronto@petomaccallum.com

**Distribution:**

- 5 cc: AECOM for distribution to MTO, Project Manager  
+ one digital copy (PDF)
- 1 cc: AECOM for distribution to MTO, Pavements and  
Foundations Section + one digital copy (PDF)  
and Drawing (AutoCAD)
- 2 cc: AECOM + one digital copy (PDF)
- 1 cc: PML Kitchener
- 1 cc: PML Toronto

PML Ref.: 09TF042-MRN  
Index No.: 358FDR  
GEOCRES No.: 41H-142  
October 29, 2014



## TABLE OF CONTENTS

1. INTRODUCTION.....	1
2. FOUNDATIONS .....	3
2.1 General.....	3
2.2 Spread Footings.....	4
2.3 Piles.....	7
3. ABUTMENT WALLS .....	7
4. APPROACH EMBANKMENTS .....	8
5. EXCAVATION AND GROUNDWATER CONTROL .....	10
6. CLOSURE .....	12

Table 1 – Summary of Advantages, Disadvantages and Recommended Foundations

Table 2 – List of Standard Specifications Referenced in Report

Figure 1 – Rock Fill Drainage in Slope Flattened Areas

Appendix 1 – Non-Standard Special Provisions:

- Inspection of Footings by a Specialist Rock Mechanics Engineer
- Rock Blasting / Excavation for Footings Construction

**FOUNDATION DESIGN REPORT**  
for  
Magnetawan River Northbound Bridge  
Highway 69  
Site No. 44-457/1  
W.P. 5134-08-01  
Magnetawan First Nation, Ontario

---

**1. INTRODUCTION**

This report provides foundation engineering comments and recommendations regarding design and construction of the foundations and approach embankments for the proposed construction of a bridge to carry Highway 69 (New) northbound traffic over the Magnetawan River in Magnetawan First Nation, Ontario. The investigation was conducted for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The bridge is at approximate Station 21+624, Highway 69 chainage, in Magnetawan First Nation, about 90 km south of Sudbury. The bridge is proposed to be a 3-span structure with an approximate total length of 180 m and width of 14 m (ref. General Arrangement Drawing 1 'Hwy. 69 – NBL Magnetawan River Crossing' prepared by AECOM in May 2012).

The road grade on Highway 69 (New) at the bridge location is planned at elevation 192.5 at the south abutment and elevation 195.5 at the north abutment, some 14.0 to 15.5 m above the normal water level in the Magnetawan River. The approach embankments to the structure are envisaged to be 4 to 6 m high at the south abutment and about 1 m high at the north abutment (interpolated from ground surface elevations and the proposed road grade).

In summary, the site is located about 260 m east of the existing Highway 69 on a rock outcrop where the subsurface stratigraphy revealed in the boreholes comprised surficial topsoil, sandy/silty soils and/or clayey silt over bedrock or exposed bedrock. Cobbles and boulders were encountered in 6 boreholes. The bedrock surface was contacted at depths of 0.0 to 1.7 m (elevation 177.8 to 196.6). Although subject to seasonal variations and weather dependent precipitation, the water level in the river is normally near elevation 179.0. This water level was measured as low as elevation 176.7 on July 24, 2013. The Magnetawan River is normally about 70 m wide and flows to the west at the site.



The depth to and surface elevation of the bedrock identified in the boreholes drilled at this site are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
South Approach	N-1	0.7	187.1
South Abutment	1N-1	0.1	188.0
	1N-2	0.2	187.8*
	1N-3	0.5	186.4
	1N-4	0.5	185.8*
	1N-5	0.1	187.6
	1N-6	0.0	188.1*
	1N-7	0.3	187.7
	1N-8	0.1	187.2*
	1N-9	0.1	186.6
South Pier	2N-1	1.5	178.8
	2N-2	1.4	178.6*
	2N-3	1.7	178.1
	2N-4	1.5	177.8*
	2N-5	1.4	178.2
	2N-6	0.2	179.4*
	2N-7	1.3	178.6
	2N-8	1.5	177.9*
	2N-9	0.6	177.8
North Pier	3N-1	0.0	178.5*
	3N-2	0.3	179.1
	3N-3	0.9	179.3*
	3N-4	0.3	179.9
	3N-5	0.1	180.0
	3N-6	0.2	180.7
	3N-7	0.3	180.6*
	3N-8	0.0	181.2
	3N-9	0.5	181.3*
North Abutment	4N-1	0.1	194.0
	4N-2	0.0	194.4*
	4N-3	0.0	195.3*
	4N-4	0.0	195.7*
	4N-5	0.0	194.3*
	4N-6	0.0	195.1
	4N-7	0.0	195.7*
	4N-8	0.0	195.9
North Approach	N-2	0.0	196.6

\* confirmed by rock coring



In view of the very small depth of the bedrock below the ground surface and the planned grades of the bridge deck, it is considered that integral abutments will require deep trenches or coring of large diameter deep holes to install the piles and this is not economical. The structure may be designed with semi-integral or conventional abutments.

It is noteworthy that the very poor rock quality conditions may require local remediation to adequately withstand the lateral load transferred from spread footings. These measures include rock bolting or grouting and should be evaluated and determined at the time of construction. These remedial measures should be paid out of a contingency allowance in the contract. A NSSP should be included in the tender documents to alert the contractor of the possible local remediation necessity to adequately withstand the lateral forces.

The "red flag" issues outlined in the preceding paragraphs and the recommended methods of overcoming these issues noted in the following sections of the report are intended to alert and aid the designer and the contractor. These comments and recommendations are based on the conditions revealed during the investigations and no responsibility is assumed by the consultants or the MTO for alerting the contractor to all critical issues for each foundation alternative. The requirements to deliver acceptable construction quality remain the responsibility of the contractor.

## **2. FOUNDATIONS**

### **2.1 General**

The design road grade at the bridge location is at elevation 192.5 to 195.5, about 1 to 6 m and 13 to 16 m above the ground surface at the abutments and piers respectively.

It is recommended that the abutment and pier foundations be supported by spread footings founded on bedrock.

Spread footings founded on bedrock are considered to be the preferred foundation system due to the shallow depth to bedrock at the locations of the abutments and piers (less than 2 m). It is noteworthy that boulders present at the site should be removed prior to placing the footings or fill. The need to remove boulders should be specified in contract documentation as a notice to the contractor.



The seismic coefficient for the conditions at this site is 1.0 (Type I soil profile as per clause 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC), CAN/CSA-S6-00). The zonal acceleration ratio is 0.05. The bridge site is located in Seismic Performance Zone 1.

All footings subject to frost action should be provided with 2.0 m of earth cover or equivalent thermal insulation. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover. Footings bearing directly on bedrock do not require protection from frost.

Construction of the footings should be performed and monitored in accordance with OPSS 902 to verify the competency of the founding surface. In addition, a rock engineering specialist should be retained to examine the integrity and/or impact on bedrock below the footings, should blasting be required near the bridge foundations.

Further comments and recommendations for design of the foundations are provided in the following sections. A summary of the advantages, disadvantages and the preferred foundation type from a foundation engineering perspective is given in Table 1. The standard specifications referenced in this report are listed in Table 2.

## **2.2 Spread Footings**

As discussed in section 2.1, the foundations for the abutments and piers may be constructed as footings on bedrock. The anticipated depth and elevation to bedrock at each borehole location are tabulated in section 1.0. The bedrock surface level within the footprints of the foundation elements ranges from elevation 185.8 to 188.1 at the south abutment, from elevation 177.8 to 179.4 at the south pier, from elevation 178.5 to 181.3 at the north pier and from elevation 194.0 to 195.9 at the north abutment. The inferred surface of the bedrock generally slopes down to the southeast at inclinations of 2 to 8° at the south abutment, to the east at angles of 1 to 7° at the south pier, to the south at angles of 4 to 14° at the north pier and to the southwest at inclinations of 2 to 7° at the north abutment, locally dipping at maximum angles of 13°, 16°, 30° and 16° respectively.

The bedrock generally comprises a slightly to moderately weathered high strength granitic gneiss and is classified as poor to excellent quality (RQD of 33 to 100%) with a core recovery in excess of 44%. Very poor quality rock was identified in a few core samples in boreholes 2N-6, 3N-3, 4N-2, 4N-3 and 4N-5 – the upper 0.3 to 0.6 m thick zones in boreholes 2N-6, 3N-3, 4N-5 and 0.5



to 0.7 m long core samples at depths of 1.5 and 2.4 m (elevation 192.9) in boreholes 4N-2 and 4N-3. It is considered that the rock is capable of adequately supporting the foundation loads.

Footings bearing on the high strength bedrock should be designed using a factored geotechnical bearing resistance of 10 MPa at ultimate limit states (ULS). In case of the footings founded on the very poor quality bedrock that has been remediated, the factored geotechnical bearing resistance at ULS of 5 MPa may be used. The geotechnical reaction at serviceability limit states (SLS) allows for 25 mm compression of the founding medium. Considering the bedrock to be non-yielding, the design will not be governed by settlement criteria since the loading required to produce 25 mm deformation would be much larger than the factored geotechnical resistance at ULS. Consequently the geotechnical reaction at SLS should be taken the same as the factored geotechnical resistance at ULS for computation purposes. The geotechnical bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC.

Mass concrete could be placed to provide a level founding surface for the footings where required. Mass concrete could also be employed to raise the subgrade to the design level of the footings. The need to expand the plan area at the base of the mass concrete to provide for stress distribution (2V:1H), place reinforcing steel in the mass concrete and/or use high strength concrete to prevent overstressing will be dictated by structural design considerations including the actual thickness of the mass concrete.

Subject to these comments, the bearing resistance provided for footings bearing on bedrock is considered to be appropriate for mass concrete with an unconfined compressive strength of at least 35 MPa. If the actual bearing pressure is less than 8 MPa, the unconfined compressive strength of the concrete could be reduced in direct linear proportion to the actual bearing stress to a minimum of 25 MPa.

Comments concerning excavation of bedrock to enable construction of the footings are provided in section 5 of this report.

The horizontal force imposed on the foundations will be resisted in part by the friction force developed between the underside of the footing and the bedrock. An unfactored friction factor of





0.7 is recommended for footings constructed on rough bedrock surfaces (asperity height of at least 25 mm).

The need to install anchors / dowels to resist sliding if the slope of the bedrock surface referred to previously is unfavourably inclined relative to the direction of the force imposed by the foundation loads should be considered by the structural engineer. Design, installation and testing of the anchors subjected to tensile stresses should be conducted in accordance with SP 999S26 and clause 6.10.4 of the CHBDC.

A NSSP should be included in the tender documents for inspection of the footing subgrade by a specialist rock mechanics engineer. Based on the inspection, rock bolts or grouting and/or local scaling may be required. Refer to Appendix 1 for an example of the NSSP "Inspection of Footings by a Specialist Rock Mechanics Engineer".

The lateral resistance of footings founded on bedrock could be increased by means of a shear key and/or by installing anchors into the bedrock (SP 999S26). The increased lateral resistance will be provided by the shear strength of steel dowels if used, the horizontal resistance of the bedrock, the horizontal component of tensile forces developed in any inclined anchors and/or a greater frictional resistance between the footing and rock if the anchors are prestressed to increase the vertical pressure. The factored horizontal resistance at ULS of the bedrock is considered to be 5000 kPa.

If dowels into concrete are employed, a NSSP should be included in the tender documents to provide specific direction for the contractor during installation and testing of the dowels.

If anchors are installed, a factored bond stress at the rock/grout interface of 1.4 MPa at ULS (a resistance factor of 0.4 is applied for a minimum 35 MPa grout) is recommended for design. The anchors should extend at least 30 bar diameters into sound bedrock and be spaced at a distance of at least four times the diameter of the anchor hole. The total capacity of a group of closely spaced anchors may be less than the summed capacities of the individual anchors; the impact of anchor interaction should be assessed if the spacing is less than one-fifth of the anchor length.



## 2.3 Piles

Taking into account the shallow depth to bedrock at the locations of the abutments and piers (less than 2 m), use of steel H-piles driven to bedrock through the embankment fill is not considered to be a suitable method of supporting the south and north abutment foundations. Based on the proposed abutment grades, it is very likely that local bedrock excavation or large diameter coring to provide for the structurally required minimum 3 to 5 m free pile length for integral abutments would be necessary as well. It is therefore not recommended to use steel H-piles to support the foundation loads at the site.

## 3. ABUTMENT WALLS

The abutment walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure may be computed using the equivalent fluid pressure diagrams presented in Section 6.9 of the CHBDC or employing the following equation, assuming a triangular pressure distribution:

$$p = K (\gamma h + q) + C_p + C_s$$

where  $K$  = coefficient of lateral earth pressure (dimensionless)  
 $\gamma$  = unit weight of free-draining granular material,  $\text{kN/m}^3$   
 $h$  = depth below final grade, m  
 $q$  = surcharge load, kPa, if present  
 $C_p$  = compaction pressure, kPa (refer to clause 6.9.3 of CHBDC)  
 $C_s$  = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)  
 where  $\phi$  = angle of internal friction of retained soil ( $35^\circ$  for Granular B Type II)  
 $\delta$  = angle of friction between the soil and wall ( $23.5^\circ$  for Granular B Type II)

The seismic site coefficient and zonal acceleration ratio for the conditions at this site were provided in section 2.1.

Free-draining granular material or rockfill should be used as backfill behind the walls. The following parameters are recommended for design:

Parameters	Granular A or Granular B Type II	Rockfill
Angle of Internal Friction, degrees	35	42
Unit Weight, $\text{kN/m}^3$	22.8	18.0



Parameters	Granular A or Granular B Type II	Rockfill
Coefficient of Active Earth Pressure $K_a$	0.27	0.20
Coefficient of Earth Pressure At-Rest $K_o$	0.43	0.33
Coefficient of Passive Earth Pressure $K_p$	3.69	5.04

The coefficient of earth pressure at-rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures. The earth pressure coefficients should be reviewed if the slope of the backfill exceeds  $10^\circ$  to the horizontal. Alternatively, the material above the top of the wall could be treated as a surcharge load ( $q$  in the preceding equation).

A weeping tile system (OPSS 405 and OPSD 3190.100) should be installed to minimise the build-up of hydrostatic pressure behind the walls. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade.

Backfilling adjacent to retaining structures should be carried out in conformance to Ontario Provincial Standards specifications for granular or rock backfill at abutments (OPSD 3101.150 and 3101.200).

Operation of compaction equipment adjacent to retaining structures should be restricted to limit the compaction pressure noted in clause 6.9.3 of the CHBDC. Refer to OPSS 501 for additional information in this regard.

#### **4. APPROACH EMBANKMENTS**

The height of fill embankments will be 4 to 6 m at the south approach and about 1 m at the north approach. It is anticipated that the approach embankments will be constructed with earth borrow, granular material or rockfill. Construction of the fill on bedrock is considered to be feasible.



The topsoil identified at the abutment locations and along the alignment of the approach fills within 20 m of the abutments should be stripped prior to placement of the embankment fill. All loose boulders should be removed from each approach embankment footprint.

The embankments should be constructed in accordance with OPSD 201.020, 202.010 and SP 206S03. The side slopes of the approach embankments should be inclined no steeper than 2H:1V for earth fill and 1.25H:1V for rockfill. A 2 m wide mid-height berm for erosion control and slope maintenance purposes is not necessary at the site.

Where slope flattening is proposed, a drainage gap should be provided in accordance with OPSD 202.020. Where slopes are flattened to eliminate the need for a guiderail, a granular infilled drainage gap should be provided in accordance with the Northeastern Region Pavement Design Practices and Guidelines as shown in Figure 1, appended. OPSS Granular B Type II should be used for the drainage gaps.

Where the bedrock surface slopes in the direction transverse to the roadway alignment, it should be benched in accordance with OPSD 208.010 to provide stable conditions.

It is considered that the approach embankments constructed in accordance with these recommendations will be stable. Settlement of the road surface will only be governed by 'consolidation' of the newly placed fill (settlement of the embankment fill due to consolidation of the bedrock at both embankments is negligible).

The backfill placed adjacent to the abutments will be 1 to 6 m thick. The magnitude of 'consolidation' of this fill will be dependent on the workmanship employed by the contractor and, if placed in 200 to 300 mm thick lifts compacted to 100% of the standard Proctor maximum dry density in accordance with the requirements of OPSS 902 and OPSS 501 (Method A), should be in the order of 15 mm at the south abutment and about 5 mm at the north abutment. The settlement of the approach fill surface near the abutments should be essentially complete within 2 to 3 months after placement of the fill.



The settlement of the approach embankments made up of rockfill if used beyond the granular fill zone at the abutments is estimated to be 25 to 50 mm at the south approach and 5 to 10 mm at the north approach. The settlement remaining after 6 and 12 months following fill placement is 5 to 10 mm and about 5 mm respectively. These values have been assessed using "Post-construction rock fill settlement and guidelines for estimating rock fill quantity" issued by MTO on September 14, 2010.

The embankment platform founded on bedrock should be widened by 1 m in accordance with the Northeastern Region Engineering Directive (NRE 98-200).

Earth fill slopes where employed should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 803 or 804 for time constraints and the type of seed and mulch required.

## **5. EXCAVATION AND GROUNDWATER CONTROL**

It is expected that excavation for construction of spread footings founded on bedrock will extend through the sandy/silty soils and/or clayey silt to a depth not exceeding 2 m at the abutments and piers.

The typically loose to compact sandy/silty soils and firm to stiff clayey silt are classified as Type 3 soils according to the Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Temporary cut slopes in earth over the full depth of excavation should therefore be inclined at an angle of 45° to the horizontal. The need to excavate flatter sideslopes if very loose sandy/silty soils, soft to very soft silty clay / clayey silt, excessively soft/wet materials or concentrated seepage zones are encountered locally during construction should be considered.

It is noted that steep rock faces are present at the locations of the bridge piers. Bedrock is classified as Type 1 soil. In general, near vertical sidewalls may be utilised for excavations in bedrock. However, where the rock quality is poor to very poor, the resulting excavation slope may need to be flatter subject to local site inspections during construction. Examination of the sidewalls and removal of any loosened rock fragments should be carried out continually for the safety of workmen.



Mechanical means such as a large excavator equipped with a tiger-toothed bucket in conjunction with a jack-hammer or hoe ram is the preferred method of excavation to shallow depths in rock scaling at foundation locations (SP 299F03). Conventional rock excavation techniques such as blasting (OPSS 120), controlled blasting (SP 299F06) and trim blasting (SP 299F04) are likely to be required as well. The actual equipment required and method of excavation within the bedrock will be dependent upon the geometry of cut and the relative depth of excavation into the bedrock. Mass concrete could be employed to level minor variations in the bedrock surface.

If blasting is required, a NSSP should be prepared to provide specific direction to the contractor to control the blasting / rock excavation activities to prevent fracturing and/or disturbance of the bedrock surface on which footings will be founded; require that a blasting specialist be retained to establish the charge to minimise overbreak; advise the contractor that any overblasting / overexcavation will be the sole responsibility of the contractor and require that loosened rock resulting from blasting operations be removed by mechanical means. It should also be specified that the vertical faces of the bedrock behind the pier footings are load bearing and the integrity of these faces should be preserved by carefully controlled rock excavation. Refer to Appendix 1 for an example of the NSSP "Rock Blasting / Excavation for Footings Construction".

In addition, the Department of Fisheries Guideline for use of explosives in or near Canadian Fisheries Water (Canadian Technical Report of Fisheries and Aquatic Sciences 2107, dated 1998) should be followed when conventional rock excavation techniques such as blasting are required near the Magnetawan River to protect the water environment and fish habitat.

No groundwater was observed in any of the boreholes during and upon completion of drilling. The stabilised groundwater level is expected to be consistent with the water level in the Magnetawan River, normally near elevation 179.0 and at elevation 176.7 to 177.2 in July 2013. It is anticipated that conventional sump pumping techniques will be sufficient to control seepage of groundwater into the foundation excavations. Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.



## 6. CLOSURE

This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C.M.P. Nascimento, P.Eng., Project Manager, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



Grigory O. Degil, PhD, P.Eng.  
Senior Foundation Engineer



Carlos M.P. Nascimento, P.Eng.  
Project Manager



Brian R. Gray, MEng, P.Eng.  
MTO Designated Principal Contact

GD/CN/BRG:ak



**TABLE 1**  
**SUMMARY OF ADVANTAGES, DISADVANTAGES AND RECOMMENDED FOUNDATIONS**

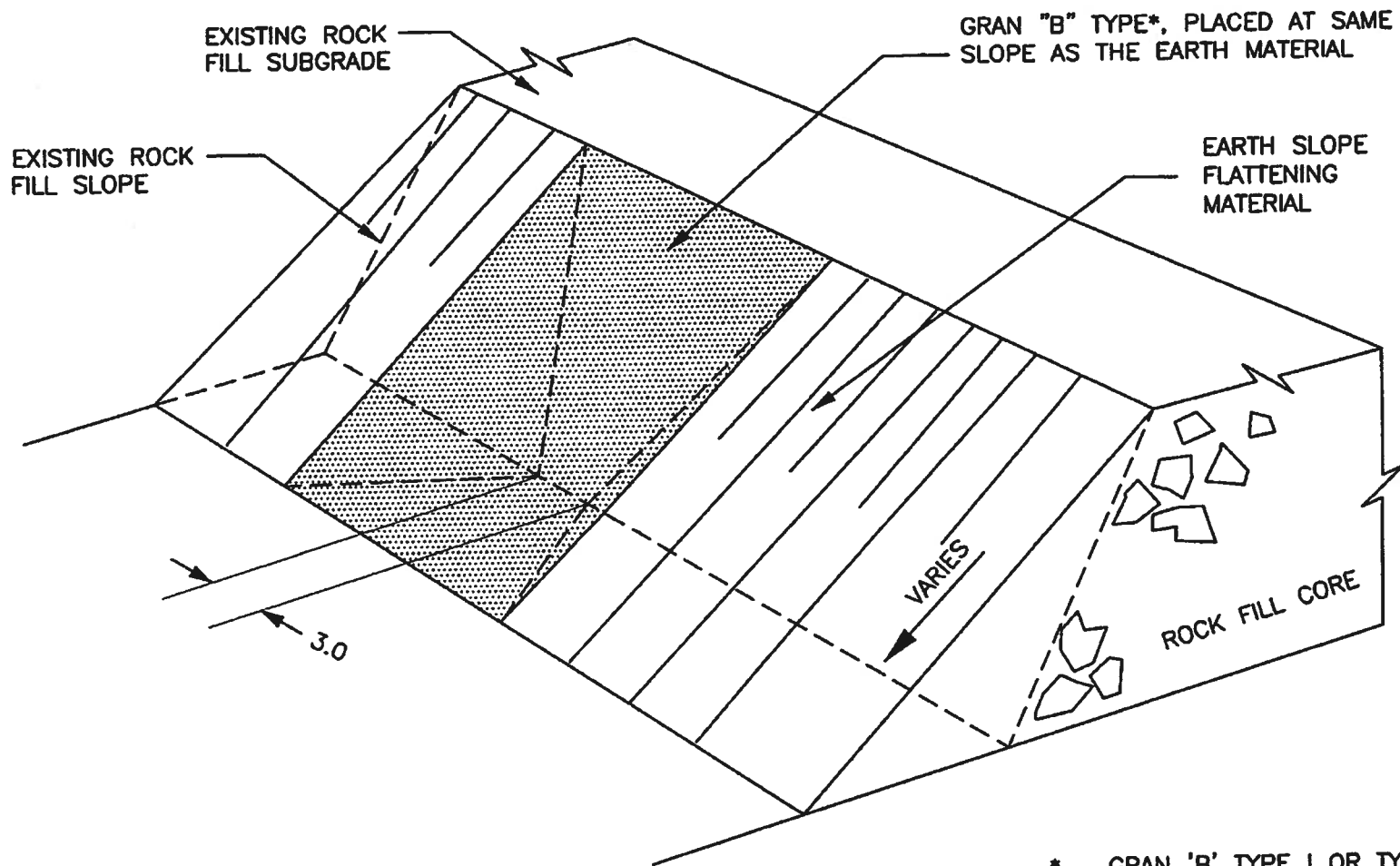
FOUNDATION TYPE	ADVANTAGES	DISADVANTAGES	RECOMMENDED FOUNDATION TYPE
SOUTH AND NORTH ABUTMENTS			
Spread footings on rock	<ul style="list-style-type: none"><li>• Ease of construction</li><li>• Minimal requirement for rock excavation</li><li>• No requirement to provide erosion protection</li></ul>	<ul style="list-style-type: none"><li>• Need to place mass concrete to provide a level surface</li></ul>	Spread footings
Spread footings on engineered fill pad	Not appropriate		
Driven piles	<ul style="list-style-type: none"><li>• High capacity</li><li>• Allows for integral abutments</li></ul>	<ul style="list-style-type: none"><li>• Too short piles; would require rock trenches or large diameter drilled holes</li><li>• High cost relative to footings</li></ul>	
Caissons	<ul style="list-style-type: none"><li>• High capacity</li></ul>	<ul style="list-style-type: none"><li>• Special construction methods on sloping bedrock</li><li>• High cost relative to other alternatives</li></ul>	





**TABLE 2**  
**LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT**

<b>DOCUMENT</b>	<b>TITLE</b>
OPSS 120	General Specification for the Use of Explosives
OPSS 405	Construction Specification for Pipe Subdrains
OPSS 501	Construction Specification for Compacting
OPSS 803	Construction Specification for Sodding
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavation and Backfilling - Structures
SP 206S03	Construction Specification for Grading
SP 299F03	Rock Excavation (Machine Scaling)
SP 299F04	Rock Excavation (Trim Blasting)
SP 299F06	Rock Excavation (Controlled Blasting)
SP 999S26	Requirements for Design, Installation and Testing of Temporary and Permanent Pre-Stressed Anchors in Soil and Rock
OPSD-201.020	Rock Grading-Divided Rural
OPSD-202.010	Slope Flattening Using Excess Material on Earth or Rock Embankment
OPSD-202.020	Drainage Gap for Slope Flattening on Rock or Granular Embankment
OPSD-208.010	Benching of Earth Slopes
OPSD-3101.150	Minimum Granular Backfill Requirements - Abutments
OPSD-3101.200	Walls Abutment, Backfill Rock
OPSD-3190.100	Retaining Wall and Abutment Wall Drain Detail
NRE 98-200	Northeastern Region Directive - Platform Widening



\* GRAN 'B' TYPE I OR TYPE II AS RECOMMENDED FOR PROJECT.

FIGURE 1: ROCK FILL DRAINAGE IN SLOPE FLATTENED AREAS

NOT TO SCALE



## **APPENDIX 1**

### Non-Standard Special Provisions:

- Inspection of Footings by a Specialist Rock Mechanics Engineer
- Rock Blasting / Excavation for Footings Construction



---

## **INSPECTION OF FOOTINGS BY A SPECIALIST ROCK MECHANICS ENGINEER**

---

### **Non-Standard Special Provision**

---

The bedrock footing subgrade shall be inspected by a Specialist Rock Mechanics Engineer. The Engineer shall report on the acceptance of the footing subgrade.

---

## **ROCK BLASTING / EXCAVATION FOR FOOTINGS CONSTRUCTION**

---

### **Non-Standard Special Provision**

---

Blasting / rock excavation shall be controlled to prevent fracturing and/or disturbance of the bedrock footing subgrade. A rock blasting specialist should be retained to establish the charge to minimise overbreak. Any overblasting / overexcavation shall be the sole responsibility of the Contractor.

The impact on bedrock by blasting at the foundation locations and the integrity of the footing subgrade shall be inspected by a Specialist Rock Mechanics Engineer.

The Contractor must be aware that the vertical faces of the bedrock behind the pier footings are load bearing and the integrity of these faces should be preserved by carefully controlled rock excavation.

Loosened rock resulting from blasting operations should be removed by mechanical means. Local remediation may be required at the footings based on the inspection by a Specialist Rock Mechanics Engineer. The remedial methods shall be provided to the Contractor by the Specialist Rock Mechanics Engineer.